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An Analysis of McLean County, Illinois Farmers' Perceptions of Genetically Modified Crops

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McLean County, Illinois farmers were surveyed in order to explore their perceptions of biotechnology and genetically modified crops, and to analyze the relationships between those perceptions and choices regarding use of genetically modified crops. Statistical analyses revealed that perceptions could be used to distinguish between users and non-users of genetically modified crops, but the approach was more effective for past use than for planned use. Perceptions that were related to past use of genetically modified crops included satisfaction with the benefits of biotechnology, the perception that biotechnology would be beneficial to agriculture, and the perception that farmers were well informed and could easily obtain objective information about biotechnology. Perceptions of the agronomic and economic benefits of genetically modified crops, with the possible exception of Bt corn, were of limited use when distinguishing between users and non-users. Age, education, and farm size had limited impact on choices regarding genetically modified crops.

Key words: Biotechnology, genetically modified corn, genetically modified soybeans, farmer perceptions.

Introduction

In an essay on biotechnology, Kershen (1999) argued that acceptance or rejection of biotechnology would not be based upon information about, or understanding of, the science and technology, but rather upon ideological beliefs and cultural values of individual human beings. When contemplating the issue from the narrower perspective of the farmer, Hillyer (1999) proposed that profitability would determine whether or not a farmer would adopt biotechnology. Fernandez-Cornejo and McBride (2002) proposed that factors such as producer flexibility, consumer preferences, and farmer attributes and perceptions would also influence adoption. The purpose of the study described in this paper was to explore McLean County, Illinois farmers' perceptions of biotechnology, which should reflect their beliefs and values, and analyze the impact of those perceptions on choices pertaining to genetically modified (GM) crops.

Based upon a review of field research and related literature, Carpenter and Gianessi (1999) concluded that farmers rapidly adopted herbicide-tolerant (HT) soybeans in the late 1990s because of the simplicity and flexibility of Roundup Ready weed control and the notion that the Roundup Ready system solved some of the problems associated with conventional weed management systems. Fernandez-Cornejo and McBride (2000) reported that US farmers adopted HT soybeans because of decreased pesticide input costs and increased yields that resulted from improved pest control. In a follow-up study, Fernandez-Cornejo and McBride (2002) found that US farmers' adoption of HT corn had a positive impact on farm net returns, whereas the adoption of Bt corn had a negative impact on farm net returns. In addition, the adoption of HT soybeans had no significant impact on farm net returns. These results suggested that factors other than net returns, such as easier management and time savings, might have influenced adoption of GM crops on some farms.

Advantages of GM soybeans, as perceived by Ohio grain farmers, were lower pesticide costs and lower overall production costs (Darr & Chern, 2002). Perceived advantages of Bt corn were lower pesticide costs, lower pesticide use, higher yields, and improved insect control. A concern associated with Bt corn was an inability to market the crop, and a concern associated with GM soybeans was the cost of using Monsanto's seed. Ohio farmers who segregated GM crops from non-GM crops were more likely to adopt Bt corn and GM soybeans, theoretically because they could collect premiums paid for non-GM crops while taking advantage of reduced management and production costs associated with GM crops.

Pilcher et al. (2002) reported that slightly more than one-half of Illinois Bt corn producers believed that yields were higher with Bt corn compared to non-Bt hybrids, and approximately one-third of producers believed that yields were similar. With regard to economic returns, slightly more than half of the Illinois Bt

Table 1. Categories of age and education as reported by respondents.

Age			Education		
Category (yrs)	Number	% of those reporting	Category	Number	% of those reporting
< 20	0	0.0	**Less than high school**	2	1.5
21 –30	2	1.5	**High school degree**	45	34.1
31- 40	13	9.8	**Some college or 2-yr degree**	32	24.2
41- 50	39	29.3	**4-yr degree**	36	27.3
51- 60	48	36.1	**Some graduate courses**	4	3.0
> 60	31	23.3	**Graduate degree**	13	9.8
Total	**133**	**100.0**	**Total**	**132**	**100.0**

corn producers believed that returns were higher with Bt corn, whereas slightly less than one-fourth believed that returns were similar. Merrill, Goldberger, and Foltz (2005) reported that a majority of Wisconsin farmers realized higher yields, higher expenses, and higher profits with Bt corn, and lower expenses with HT corn compared to conventional corn varieties. On the other hand, there was disagreement about the yield and profit benefits from HT corn and soybeans.

With regard to perceptions, Darr and Chern (2002) reported that farmers who believed that labeling of GM-based foods was somewhat or extremely necessary were more likely to adopt Bt corn. Alternatively, perceived personal knowledge of biotechnology and perceived risk of GM-based foods were not significant predictors of GM crop adoption. The authors concluded that adoption of life science technology was affected by attitudes toward, and beliefs about, GM crops, including opinions about Monsanto's delivery of GM technology to farmers. Alexander, Fernandez-Cornejo, and Goodhue (2003) concluded that the controversy that surrounded GM crops affected Iowa Farm Bureau members' GM and non-GM crop acreage allocation decisions. Producers who agreed with the statement that consumers would not accept biotech food products had lower shares of GM corn in 2000, while soybean shares appeared to be invariant to beliefs about consumer acceptance. Van Scharrel (2003) reported that South Dakota corn and soybean producers' attitudes toward the StarLink case and their perceived personal knowledge of biotechnology influenced adoption of at least one transgenic crop.

When farmer attributes were investigated, differences in geographic scope and empirical procedures might have led to what appear to be inconsistent results. Fernandez-Cornejo and McBride (2002) applied a Tobit model to data from three USDA national surveys and concluded that adoption of both Bt corn and HT corn was positively related to farm size, but adoption of HT soybeans was not affected by farm size. By contrast, Fernandez-Cornejo, Klotz-Ingram, and Jans (2002) focused on nation-wide adoption of HT soybeans in 1997, and they concluded that farm size had a positive impact on adoption. Darr and Chern (2002) analyzed adoption of GM crops by Ohio farmers using a Tobit model, and they found that income and farm size were not good predictors of either Bt corn or GM soybean adoption. Alexander et al. (2003) reported that larger Iowa farms, as reflected by higher gross farm incomes, tended to have higher shares of GM corn and soybeans.

Van Scharrel (2003) applied logistic regression analysis to data collected from South Dakota farms and concluded that total cropland acreage was positively associated with adoption of HT soybeans. Merrill et al. (2005) found that large Wisconsin farms were more likely than small farms to adopt genetically engineered crops, with the difference being more pronounced for corn. Fernandez-Cornejo and McBride (2002) speculated that observed differences in empirical results among HT soybeans, Bt corn, and HT corn were due to variations in adoption rates among the three crops because adoption is most strongly related to farm size during the innovator stage. As diffusion increases, the impact of farm size on adoption generally decreases.

Results also appeared to be inconsistent when adoption of GM crops was compared to farmer education and farmer age. Fernandez-Cornejo and McBride (2002) concluded that adoption of Bt corn and HT corn, but not HT soybeans, was positively affected by education. Alexander et al. (2003), on the other hand, reported that more years of schooling were associated with lower shares of GM soybeans, and Fernandez-Cornejo et al. (2002) reported that greater education had a positive impact on HT soybean adoption. Darr and Chern (2002) found that farmers with at least some college education were more likely to adopt both Bt corn and GM soybeans. Darr and Chern also reported that older farmers

were more likely to adopt Bt corn, but Van Scharrel (2003) reported that farmer age was negatively associated with previous adoption of Bt corn as well as intentions to plant Bt corn.

With regard to relationships between farmer attributes and knowledge of agricultural biotechnology, Tegegne, Muhammad, Ekanem, and Singh (2003) found that age, education, and farm size were significantly related to self-reported knowledge for a sample of small farmers in Tennessee. Farmers with more education, those with larger operations, and younger farmers had greater self-reported knowledge.

Methodology

A questionnaire was developed based upon information obtained from a review of literature, particularly Van Scharrel's 2003 study of South Dakota farmers. The questionnaire was mailed once to 400 randomly selected farmers whose names and addresses were obtained from the McLean County, Illinois Farm Services Agency. A single county was studied because geographical limitation allowed greater control over differences in climate, soil types, topography, and corn borer infestations, all of which can affect the relative performance of GM crops.

One set of questions on the questionnaire asked respondents to identify appropriate categories for gender, age, and level of education; to report whether they planned to produce livestock; and to report number of tillable acres farmed at the time the questionnaire was completed. A second set of questions asked respondents to report choices related to GM crops, specifically whether they had planted GM crops in the past and if they planned to plant GM corn or soybeans in the next crop year. The final section of the questionnaire consisted of 40 statements that pertained to biotechnology and GM crops, hereafter referred to as perception statements, and a 5-point Likert scale. Respondents were asked to identify the degree to which they agreed or disagreed with each perception statement. The Internal Review Board at Illinois State University approved the questionnaire and the cover letter that accompanied it.

To determine if perceptions could be used to explain choices pertaining to GM crops, a three-step procedure was used. First, Likert-scale responses to perception statements were combined with choices regarding GM crops in chi-square tests of independence. Next, perception statements that were significant in chi-square tests of independence were subjected to factor analysis in order to create a reduced number of variables that were uncorrelated with one another but still contained useful information from original responses to perception statements. Finally, weighted factor scores from factor analysis were used as independent variables in binary logistic regression analysis. The purpose of binary logistic regression was to determine if information about McLean County, Illinois farmers' perceptions of biotechnology and GM crops could be used to classify their past and future choices regarding GM crops. Binary dependent variables included (a) past experience with GM crops, specifically whether a farmer had previously planted or not planted GM crops, and (b) plans to plant or not plant GM corn or soybeans in the next crop year. All statistical analyses were conducted with SPSS 12.0, and a .05 level of statistical significance was utilized.

Results and Discussion

Of the 400 questionnaires that were mailed, 156 (39.0%) were returned by respondents. Of the 156 that were returned, 10 were returned by individuals who reported that they were retired, and 11 were returned by individuals who reported that they would not plant crops during the next crop year. One respondent indicated that she or he would produce livestock but not crops. The remaining 134 questionnaires contained useable information.

Gender was reported by 119 individuals, 117 of whom were male. Tillable acres farmed (with an average of 976.1 ± 126.2) was reported by 132 individuals, and ranged from 15 to 15,000 acres. Information regarding age and education is recorded in Table 1. Nearly 60% of those who provided information about age were over the age of 50, and 23.3% were older than 60. Of those who reported an education level, 35.6% had earned a high school degree or less. Slightly more than 40% had earned at least a baccalaureate degree, including 9.8% who reported earning a graduate degree.

According to the 2002 Census of Agriculture (National Agricultural Statistics Service, 2002), there were 1442 farms in McLean County, Illinois. The average farm size was 477 acres, the average age of a farm operator was 54.8 years, and the gender ratio of farm operators was 1363 males (94.5%) to 79 females (5.5%). Data collected in this study indicated that the average farm size for survey respondents (976.1 tillable acres) was larger than the average farm size for all McLean County farmers (477 tillable acres), and the ratio of male to female operators appeared to be slightly larger among respondents than among all McLean County farmers. On the other hand, the average age of respondents appeared to be similar to the average age of

all McLean County farmers. The 134 farmers whose responses were used in this study represented approximately 9% of the farmers in McLean County.

Table 2 contains results for questions about crop and livestock production. Of the 134 respondents who indicated that they would produce crops during the next crop year, 30 (22.4%) indicated that they would also produce livestock. One hundred twenty-six respondents (94.0%) reported that they had planted GM crops in the past, and 123 of 133 (92.5%) respondents reported that they would plant GM crops during the next crop year.

Response frequencies for the 40 perception statements are displayed in Table 3. A majority of respondents agreed that biotechnology would be beneficial to agriculture, including world, US, and Illinois agriculture. Approximately 87% of McLean County respondents agreed that biotechnology would be beneficial to Illinois agriculture, which was similar to Van Scharrel's 2003 finding that 89.3% of South Dakota farmer respondents agreed that biotechnology would be beneficial to most South Dakota farmers. A majority of McLean County respondents agreed that biotechnology would help find new uses for agricultural products, while 33.6% agreed that biotechnology would lead to surpluses of agricultural products. In Van Scharrel's study, 36.3% of South Dakota farmer respondents agreed that biotechnology would hurt American farmers by increasing farm surpluses.

A majority of McLean County respondents agreed with the statements that many of the problems encountered in conventional agriculture would be eliminated by biotechnology, and that GM crops have made farm management easier. Approximately one-third of respondents agreed that biotechnology would benefit large farm operations more than small operations, while 49.3% agreed that biotechnology would make them more dependent upon large corporations for farm inputs. The latter figure is noticeably smaller than the 71.3% of South Dakota farmer respondents who agreed that biotechnology would lead farmers to become more dependent upon larger corporations for many of their inputs. Nearly two-thirds of McLean County respondents, or 63.5%, agreed that GM crops enabled them to depend less on agricultural chemicals, whereas only 49.0% of South Dakota farmer respondents agreed that biotechnology would enable farmers to become less dependent upon agricultural chemicals.

With regard to negative influences on GM crop planting decisions, McLean County farmers appeared to be most concerned about technology fees associated with GM seeds, followed by (a) restrictions on saving GM seeds, (b) lawsuits filed by seed companies against farmers, and finally, (c) the StarLink case. Results were similar for South Dakota farmers. With regard to consumer attitudes toward GM crops, both McLean County farmers and South Dakota farmers were more concerned about the attitudes of foreign consumers than the attitudes of US consumers.

Table 2. Responses to questions that pertained to crop and livestock production.

Question	Yes	No
Will you produce crops during the next crop year?	134	0
Will you produce livestock during the next crop year?	30	104
Have you planted genetically modified crops in the past?	126	8
Will you produce genetically modified crops during the next crop year?	123	10

With regard to the relative performances of GM crops, specifically Bt corn, HT corn, and HT soybeans, McLean County farmers were most likely to agree that HT soybeans generated lower expenses per acre than their conventional counterparts. They were also most likely to agree that Bt corn varieties produced higher yields than their conventional counterpart, while they were least likely to agree that HT corn varieties generated more profit per acre than their conventional counterparts. These results were consistent with the observations of South Dakota farmers with the exception of profit per acre, where South Dakota farmers perceived little difference between HT corn and HT soybeans.

While only 40.3% of McLean County respondents agreed that segregation of GM crops from non-GM crops was practical, 67.9% agreed that segregation was necessary. A large percentage of McLean County respondents, specifically 86.6%, stated that they were concerned about increased regulation of GM crops in international trade, and 82.1% stated that they were concerned about receiving lower prices for GM crops.

In general, McLean County farmers were equally satisfied with the benefits of biotechnology as both producers and consumers, with 71.6% of respondents agreeing or strongly agreeing that they were satisfied with the benefits as either producers or consumers. Slightly less than 77% of McLean County respondents agreed that biotechnology would be beneficial to consumers (compared to 55.8% for South Dakota farmers) but only 47.7% agreed that those benefits would come in the form of improved quality and nutritional value of

Table 3. Likert-scale responses to 40 statements that pertained to biotechnology and genetically modified (GM) organisms (1=strongly agree; 5=strongly disagree).

Perception statement	Percent of respondents				
	1	2	3	4	5
Biotechnology will be beneficial to world agriculture.	53.7	38.1	4.5	1.5	2.2
Biotechnology will be beneficial to US agriculture.	50.0	38.8	3.0	6.7	1.5
Biotechnology will be beneficial to Illinois agriculture.	50.0	36.6	6.0	5.2	2.2
Biotechnology will help find new uses for agricultural products.	37.3	40.3	17.2	3.7	1.5
Biotechnology will lead to surpluses of agricultural products.	11.2	22.4	32.1	25.4	9.0
Many of the problems encountered in conventional agriculture (e.g., insect and weed problems) are eliminated by biotechnology.	18.7	55.2	10.4	12.7	3.0
Introduction of GM crops has made farm management easier.	25.4	47.0	11.9	11.2	4.5
Biotechnology benefits large farm operations more than small operations.	13.4	20.1	19.4	30.6	16.4
Biotechnology makes me more dependent upon large corporations for farm inputs.	20.9	28.4	25.4	15.7	9.7
GM crops enable me to depend less on agricultural chemicals.	15.7	47.8	14.2	17.9	4.5
Technology fees affect my GM crop planting decisions.	24.6	46.3	14.9	9.7	4.5
Restrictions on saving GM seed affect my GM crop-planting decisions.	21.6	26.9	25.4	19.4	6.7
Lawsuits filed by seed companies against farmers affect my GM crop-planting decisions.	14.9	23.9	28.4	22.4	10.4
The StarLink case affects my GM crop planting decisions.	14.2	23.9	29.1	20.9	11.9
US consumer attitudes toward GM products affect my GM crop planting decisions.	15.7	31.3	22.4	21.6	9.0
Foreign consumer attitudes toward GM products affect my GM crop planting decisions.	17.9	43.3	13.4	15.7	9.7
Bt corn generates lower expenses per acre than conventional corn.	3.7	22.4	25.4	36.6	11.9
Herbicide-tolerant corn generates lower expenses per acre than conventional corn.	2.2	24.6	38.1	26.9	8.2
Herbicide-tolerant soybeans generate lower expenses per acre than conventional soybeans.	15.7	39.6	17.9	23.1	3.7
Bt corn produces higher yields than conventional corn.	11.2	39.6	29.1	14.9	5.2
Herbicide-tolerant corn produces higher yields than conventional corn.	2.2	14.2	57.5	17.9	8.2
Herbicide-tolerant soybeans produce higher yields than conventional soybeans.	4.5	25.4	34.3	26.9	9.0
Bt corn generates more profit per acre than conventional corn.	8.2	33.6	39.6	13.4	5.2
Herbicide-tolerant corn generates more profit per acre than conventional corn.	2.2	14.2	57.5	20.1	6.0
Herbicide-tolerant soybeans generate more profit per acre than conventional soybeans.	6.7	38.1	26.1	23.1	6.0
Market segregation of GM crops from non–GM crops is practical.	11.9	28.4	21.6	29.9	8.2
Market segregation of GM crops from non–GM crops is necessary.	29.1	38.8	19.4	11.2	1.5
As a farm producer, I am concerned about increased regulation of GM crops in international trade.	33.6	53.0	9.7	2.2	1.5
As a farm producer, I am concerned about receiving lower prices for GM crops.	40.3	41.8	10.4	6.7	0.7
As a farm producer, I am satisfied with the benefits of biotechnology.	19.4	52.2	12.7	11.9	3.7
Biotechnology will be beneficial to consumers.	30.6	46.3	14.9	6.0	2.2
Biotechnology improves the overall quality and nutritional values of food products.	20.1	27.6	39.6	9.0	3.7
Food that contains GM ingredients should be labeled as such.	14.2	29.9	32.1	17.9	6.0
Consumers concerns about food products made from GM crops are exaggerated.	29.1	36.6	23.1	8.2	3.0
As a consumer, I am satisfied with the benefits of biotechnology.	27.6	44.0	15.7	9.7	3.0
Growing GM crops is ethical.	36.6	41.8	17.2	2.2	2.2
Utilization of biotechnology in animal production is ethical.	20.1	33.6	33.6	8.2	4.5
Farmers in general have a sufficient knowledge of biotechnology.	5.2	41.8	20.1	25.4	7.5
I am well informed about biotechnology.	18.7	46.3	17.2	14.2	3.7
I can easily obtain objective information about biotechnology.	19.4	47.0	17.9	11.2	4.5

food. Approximately two-thirds of McLean County respondents agreed that consumer concerns about food made from GM crops were exaggerated, which was similar to the value of 62.3% for South Dakota farmer respondents. On the other hand, only 44.1% of McLean County respondents agreed that food with GM ingredients should be labeled as such, compared to 60.3% of South Dakota farmers.

A majority of McLean County farmers believed that biotechnology was ethical, but it was more acceptable for crop production than for animal production. While 78.4% of respondents agreed that growing GM crops was ethical, only 53.7% agreed that utilization of biotechnology in animal production was ethical. For South Dakota farmers, 71.3% disagreed with the statement that growing genetically modified crops was ethically wrong.

McLean County farmers perceived themselves to be well informed about biotechnology, but they were less sure about the knowledge possessed by other farmers. Sixty-five percent of respondents agreed that they, as individuals, were well informed about biotechnology, but only 47.0% agreed that farmers in general had sufficient knowledge of biotechnology. Approximately two-thirds of McLean County respondents agreed that they could easily obtain objective information about biotechnology. South Dakota farmers, on the other hand, appeared to be less confident in their knowledge of biotechnology, based upon the fact that only 45.9% agreed that they were well informed about biotechnology. Approximately 28% of South Dakota respondents agreed that farmers had adequate knowledge of biotechnology, and 35.0% disagreed with the statement that it had been difficult to obtain objective information about biotechnology.

Chi-Square Tests of Independence

Chi-square tests of independence were conducted to reveal statistically significant relationships among perceptions of biotechnology, choices pertaining to GM crops, and farmer attributes. All multi-valued variables were collapsed to bivariate in order to minimize the number of cells in contingency tables that had expected values of less than five. Fischer's Exact Test was used to adjust for those few remaining situations where expected values were less than five.

Table 4 contains results for tests of independence between history of planting GM crops and perceptions of biotechnology and GM crops, and it shows only those comparisons for which the hypothesis of independence was rejected. The first three test results indicated that individuals who had planted GM crops in the past were more likely to agree with statements that biotechnology would benefit world, US, and Illinois agriculture. They were also more likely to agree with the statements that biotechnology eliminates many of the problems encountered in conventional agriculture and that the introduction of GM crops has made farm management easier.

McLean County farmers who had planted GM crops in the past were less likely to agree that US consumer attitudes toward GM crops had affected their GM crop planting decisions. They were more likely to agree that (a) biotechnology would be beneficial to consumers, (b) biotechnology improves the overall quality and nutritional value of food products, and (c) consumer concerns about food products made from GM crops are exaggerated. Respondents who had planted GM crops in the past were more likely to agree that they were satisfied with the benefits of biotechnology, both as producers and consumers. They were also more likely to agree that biotechnology was ethical in both plant and animal production, and that they were well informed about, and could easily obtain, objective information about biotechnology. Finally, McLean County farmers who had planted GM crops in the past were more likely to agree that HT soybeans generated more profit per acre than conventional soybeans.

Tables 5 and 6 display results for tests of independence between plans to plant GM corn and soybeans during the next crop year and perceptions of biotechnology and GM crops. The tables include only those comparisons for which the hypothesis of independence was rejected. Results revealed that respondents who planned to plant GM corn and respondents who planned to plant GM soybeans were more likely to agree that biotechnology would be beneficial to world and US agriculture. Those same respondents were also more likely to agree that (a) they were satisfied with the benefits of biotechnology as a producer as well as a consumer, (b) biotechnology would be beneficial to consumers, (c) biotechnology improves the quality and nutritional value of food products, and (d) growing GM crops is ethical.

Those respondents who planned to plant GM corn were more likely to agree that (a) biotechnology will help find new uses for agricultural products, (b) Bt corn produces higher yields than conventional corn, (c) Bt corn generates more profit per acre than conventional corn, and (d) they, as individuals, were well informed about biotechnology. Although respondents who

Table 4. Tests of independence: History of planting GM crops vs. perceptions of biotechnology and GM crops.

Perception statement		Planted GM crops in past[a]		Sig.[b]
		Yes	No	
Biotechnology will be beneficial to world agriculture.	Agree	91.0%	0.7%	
	No opinion or disagree	3.0%	5.2%	0.000
Biotechnology will be beneficial to US agriculture.	Agree	86.6%	2.2%	
	No opinion or disagree	7.5%	3.7%	0.000
Biotechnology will be beneficial to Illinois agriculture.	Agree	84.3%	2.2%	
	No opinion or disagree	9.7%	3.7%	0.001
Many of the problems encountered in conventional agriculture (e.g., insect and weed problems) are eliminated by biotechnology.	Agree	71.6%	2.2%	
	No opinion or disagree	22.4%	3.7%	0.029
Introduction of GM crops has made farm management easier.	Agree	70.9%	1.5%	
	No opinion or disagree	23.1%	4.5%	0.006
US consumer attitudes toward GM products affect my GM crop-planting decisions.	Agree	41.8%	5.2%	
	No opinion or disagree	52.2%	0.7%	0.026
Herbicide-tolerant soybeans generate more profit per acre than conventional soybeans.	Agree	44.8%	0.0%	
	No opinion or disagree	49.3%	6.0%	0.008
As a farm producer, I am satisfied with the benefits of biotechnology.	Agree	70.9%	0.7%	
	No opinion or disagree	23.1%	5.2%	0.001
Biotechnology will be beneficial to consumers.	Agree	76.1%	0.7%	
	No opinion or disagree	17.9%	5.2%	0.000
Biotechnology improves the overall quality and nutritional values of food products.	Agree	47.8%	0.0%	
	No opinion or disagree	46.3%	6.0%	0.007
Consumers concerns about food products made from GM crops are exaggerated.	Agree	65.7%	0.0%	
	No opinion or disagree	28.4%	6.0%	0.000
As a consumer, I am satisfied with the benefits of biotechnology.	Agree	70.9%	0.7%	
	No opinion or disagree	23.1%	5.2%	0.001
Growing GM crops is ethical.	Agree	78.4%	0.0%	
	No opinion or disagree	15.7%	6.0%	0.000
Utilization of biotechnology in animal production is ethical.	Agree	53.7%	0.0%	
	No opinion or disagree	40.3%	6.0%	0.002
I am well informed about biotechnology.	Agree	63.4%	1.5%	
	No opinion or disagree	30.6%	4.5%	0.022
I can easily obtain objective information about biotechnology.	Agree	64.9%	1.5%	
	No opinion or disagree	29.1%	4.5%	0.017

[a] *Percent of respondents.*

[b] *Significance from Fisher's Exact Test (2-sided).*

planned to plant GM corn generally did not agree with the statement that HT soybeans produced higher yields than conventional soybeans, they were less likely to disagree with this statement than were respondents who

Table 5. Tests of independence: Plan to plant GM corn vs. perceptions of biotechnology and GM crops.

Perception statement		Plan to plant GM corn[a] Yes	No	Sig.[b]
Biotechnology will be beneficial to world agriculture.	Agree	65.4%	27.1%	
	No opinion or disagree	0.8%	6.8%	0.000
Biotechnology will be beneficial to US agriculture.	Agree	62.4%	26.3%	
	No opinion or disagree	3.8%	7.5%	0.008
Biotechnology will help find new uses for agricultural products.	Agree	55.6%	21.8%	
	No opinion or disagree	10.5%	12.0%	0.015
Bt corn produces higher yields than conventional corn.	Agree	45.1%	6.0%	
	No opinion or disagree	21.1%	27.8%	0.000
Herbicide-tolerant soybeans produce higher yields than conventional soybeans.	Agree	24.1%	6.0%	
	No opinion or disagree	42.1%	27.8%	0.029
Bt corn generates more profit per acre than conventional corn.	Agree	33.8%	8.3%	
	No opinion or disagree	32.3%	25.6%	0.005
As a farm producer, I am satisfied with the benefits of biotechnology.	Agree	51.9%	20.3%	
	No opinion or disagree	14.3%	13.5%	0.040
Biotechnology will be beneficial to consumers.	Agree	56.4%	21.1%	
	No opinion or disagree	9.8%	12.8%	0.004
Biotechnology improves the overall quality and nutritional values of food products.	Agree	39.1%	9.0%	
	No opinion or disagree	27.1%	24.8%	0.000
As a consumer, I am satisfied with the benefits of biotechnology.	Agree	54.1%	18.0%	
	No opinion or disagree	12.0%	15.8%	0.001
Growing GM crops is ethical.	Agree	57.1%	21.8%	
	No opinion or disagree	9.0%	12.0%	0.006
I am well informed about biotechnology.	Agree	49.6%	15.0%	
	No opinion or disagree	16.5%	18.8%	0.001

[a] Percent of respondents.

[b] Significance from Fisher's Exact Test (2-sided).

planned not to plant GM corn. Those respondents who planned to plant GM soybeans were more likely to agree that (a) biotechnology would be beneficial to Illinois agriculture, (b) many of the problems encountered in conventional agriculture are eliminated by biotechnology, and (c) consumer concerns about food products from GM crops are exaggerated. Those respondents who planned to plant GM soybeans were less likely to agree that restrictions on saving GM seed and lawsuits filed by seed companies against farmers affected their GM crop planting decisions. Finally, although respondents who planned to plant GM soybeans generally did not agree that HT soybeans generate more profit per acre than conventional soybeans, they were less likely to disagree with this statement than were respondents who planned not to plant GM soybeans.

Tables 7 and 8 display results for statistically significant tests of independence among farmer attributes and perceptions of biotechnology and GM crops. McLean County farmers over the age of 50 (Table 7) were less likely to agree that biotechnology would lead to surpluses of agricultural products, and less likely to agree that Bt corn generates more profit per acre than conventional corn. The latter result is consistent with Van Scharrel's 2003 observation that farmer age was negatively associated with previous adoption of Bt corn as well as intentions to plant Bt corn.

Farmers with 1,000 or more tillable acres (Table 8) were more likely to agree that biotechnology would help

Table 6. Tests of independence: Plan to plant GM soybeans vs. perceptions of biotechnology and GM crops.

Perception statement		Plan to plant GM soybeans[a]		Sig. [b]
		Yes	No	
Biotechnology will be beneficial to world agriculture.	Agree	88.0%	4.5%	
	No opinion or disagree	2.3%	5.3%	0.000
Biotechnology will be beneficial to US agriculture.	Agree	84.2%	4.5%	
	No opinion or disagree	6.0%	5.3%	0.000
Biotechnology will be beneficial to Illinois agriculture.	Agree	82.0%	4.5%	
	No opinion or disagree	8.3%	5.3%	0.000
Many of the problems encountered in conventional agriculture (e.g., insect and weed problems) are eliminated by biotechnology.	Agree	70.7%	3.8%	
	No opinion or disagree	19.5%	6.0%	0.004
Restrictions on saving GM seed affect my GM crop-planting decisions.	Agree	41.4%	7.5%	
	No opinion or disagree	48.9%	2.3%	0.042
Lawsuits filed by seed companies against farmers affect my GM crop planting decisions.	Agree	31.6%	6.8%	
	No opinion or disagree	58.6%	3.0%	0.032
Herbicide-tolerant soybeans generate more profit per acre than conventional soybeans.	Agree	44.4%	0.8%	
	No opinion or disagree	45.9%	9.0%	0.006
As a farm producer, I am satisfied with the benefits of biotechnology.	Agree	68.4%	3.8%	
	No opinion or disagree	21.8%	6.0%	0.008
Biotechnology will be beneficial to consumers.	Agree	74.4%	3.0%	
	No opinion or disagree	15.8%	6.8%	0.000
Biotechnology improves the overall quality and nutritional values of food products.	Agree	47.4%	0.8%	
	No opinion or disagree	42.9%	9.0%	0.002
Consumers concerns about food products made from GM crops are exaggerated.	Agree	62.4%	3.8%	
	No opinion or disagree	27.8%	6.0%	0.034
As a consumer, I am satisfied with the benefits of biotechnology.	Agree	67.7%	4.5%	
	No opinion or disagree	22.6%	5.3%	0.046
Growing GM crops is ethical.	Agree	75.2%	3.8%	
	No opinion or disagree	15.0%	6.0%	0.001

[a] *Percent of respondents.*

[b] *Significance from Fisher's Exact Test (2-sided).*

find new uses for agricultural products, but they were also more likely to agree that biotechnology would lead to surpluses of agricultural products. Additionally, farmers with 1,000 or more tillable acres were more likely to agree that they were well informed about biotechnology and that they could easily obtain objective information about biotechnology. The latter result was consistent with Tegegne et al. (2003), who found that Tennessee farmers' self-reported knowledge of agricultural biotechnology was positively related to farm size. However, they also found significant relationships between self-reported knowledge and age and education, which was not the case in *this* study.

When farmer attributes were paired with past or planned GM crop-planting decisions, only one pair of variables had a significant relationship. Specifically, farmers with 1,000 or more tillable acres were more likely than farmers with less than 1,000 acres to state that they planned to plant GM corn (results not shown). There were no significant relationships between the presence of livestock on the farm and choices related to GM crops.

Table 7. Tests of independence: Age vs. perceptions of biotechnology and GM crops.

Perception statement		Age (years)[a] <51	>50	Sig. [b]
Biotechnology will lead to surpluses of agricultural products.	Agree	20.3%	13.5%	
	No opinion or disagree	20.3%	45.9%	0.001
Bt corn generates more profit per acre than conventional corn.	Agree	21.8%	20.3%	
	No opinion or disagree	18.8%	39.1%	0.032

[a] *Percent of respondents.*
[b] *Significance from Fisher's Exact Test (2-sided).*

Table 8. Tests of independence: Farm size vs. perceptions of biotechnology and GM crops.

Perception statement		Farm size (acres) [a] <1,000	1,000 +	Sig. [b]
Biotechnology will help find new uses for agricultural products.	Agree	48.5%	28.8%	
	No opinion or disagree	18.9%	3.8%	0.045
Biotechnology will lead to surpluses of agricultural products.	Agree	17.4%	15.2%	
	No opinion or disagree	50.0%	17.4%	0.028
I am well informed about biotechnology.	Agree	38.6%	26.5%	
	No opinion or disagree	28.8%	6.1%	0.007
I can easily obtain objective information about biotechnology.	Agree	40.2%	25.8%	
	No opinion or disagree	27.3%	6.8%	0.032

[a] *Percent of respondents.*
[b] *Significance from Fisher's Exact Test (2-sided).*

Factor Analysis and Binary Logistic Regression

Tables 9 through 11 provide combined results for factor analysis and binary logistic regression analysis. Perception statements that were significantly related to GM crop choices in Tables 4 through 6 were subjected to factor analysis, and factors that generated Eigenvalues greater than one are displayed in Tables 9 through 11. For each factor, the individual perception statements that loaded into the factor with a loading value greater than 0.6 are shown. Those particular perception statements were assumed to sufficiently represent their respective factors. Given m observations and n factors, SPSS computed m x n weighted factor scores for each of the three GM crop choices.

With regard to binary logistic regression analysis, each table includes odd ratios (e raised to the power of the estimated regression parameter or logit) for weighted factor scores that served as independent variables together with their respective levels of statistical significance. The odds ratio signifies the change in the odds that the binary dependent variable equals one, or that an event occurs in response to a one-unit change in the independent variable after controlling for all other independent variables. The events that were analyzed in this study included planting GM crops in the past, planning to plant GM corn during the next crop year, and planning to plant GM soybeans during the next crop year. To simplify interpretation of odds ratios, Likert ratings were recoded prior to factor analysis and binary logistic regression analysis. Prior to recoding, a higher numeric value was associated with greater disagreement with a perception statement, whereas after recoding, a higher numeric value was associated with greater agreement with a perception statement. Other reported statistics included chi-square values for the Hosmer and Lemeshow goodness-of-fit test, Nagelkerke R-square values, and finally, percentages of correctly classified cases. A non-significant Hosmer and Lemeshow chi-square statistic indicated that a model had adequate fit.

Table 9 shows results for McLean County respondents who had planted GM crops in the past versus those who had not. Three of the five factors that were included in the model were found to be significant at the .05 level. Factor 1 appeared to represent satisfaction with the benefits of biotechnology as both a producer and a consumer. Greater agreement with the three statements (a) "as a consumer, I am satisfied with the benefits of biotechnology;" (b) "growing GM crops is ethical;" and (c) "as a farm producer, I am satisfied with the benefits of biotechnology" (a one-unit increase in the weighted factor score) was associated with a 12.2-fold increase in the odds that a farmer had planted GM crops in the past. Factor 2 appeared to represent the perceived benefits of biotechnology to agriculture throughout the world. Greater agreement with the three statements (a) "biotechnology will be beneficial to US agriculture," (b) "biotechnology will be beneficial to Illinois agriculture," and (c) "biotechnology will be beneficial to world agriculture" (a one-unit increase in the weighted factor score) was associated with a 4.8-fold increase in the odds that a farmer had planted GM crops in the past. Finally, factor 3 appeared to represent self-perceived, personal knowledge of biotechnology.

Table 9. Results from binary logistic regression with weighted factor scores from factor analysis as independent variables: Planted GM crops in past.

Factors[a] and perception statements with factor loading values > 0.60	Odds ratio	Sig.
Factor 1	**12.181**	**0.022**
As a consumer, I am satisfied with the benefits of biotechnology.		
Growing GM crops is ethical.		
As a farm producer, I am satisfied with the benefits of biotechnology.		
Factor 2	**4.824**	**0.010**
Biotechnology will be beneficial to US agriculture.		
Biotechnology will be beneficial to Illinois agriculture.		
Biotechnology will be beneficial to world agriculture.		
Factor 3	**4.397**	**0.032**
I can easily obtain objective information about biotechnology.		
I am well informed about biotechnology.		
Factor 4	**6.003**	**0.071**
Biotechnology improves the overall quality and nutritional values of food products.		
Biotechnology will be beneficial to consumers.		
Factor 5	**1.974**	**0.265**
Many of the problems encountered in conventional agriculture (e.g., insect and weed problems) are eliminated by biotechnology.		
Introduction of GM crops has made farm management easier.		
Constant	**1839.734**	**0.002**
Chi-square[b]	**0.203 (*P*=1.00)**	
Nagelkerke R-square	**0.737**	
Correct yes (%)	**100.0**	
Correct no (%)	**62.5**	
Correct overall (%)	**97.8**	

[a] Factors with Eigenvalues > 1 as determined by principal components analysis with Varimax orthogonal rotation. Five factors accounted for 64.4% of the variance in the original data.

[b] Hosmer and Lemeshow test; significant P values indicate inadequate fit.

Greater agreement with the statements "I can easily obtain information about biotechnology," and "I am well informed about biotechnology" (a one-unit increase in the weighted factor score) was associated with a 4.4-fold increase in the odds that a farmer had planted GM crops in the past. The factor associated with the nutritional value of food and benefits of biotechnology to consumers, and the factor associated with management benefits to producers, were not statistically significant at the .05 level. The model correctly classified 100% of those who had planted GM crops in the past and 62.5% of those who had not planted GM crops in the past.

Table 10. Results from binary logistic regression with weighted factor scores from factor analysis as independent variables: Plan to plant GM corn.

Factors[a] and perception statements with factor loading values > 0.60	Odds ratio	Sig.
Factor 1	**1.582**	**0.031**
As a consumer, I am satisfied with the benefits of biotechnology.		
As a farm producer, I am satisfied with the benefits of biotechnology.		
Growing GM crops is ethical.		
Factor 2	**2.216**	**0.000**
Biotechnology improves the overall quality and nutritional values of food products.		
Biotechnology will help find new uses for agricultural products.		
I am well informed about biotechnology.		
Biotechnology will be beneficial to consumers.		
Factor 3	**2.746**	**0.000**
Bt corn generates more profit per acre than conventional corn.		
Bt corn produces higher yields than conventional corn.		
Factor 4	**1.976**	**0.009**
Biotechnology will be beneficial to US agriculture.		
Biotechnology will be beneficial to world agriculture.		
Constant	**2.350**	**0.000**
Chi-square[b]	**6.887 (*P*=0.549)**	
Nagelkerke R-square	**0.386**	
Correct yes (%)	**90.9**	
Correct no (%)	**53.3**	
Correct overall (%)	**78.2**	

[a] Factors with Eigenvalues > 1 as determined by principal components analysis with Varimax orthogonal rotation. Four factors accounted for 62.5% of the variance in the original data.

[b] Hosmer and Lemeshow test; significant P values indicate inadequate fit.

Table 10 contains results for McLean County respondents who planned to plant GM corn during the next crop year versus those who had not. Factor 1, which appeared to represent satisfaction with the benefits of biotechnology as both a producer and a consumer, was significant at the .05 level. Greater agreement with the three statements (a) "as a consumer, I am satisfied with the benefits of biotechnology;" (b) "as a farm pro-

ducer, I am satisfied with the benefits of biotechnology;" and (c) "growing GM crops is ethical" (a one-unit increase in the weighted factor score) was associated with a 1.6-fold increase in the odds that a farmer planned to plant GM corn during the next crop year. Factors 2 through 4 were significant at the .01 level.

Factor 2 appeared to represent the benefits of biotechnology to food and to consumers. Greater agreement with the four statements (a) "biotechnology improves the overall quality and nutritional value of food," (b) "biotechnology will help find new uses for agricultural products," (c) "I am well informed about biotechnology," and (d) "biotechnology will be beneficial to consumers" (a one-unit increase in the weighted factor score) was associated with a 2.2-fold increase in the odds that a farmer planned to plant GM corn during the next crop year.

Factor 3, which had the strongest impact on the dependent variable, appeared to represent the direct economic and agronomic benefits of Bt corn to producers. Greater agreement with the statements that "Bt corn generates more profit per acre than conventional corn," and "Bt corn produces higher yields than conventional corn" (a one-unit increase in the weighted factor score) was associated with a 2.7-fold increase in the odds that a farmer planned to plant GM corn during the next crop year. Finally, factor 4 appeared to represent the perceived benefits of biotechnology to agriculture throughout the world. Greater agreement with the statements "biotechnology will be beneficial to US agriculture," and "biotechnology will be beneficial to world agriculture" (a one-unit increase in the weighted factor score) was associated with a 2.0-fold increase in the odds that a farmer planned to plant GM corn during the next crop year. The model correctly classified 90.9% of farmers who had planned to plant GM corn during the next crop year and 53.3% of farmers who had not planned to plant GM corn.

Table 11 displays results for McLean County respondents who planned to plant GM soybeans during the next crop year versus those who had not. Two factors, the first of which appeared to represent the perceived benefits of biotechnology to agriculture throughout the world, and the second of which appeared to represent perceived benefits of biotechnology to food and consumers, were significant at the .01 level. With regard to factor 1, greater agreement with the three statements (a) "biotechnology will be beneficial to Illinois agriculture," (b) "biotechnology will be beneficial to US agriculture," and (c) "biotechnology will be beneficial to world agriculture" (a one-unit increase in the weighted factor score) was associated with a 2.6-fold increase in the odds that a farmer planned to plant GM soybeans during the next crop year.

With regard to factor 2, greater agreement with the statements "biotechnology improves the overall quality and nutritional value of food," and "biotechnology will be beneficial to consumers" (a one-unit increase in the weighted factor score) was associated with a 3.1-fold increase in the odds that a farmer planned to plant GM soybeans during the next crop year. Factor 4, which appeared to represent negative consequences of purchasing GM soybean seeds, was significant at the .05

Table 11. Results from binary logistic regression with weighted factor scores from factor analysis as independent variables: Plan to plant GM soybeans.

Factors[a] and perception statements with factor loading values > 0.60	Odds ratio	Sig.
Factor 1	**2.617**	**0.000**
Biotechnology will be beneficial to Illinois agriculture.		
Biotechnology will be beneficial to US agriculture.		
Biotechnology will be beneficial to world agriculture.		
Factor 2	**3.068**	**0.004**
Biotechnology improves the overall quality and nutritional values of food products.		
Biotechnology will be beneficial to consumers.		
Factor 3	**1.721**	**0.084**
Consumers concerns about food products made from GM crops are exaggerated.		
As a consumer, I am satisfied with the benefits of biotechnology.		
Growing GM crops is ethical.		
Factor 4	**0.452**	**0.046**
Restrictions on saving GM seed affect my GM crop-planting decisions.		
Lawsuits filed by seed companies against farmers affect my GM crop-planting decisions.		
Constant	**28.907**	**0.000**
Chi-square[b]	**4.620 (*P*=0.797)**	
Nagelkerke R-square	**0.469**	
Correct yes (%)	**98.3**	
Correct no (%)	**46.2**	
Correct overall (%)	**93.2**	

[a] Factors with Eigenvalues > 1 as determined by principal components analysis with Varimax orthogonal rotation. Four factors accounted for 65.0% of the variance in the original data.

[b] Hosmer and Lemeshow test; significant P values indicate inadequate fit.

level. Greater disagreement with the statements "restrictions on saving GM seed affect my GM crop planting decisions," and "lawsuits filed by seed companies against farmers affect my GM crop planting decisions" (a one unit decrease in the weighted factor score) was associated with a 2.2-fold increase in the odds that a farmer planned to plant GM soybeans during the next crop year. Overall, the model correctly classified 98.3% of farmers who planned to plant GM soybeans during the next crop year and 46.2% of farmers who did not plan to plant GM soybeans.

Based upon Hosmer and Lemeshow chi-square statistics, all three models had adequate fit. Nagelkerke R-square values ranged from a high of 0.737 for the history of planting GM crops model to a low of 0.386 for the plan to plant GM corn model. When number of tillable acres was added to all three models as a continuous independent variable, it was found to be insignificant in all cases (results not shown). Given that 92% of respondents reported that they would plant at least one GM crop during the next crop year, this result would appear to support the theory that the impact of farm size on adoption generally decreases as diffusion increases (Fernandez-Cornejo & McBride, 2002).

Summary and Conclusions

The purpose of this study was to explore McLean County, Illinois farmers' perceptions of biotechnology and analyze the impact of those perceptions on choices pertaining to GM crops. Results revealed that even within a small geographic area where decision-makers are relatively homogeneous, and utilization of GM crops is predominant, perceptions can be used to distinguish between those who utilize GM crops and those who do not.

McLean County, Illinois farmers who had utilized GM crops in the past were more likely to be satisfied with the benefits of biotechnology as both producers and consumers than were their counterparts. Those who had utilized GM crops in the past, as well as those who planned to plant a GM crop during the next crop year, were more likely to agree that biotechnology would be beneficial to US and world agriculture. Individuals who planned to plant GM corn and individuals who planned to plant GM soybeans during the next crop year were more likely to agree that biotechnology improves the overall quality and nutritional value of food products, and that biotechnology will be beneficial to consumers. McLean County, Illinois farmers who planned to plant GM corn during the next crop year were more likely to agree that Bt corn generates higher yields and more profit per acre than conventional corn, and McLean County, Illinois farmers who planned to plant GM soybeans during the next crop year were less likely to agree that seed-saving restrictions and lawsuits filed by seed companies against farmers had affected their GM crop planting decisions.

It appeared that the perceptions considered in this study were, for the most part, independent of education and minimally dependent upon age and farm size. Farmers over the age of 50 were less likely to agree that biotechnology will lead to surpluses of agricultural products and less likely to agree that Bt corn generates more profit per acre than conventional corn. Farmers with 1,000 or more tillable acres were more likely to agree that biotechnology would help find new uses for agricultural products and less likely to agree that biotechnology would lead to surpluses of agricultural products. Operators of larger farms were also more likely to agree that they were well informed about biotechnology and that they could easily obtain objective information about biotechnology. Statistically, education, age, and farm size had no impact on choices regarding GM crops.

The results of this study were consistent with Darr and Chern's (2002) contention that adoption of life science technology is affected by more than potential cost benefits and decreased pesticide use. It is noteworthy that perceptions of the agronomic and economic benefits of GM crops, with the possible exception of Bt corn, were of limited use when distinguishing users of GM crop technology from non-users.

The most important conclusion that can be drawn from this study is that McLean County, Illinois farmers who utilized or planned to utilize GM crop technology had more optimistic perceptions of biotechnology and GM crops than did those who chose not to use the technology, not only from the perspective of a producer, but also from the perspective of a consumer.

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