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

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There are parties interested in learning more about farmers' perceptions of genetically modified (GM) crops and the factors that influence their decisions regarding production of GM crops. The purpose of this study was to explore and analyze McLean County, Illinois farmers' perceptions of GM crops and their GM cropping decisions so that additional information could be contributed to the already existing body of knowledge.

Earlier Literature

Bultena and Lasley (1990) predicted that Iowa farmers would adopt biotechnology because the farmers anticipated reduced dependence on agriculture chemicals, increased efficiency in farm production, and greater profits. However, some respondents were concerned about greater dependence on corporations for farm inputs and the possibility that biotechnology would benefit large farms more than small farms. Only 5% of respondents were satisfied with currently available information about potential benefits of and problems associated with biotechnology, while 55% believed that they were relatively uninformed about the new technologies and developments in the field of biotechnology.

Klotz-Ingram, Jans, Fernandez-Cornejo, and McBride (1999) studied cotton producers in a 12-state area and found that herbicide usage was not significantly affected by the adoption of herbicide resistant (HT) cotton, but that pest resistant (Bt) cotton did reduce usage of insecticides. The authors concluded that cotton producers adopted GM cotton with pest resistant traits in order to improve pest control and increase yields at lower levels of pesticide costs.

Chen, Barham, and Buttel (2001) studied a panel of Wisconsin corn and soybean producers over a four-year period and found that adoption rates had increased for HT corn and soybeans, but had declined for Bt corn. Growers of HT soybeans reported reduced usage of herbicides, lower expenses, and greater profits compared to conventional varieties, but there appeared to be little advantage in yields. Most growers of Bt corn observed reduced pest damage compared to conventional varieties, but only a minority agreed that there were decreases in pesticide usage. Less than half of the respondents reported higher profits with Bt corn compared to conventional varieties. Among reasons for non-adoption of GM varieties were lack of information about biotech varieties, satisfaction with the performance of currently available non-GM varieties, uncertainty about marketing GM products, lower prices, segregation requirements, and high-level scrutiny of GM products from European countries. Dis-adopters of Bt varieties cited higher expenses, lower profits, and lower yields, and dis-adopters of HT varieties cited disappointing production performance and market uncertainties.

Darr and Chern (2002) analyzed data from Ohio farmers and found that individuals who did not consider themselves to be knowledgeable of GMOs were less likely to adopt GM soybeans. They also observed that an increasing number of producers were willing to segregate GM soybeans in order to receive price premiums or to take advantage of potential niche markets for non-GM soybean products.

Pilcher et al. (2002) conducted a survey of farmers who planted Bt corn in the states of Illinois, Iowa, Kansas, Minnesota, Nebraska, and Pennsylvania from 1996 through 1998. Effective pest control, reduced usage of pesticides, reduced need for field scouting, and reduced yield losses due to European corn borer damage were factors responsible for widespread acceptance of Bt corn.

Sluis and Scharrel (2004) surveyed South Dakota corn and soybean farmers and found that most expressed high levels of satisfaction with GM crops. A majority believed that local agriculture, but not necessarily U.S. agriculture, would benefit from agricultural biotechnology, and a large percentage believed that growing GM crops was ethical. Farmers held mixed views about the ability of biotechnology to reduce farm surpluses by finding new uses for crops and livestock. Concerns voiced by South Dakota farmers included the possibility that biotechnology would provide greater benefits to large farms than to small farms, potential for greater dependence upon large corporations for farm inputs, increased foreign competition in U.S. export markets, and uncertainty about foreign consumers' acceptance of GM products. Major reasons for the non-adoption of GM crops included low yields with some new varieties, satisfaction with current varieties, concerns about potential markets for GM crops, concerns about segregation requirements, potential for receiving low prices, and concerns about environmental and health issues. Farmers generally were not in favor of market segregation at the farm level, but they were in favor of product labeling at the consumer level. The authors concluded that technology fees associated with transgenic seeds, as well as consumers' attitudes toward biotechnology, would affect farmers' planting decisions. Logistic regression analysis revealed that adoption of Bt corn varied significantly with the age of the operator, farm size, and the presence of livestock on the farm. The odds of adopting Bt corn decreased when livestock were present, while the odds of adoption increased with income and the age of the operator. Adoption of HT corn appeared to be influenced by farm size, but there were no significant factors that explained the adoption of HT soybeans.

Methodology

A questionnaire was developed from information obtained from a review of the literature, particularly the work of Sluis and Scharrel (2002). The questionnaire was mailed to 400 randomly selected farmers whose names and addresses were obtained from the McLean County Farm Services Agency. One set of questions on the questionnaire asked respondents to identify appropriate categories for gender, age, and level of education and to report number of tillable acres farmed at the time the questionnaire was completed. A second set of questions asked respondents to indicate whether they had planted GM crops in the past and if they planned to plant GM corn or soybeans in 2003. The final section of the questionnaire consisted of 40 statements that pertained to GM crops plus a 5-point Likert scale. Respondents were asked to identify the degree to which they agreed or disagreed with each statement (1=strongly agree, 5=strongly disagree). The Internal Review Board at Illinois State University approved the questionnaire and the cover letter that accompanied it.

Data collected from questionnaires were compiled and subjected to descriptive analysis procedures. Likert-scale responses to the 40 statements that pertained to GM crops were tabulated and individual items were then subjected to reliability analysis (Chronbach's alpha). After individual items that did not appear to have an acceptable level of reliability were eliminated, remaining items were subjected to factor analysis. All factors that had an eigenvalue greater than 1 were constructed using principal components procedures, and then groups of individual items that loaded with factor loading scores of .6 or greater were tested for reliability. Based upon Chronbach's alpha figures from reliability analysis and a scree plot, the appropriate number of factors was judged to be four. Individual items that loaded into those four factors with a factor loading score of .6 or greater were tabulated, inspected for common themes, and assigned a descriptive name.

Information from factor analysis was subsequently used to create independent variables for a binary logistic regression analysis of farmers actions related to GM crops. Four sets of independent variables were utilized: 1) weighted factor scores for each of the four factors as computed by principal components analysis; 2) weighted factor scores for each of the four factors as computed by principal components analysis plus information about age, education and farm size; 3) the items that had the highest factor loading scores from each of the four factors; and 4) the items that had the highest factor loading scores from each of the four factors plus information about age, education and farm size. Dependent variables were 1) planted vs. have not planted GM crops in the past; 2) plan to plant vs. plan to not plant GM crops in 2003; and 3) discontinued vs. have not discontinued planting GM crops. All statistical analyses were conducted with SPSS 12.0 (SPSS, Inc., Chicago IL).

Results

Factor Analysis

Four hundred questionnaires were mailed, and 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 in 2003. One respondent indicated that she/he would produce livestock but not crops in 2003. The remaining 134 questionnaires contained useable information.

Gender was reported by 119 individuals, 117 of whom were male. Information on age and education categories is recorded in Table 1. Nearly 60% of those who provided information

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

about age were over the age of 50, and 23.3% were more than 60 years old. Of those who reported 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. Tillable acres farmed (976.1±126.2) was reported by 132 individuals, and ranged from 15 acres to 15,000 acres.

Table 2 contains results from questions about crop and livestock production. Of the 134 respondents that indicated that they would produce crops in 2003, 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 in 2003.

Table 2. Responses to Questions that Pertained to Production of Crops and Livestock

Question	Yes	No
Will you produce crops in 2003?	134	0
Will you produce livestock in 2003?	30	104
Have you planted genetically modified crops in the past?	126	8
Will you produce genetically modified crops this year?	123	10

Response frequencies for the 40 Likert-scale items are displayed in the Appendix. To analyze the reliability of the 40 statements, Chronbach’s alpha was applied. The computed value for all 40 items combined was .798, which indicated an acceptable level of reliability. When items were tested individually, deletion of item 43 (*Food that contains GM ingredients should be labeled as such*) increased Chronbach’s alpha from .798 to .811, indicating that item 43 was not measuring the same construct as the other 39 items. This outcome was confirmed by the fact that item 43 had the lowest item-total correlation value (-0.229) of all 40 items. Based upon results of the reliability analysis, item 43 was eliminated from subsequent analyses.

Factor analysis was applied to the remaining 39 statements in order to inspect the underlying constructs of the data set, and ultimately to reduce the number of variables to be used in subsequent analyses. The factor analysis was set so that all factors with eigenvalues greater than one were extracted using a principal components analysis procedure, and Varimax rotation with Kaiser normalization was used to generate the rotated components matrix. The results of the initial factor analysis, including Cronbach's alpha figures and all items with factor loadings greater than .6, are shown in Table 3.

The 11 extracted factors explained 72.0% of variability in the data set, and groupings of items under the factors were generally appealing. The first factor consisted of seven items that could represent the informed, ethical producer. The second group of items included well-publicized issues and concerns related to crop biotechnology, such as saving seed from GM crops and the StarLink case. Factor 3 included agricultural benefits from biotechnology from a macro perspective, and Factor 4 included potential benefits of HT corn and soybeans. Single items under Factors 10 and 11 were both related to segregation of GM crops, but they could have been logically separated because one was a statement that segregation of GM crops was necessary and the other was a statement that segregation of GM crops was practical.

Table 3. Factor Loadings for Individual Items and Cronbach's Alpha for Extracted Factors[a] with Eigenvalues > 1

Factor and associated items	Factor loadings[b]	Cronbach's alpha
Factor 1		.888
I can easily obtain objective information about biotechnology.	.793	
Consumer concerns about food products made from GM crops are exaggerated.	.772	
Utilization of biotechnology in animal production is ethical.	.754	
Farmers in general have a sufficient knowledge of biotechnology.	.703	
Growing GM crops is ethical.	.686	
As a consumer, I am satisfied with the benefits of biotechnology.	.680	
I am well informed about biotechnology.	.647	
Factor 2		.810
Restrictions on saving GM seed affect my GM crop planting decisions.	.832	
Lawsuits filed by seed companies against farmers affect my GM crop planting decisions.	.832	
Technology fees affect my GM crop planting decisions.	.705	
The StarLink case affects my GM crop planting decisions.	.644	
Factor 3		.852
Biotechnology will be beneficial to Illinois agriculture.	.822	
Biotechnology will be beneficial to U.S. agriculture.	.802	
Biotechnology will help find new uses for agricultural products.	.656	
Factor 4		.851
HT[c] soybeans produce higher yields than conventional soybeans.	.840	
HT corn generates more profit per acre than conventional corn.	.817	
HT corn produces higher yields than conventional corn.	.781	
HT soybeans generate more profit per acre than conventional soybeans.	.763	
Factor 5		.563
GM crops enable me to depend less on agricultural chemicals.	.634	
Biotechnology improves the overall quality and nutritional values of food.	.621	
Factor 6		.626
HT corn generates lower expenses per acre than conventional corn.	.786	
Bt corn generates lower expenses per acre than conventional corn.	.696	
Factor 7		.688
As a farm producer, I am concerned about receiving lower prices for GM crops.	.820	
As a farm producer, I am concerned about increased regulation of GM crops in international markets.	.763	
Factor 8		.495
Biotechnology will lead to surpluses of agricultural products.	.833	
Biotechnology makes me more dependent upon large corporations for farm inputs.	.533	
Factor 9		.753[d]
Bt corn produces higher yields than conventional corn.	.779	
Bt corn generates more profit per acre than conventional corn.	.700	
Factor 10		
Market segregation of GM crops from non-GM crops is necessary.	.735	
Factor 11		
Market segregation of GM crops from non-GM crops is practical.	.853	

[a] Principal components analysis.
[b] Varimax rotation with Kaiser normalization.
[c] Herbicide tolerant.
[d] There was a negative covariance between items, which violated reliability model assumptions.

The reliability of each factor that had multiple items was tested by applying Cronbach's alpha. Based upon a commonly used cutoff value of .7, four factors appeared to be reliable and could be confidently used in subsequent analyses. A scree plot provided additional evidence that four factors would be appropriate. Consequently, a second factor analysis was conducted, and the maximum number of factors was set to four. Results of the second factor analysis are displayed in Table 4.

Table 4. Four Extracted Factors[ab] with Factor Loadings for Individual Items and Cronbach's Alpha

Factor number, factor name and associated items	Factor loadings[c]	Cronbach's alpha
Factor 1: acceptable and beneficial		.875
As a consumer, I am satisfied with the benefits of biotechnology.	.827	
Growing GM crops is ethical.	.827	
Biotechnology will be beneficial to world agriculture.	.756	
Consumer concerns about food products made from GM crops are exaggerated.	.744	
Utilization of biotechnology in animal production is ethical.	.735	
I can easily obtain objective information about biotechnology.	.706	
Biotechnology will be beneficial to consumers.	.666	
I am well informed about biotechnology.	.663	
Biotechnology will be beneficial to Illinois agriculture.	.652	
Biotechnology will be beneficial to U.S. agriculture.	.644	
Farmers in general have a sufficient knowledge of biotechnology.	.623	
Biotechnology improves the overall quality and nutritional values of food products.	.612	
Factor 2: publicized negative perspectives		.822
Restrictions on saving GM seed affect my GM crop planting decisions.	.794	
Lawsuits filed by seed companies against farmers affect my GM crop planting decisions.	.791	
Technology fees affect my GM crop planting decisions.	.672	
The StarLink case affects my GM crop planting decisions.	.650	
Foreign consumer attitudes toward GM products affect my GM crop planting decisions.	.621	
Factor 3: micro benefits		.841
HT[d] corn produces higher yields than conventional corn.	.798	
HT corn generates more profit per acre than conventional corn.	.755	
HT soybeans produce higher yields than conventional soybeans.	.717	
Bt corn generates more profit per acre than conventional corn.	.680	
HT soybeans generate more profit per acre than conventional soybeans.	.633	
Factor 4: depressed trade and prices		.688
As a farm producer, I am concerned about increased regulation of GM crops in international markets.	.646	
As a farm producer, I am concerned about receiving lower prices for GM crops.	.607	

[a] Principal components analysis.
[b] Four factors accounted for 47.9% of the variance in the data set.
[c] Varimax rotation with Kaiser normalization.
[d] Herbicide tolerant.

Twelve items were loaded into Factor 1 in the second factor analysis compared to seven in the first factor analysis, which complicated interpretation of the underlying construct. The added items were: 1) *biotechnology will be beneficial to world agriculture*, 2) *biotechnology will be beneficial to consumers,* 3) *biotechnology will be beneficial to Illinois agriculture*, 4) *biotechnology will be beneficial to U.S. agriculture*, and 5) *biotechnology improves the overall quality and nutritional values of food products,* all of which reflected perceived benefits of biotechnology. Items 3 and 4 had been shifted from the original Factor 3, items 1 and 2 originally had factor loading values that were less than .6, and item 5 loaded under the original Factor 5. Subsequent to inspection of the 12 loaded items, Factor 1 was given the name "acceptable and beneficial."

Factor 2 contained five items, four of which loaded under the original Factor 2. The new item was *foreign consumer attitudes toward GM products affect my GM crop planting decisions,* which had a factor loading value of less than .6 in the original analysis. Because all five items have attracted media attention and could have had negative impacts on planting decisions, Factor 2 was named "publicized negative perspectives."

Factor 3 loaded five items, which included the four items from the original Factor 4 plus *Bt corn generates more profit per acre than conventional corn*. The statement about Bt corn had originally loaded with the statement, *Bt corn produces higher yields than conventional corn,* under the original Factor 9. Because all items were related to yield and farm profits from various GM corn and soybean types, Factor 3 was named "micro benefits."

Factor 4 loaded the items 1) *as a farm producer, I am concerned about increased regulation of GM crops in international markets* and 2) *as a farm producer, I am concerned about receiving lower prices for GM crops*. Both items had originally loaded under a Factor 7, and both reflected the impact of rejection of GM crops and products in many foreign markets. Factor 4 was named "depressed trade and prices." All four factors had Chronbach's alpha scores that were above or near .7, indicating acceptable reliability.

Logistic Regression

Binary logistic regression utilized factors, and information from factors, to explain past and planned behavior of farmers with regard to GM crops. Models were estimated with three dependent variables, which were 1) planted GM crops in the past (gmpast), 2) planned to plant GM crops in 2003 (gm03), and 3) discontinued planting GM crops (disgm). Four sets of independent variables were utilized, which included 1) weighted factor scores as computed by factor analysis, 2) weighted factor scores plus information about age, education, and farm size, 3) the highest loading individual item from each of the four factors, and 4) the highest loading individual item from each of the four factors plus information about age, education, and farm size. Results for weighted factor scores and weighted factor scores plus information about age, education, and farm size are displayed in Table 5.

When weighted factor scores were used as independent variables, the model correctly classified 100% of respondents who had planted GM crops in the past (gmpast), 98.4% of those who had planned to plant GM crops in 2003 (gm03), and 100% of those who would continue planting GM crops (disgm). Alternatively, the model correctly classified only 62.5% of respondents who had not planted GM crops in the past, 60.0% of those who did not plan to plant GM crops in 2003, and 60.0% of those who would not continue planting GM crops. The Hosmer and Lemeshow test indicated that the data fit the model well for gmpast and gm03, but the data did not fit the model well for disgm. Nagelkerke R-squared values ranged from .663 to .502. With regard to the explanatory power of individual factors, Factor 1 ("acceptable and beneficial") was highly significant ($P < 0.01$) in all three equations. Factor 2 ("publicized negative perspectives") was highly significant in the disgm equation and significant ($P < 0.05$) in the gm03 equation. Factor 3 ("micro benefits") was highly significant in the gm03 equation, significant in the disgm equation, and possibly significant ($P < 0.10$) in the gmpast equation. Finally, Factor 4 ("depressed trade and prices") was possibly significant in the disgm equation.

Table 5. Results from Binary Logistic Regression with Weighted Factor Scores from Factor Analysis as Independent Variables

	gmpast[a]	gmpast	gm03[b]	gm03	disgm[c]	disgm
Exp(B)						
Factor 1	0.029	0.002	0.127	0.102	0.278	20.883
	(*P*<0.01)	(*P*<0.01)	(*P*<0.01)	(*P*<0.01)	(*P*<0.01)	(*P*<0.05)
Factor 2	1.229	1.410	2.835	8.321	3.310	0.033
	(*P*=0.71)	(*P*=0.77)	(*P*<0.05)	(*P*<0.10)	(*P*<0.01)	(*P*<0.10)
Factor 3	0.327	0.089	0.256	0.160	0.373	14.430
	(*P*<0.10)	(*P*=0.10)	(*P*<0.01)	(*P*<0.05)	(*P*<0.05)	(*P*<0.05)
Factor 4	0.879	1.118	0.653	0.477	0.612	1.625
	(*P*=0.68)	(*P*=0.77)	(*P*=0.15)	(*P*<0.10)	(*P*<0.10)	(*P*=0.61)
age dummy 1		28.856		17.265		
		(*P*=0.12)		(*P*=0.16)		
age dummy 2		763.048		4.087		
		(*P*<0.10)		(*P*=0.39)		
age dummy 3		15314.582		1.639		
		(*P*=0.36)		(*P*=0.76)		
educ dummy 1				1.906		0.006
				(*P*=0.64)		(*P*=0.16)
educ dummy 2				1.064		0.000
				(*P*=0.97)		(*P*=1.00)
educ dummy 3				12.421		0.002
				(*P*=0.34)		(*P*=0.13)
Tillable acres		1.000		1.002		
		(*P*=0.81)		(*P*=0.21)		
Constant	378.291	106.128	68.961	6.684	26.093	0.010
	(*P*<0.01)	(*P*<0.05)	(*P*<0.01)	(*P*=0.20)	(*P*<0.01)	(*P*<0.01)
Chi-square[d]	1.515	0.511	3.987	0.885	11.498	2.928
	(*P*=0.99)	(*P*=1.00)	(*P*=0.86)	(*P*=1.00)	(*P*=0.18)	(*P*=0.94)
Nagelkerke R-sq.	0.663	0.799	0.545	0.646	0.502	0.690
Correct yes (%)	100.0	98.4	98.4	98.3	60.0	60.0
Correct no (%)	62.5	62.5	60.0	60.0	100.0	100.0
Correct overall (%)	97.8	96.2	95.5	95.3	98.4	98.4

[a] Have you planted GM crops in the past?
[b] Will you produce GM crops in 2003?
[c] Discontinued planting GM crops.
[d] Hosmer and Lemeshow test; high chi-square values (low *P* values) indicate lack of fit.

Estimated parameters for independent variables were reported as Exp(B), which reflected the impact of a one unit increase in the independent variable on the odds ratio of the dependent variable. For example, a one unit increase in the weighted score for Factor 1 was associated with an increase in the odds ratios associated with gmpast by a factor of 0.029, or conversely, with a decrease in the odds ratio by a factor of 34.5. Because factor scores were weighted averages of all 39 items used to compute factor loadings, they were difficult to interpret, but in general, items that had higher factor loadings carried more weight in the factor score. Hence, greater disagreement with a more heavily weighted statement tended to increase a factor score.

Addition of information about age, education, and farm size, as measured by tillable acres, moderately improved model fit as reflected by lower Hosmer and Lemeshow chi-square values and higher Nagelkerke R-squared values, but only one added variable was possibly significant in one equation. (age dummy 2 in the gmpast equation). One notable result was that addition of the new variables reversed the impact of changes in weighted factor scores on the odds ratio associated with the disgm equation, which was intuitively more appealing. Results implied that if a respondent more strongly disagreed with the idea that biotechnology was “acceptable and beneficial,” the odds ratio for discontinuing use of GM crops was increased by a factor of 20.9. Likewise, if a respondent more strongly disagreed that “publicized negative perspectives” affected her/his planting intentions, the odds ratio for discontinuing use of GM crops was decreased by a factor of 30.3. If a respondent more strongly disagreed that there were “micro benefits” associated with biotechnology, the odds ratio increased by a factor of 14.4.

If individual items that loaded into factors with high factor loadings could replace weighted factor scores as independent variables, interpretation of results should be easier. Table 6 exhibits results for models in which the highest loading items from each of the four factors in Table 4 was substituted for the respective weighted factor score. As indicated by generally lower Hosmer and Lemeshow chi-square values, lower Nagelkerke R-squared values, and poorer classification of outcomes, these models did not perform as well as the models with weighted factor scores, most likely due to loss of information. From the gmpast and gm03 equations, 100% of those who planted GM crops in the past and 100% of those who

Table 6. Results from Binary Logistic Regression with the Highest Loading Item from Each of the Four Factors from Factor Analysis Plus Age, Education, and Farm Size as Independent Variables

	gmpast[a]	gmpast	gm03[b]	gm03	disgm[c]	disgm
Exp(B)						
seed restrictions	1.430	1.338	1.854	2.291	0.354	0.292
	(*P*=0.37)	(*P*=0.56)	(*P*<0.10)	(*P*<0.05)	(*P*<0.10)	(*P*<0.05)
HT corn yields	0.849	0.779	0.609	0.498	2.113	2.858
	(*P*=0.72)	(*P*=0.75)	(*P*=0.21)	(*P*=0.15)	(*P*=0.16)	(*P*=0.11)
trade regulations	1.069	1.267	0.993	1.084	0.728	0.546
	(*P*=0.87)	(*P*=0.63)	(*P*=0.99)	(*P*=0.87)	(*P*=0.66)	(*P*=0.47)
consumer benefits	0.182	0.172	0.437	0.485	1.511	1.896
	(*P*<0.01)	(*P*<0.01)	(*P*<0.05)	(*P*<0.05)	(*P*=0.39)	(*P*=0.26)
age dummy 1		1.390		2.169		
		(*P*=0.84)		(*P*=0.58)		
age dummy 2		3.516		1.446		
		(*P*=0.51)		(*P*=0.79)		
age dummy 3		9.898		0.891		
		(*P*=0.27)		(*P*=0.94)		
educ dummy 1		1.285		1.004		0.614
		(*P*=0.87)		(*P*=1.00)		(*P*=0.73)
educ dummy 2		1.625		2.245		0.000
		(*P*=0.74)		(*P*=0.48)		(*P*=1.00)
educ dummy 3		2.467		1.421		0.405
		(*P*=0.69)		(*P*=0.80)		(*P*=0.56)
Tillable acres		1.002		1.002		0.998
		(*P*=0.23)		(*P*=0.12)		(*P*=0.20)
constant	1746.210	233.607	136.089	21.901	0.020	0.076
	(*P*<0.01)	(*P*=0.15)	(*P*=0.01)	(*P*=0.23)	(*P*=0.16)	(*P*=0.46)
Chi-square[d]	4.208	4.882	5.393	12.938	2.322	1.992
	(*P*=0.84)	(*P*=0.77)	(*P*=0.72)	(*P*=0.11)	(*P*=0.97)	(*P*=0.98)
Nagelkerke R-sq.	0.456	0.551	0.263	0.372	0.205	0.399
Correct yes (%)	100.0	99.2	100.0	100.0	0.0	0.0
Correct no (%)	50.0	50.0	20.0	30.0	100.0	99.1
Correct overall (%)	97.0	96.1	94.0	94.5	96.0	95.1

[a] Have you planted GM crops in the past?
[b] Will you produce GM crops in 2003?
[c] Discontinued planting GM crops.
[d] Hosmer and Lemeshow test; high chi-square values (low *P* values) indicate lack of fit.

planned to plant GM crops in 2003 were classified correctly. However, only 50% of those who did not plant GM crops in the past and 20% of those who did not plan to plant GM crops in 2003 were classified correctly. Worse results were obtained from the disgm equation, where 99.1% of those who had not discontinued use of GM crops were classified correctly, but 0% of those who had discontinued use of GM crops were classified correctly. Adding information about age, education, and farm size did not appreciably improve the usefulness of models with the possible exception of the gm03 equation. In that case, correct classification of respondents who planned to plant GM crops in 2003 improved from 20% to 30%.

The "seed restrictions" variable was possibly significant ($P < 0.10$) in the gm03 and the disgm equations without added (age, education, farm size) variables, and significant ($P < 0.05$) in the same equations with added variables. The "consumer benefits" variable was highly significant ($P < 0.01$) in the gmpast equations with and without added variables, and it was significant in the gm03 equations with and without added variables. Coefficients on significant independent variables were intuitively correct. If a respondent more strongly disagreed with the statement "*restrictions on saving GM seed affect my GM crop planting decisions*," the odds ratio associated with planning to plant GM crops in 2003 increased by a factor of 1.9 without added variables, and it increased by a factor of 2.3 with added variables. Results from the disgm equations indicated that if a respondent more strongly disagreed with the statement "*restrictions on saving GM seed affect my GM crop planting decisions*," the odds ratio associated with discontinuing use of GM crops decreased by a factor of 1/.354 or 2.8 without added variables and 1/.292 or 3.4 with added variables. From the gmpast equations, if a respondent more strongly disagreed with the statement "*as a consumer, I am satisfied with the benefits of biotechnology*," the odds ratio associated with planting GM crops in the past decreased by a factor of 1/.182 or 5.5 in the absence of additional variables and decreased by a factor of 1/.172 or 5.8 with additional variables. Likewise, the odds ratio associated with planning to plant crops in 2003 decreased by a factor of 1/.437 or 2.3 in the absence of additional variables and decreased by a factor of 1/.485 or 2.1 when a respondent more strongly disagreed with the statement "*as a consumer, I am satisfied with the benefits of biotechnology*."

Discussion

The purpose of this study was to explore and analyze McLean County, Illinois farmers' perceptions of genetically modified (GM) crops as well as the impacts of those perceptions on GM cropping decisions. A mail survey was used to collect information about age, education, farm size, past and planned experiences with GM crops, and perceptions of GM crops from 134 farmers. Data was subjected to factor analysis in order to analyze the underlying constructs of farmers' perceptions, and information from factor analysis was utilized in binary logistic analysis in an attempt to explain farmers' past and planned experiences with GM crops.

Factor analysis was used to construct four factors following examination of item reliability and a scree plot. Items that loaded into the first factor indicated that McLean county farmers perceived agricultural biotechnology to be acceptable and beneficial, and that their views of biotechnology were much more encompassing than the economic impacts on their own farms. The item that loaded with the highest factor loading score was the statement that "*as a consumer, I am satisfied with the benefits of biotechnology*." The second factor revealed that McLean County farmers' cropping decisions had been affected to some degree by events that had received coverage through the national, and in some cases, international media. Those events, which included the StarLink case and lawsuits filed against farmers by biotech seed companies, cast a negative shadow over biotechnology. The item that loaded into Factor 2 with the highest factor loading score was the statement that "*restrictions on saving GM seed affect my GM crop planting decisions*." The third factor reflected direct benefits of GM crops on farm operations, specifically benefits in the form of higher yields and profits. The item with the highest factor loading score in Factor 3 was the statement that "*HT corn produces higher yields than conventional corn*." The fourth factor was related to potentially negative factors in marketing genetically modified crops. The two statements with the highest factor loading scores were "*as a farmer, I am concerned about increased regulation of GM crops in international markets*," and "*as a farmer, I am concerned about receiving lower prices for GM crops*."

Binary logistic regression analysis generally revealed limited information about the relationships between McLean County farmers' GM crop decisions and their perceptions of GM crops, most likely due to the small sample that was derived from a limited geographic area. When weighted factor scores from the four factors were used as independent variables, 100% or nearly 100% of farmers who had planted GM crops in the past, or planned to plant GM crops in 2003, or had not discontinued planting GM crops were correctly classified. On the other hand, only 60 to 62.5% of farmers who had not planted GM crops in the past, or planned to not plant GM crops in 2003, or had discontinued planting GM crops were correctly classified. The record was worse when the highest loading items from each of the four factors were included as independent variables. Although results were little changed for farmers who utilized GM crops, correct classification of farmers who had not planted GM crops in the past dropped to 50%, correct classification of farmers who had planned to not plant GM crops in 2003 dropped to 20%, and correct classification of farmers who had discontinued planting GM crops dropped to 0%. Additional information about farmers' age, education and farm size increased the explanatory power of models utilizing weighted factor scores and models utilizing individual items from factors only modestly.

Binary logistic regression analysis did, however, generate some interesting and intuitively appealing results. For example, increases in Factor 1 scores, which were dominated by items that touted the positive aspects of biotechnology from a more macro perspective, were associated with increases in odds ratios for having planted GM crops in the past, having planned to plant GM crops in 2003, and having continued planting GM crops. Alternatively, increases in Factor 2 scores, which were dominated by negative perceptions of GM seeds and crops, were associated with increases in odds ratios for having planned to not plant GM crops in 2003, and having discontinued planting GM crops. Factor 3 scores, which were dominated by micro benefits to farmers, were associated with increases in odds ratios for having planned to plant GM crops in 2003, and having continued planting GM crops. Results for the two individual items that were significant, namely "*as a consumer, I am satisfied with the benefits of biotechnology*," and "*restrictions on saving GM seed affect my GM crop planting decisions*," were consistent with results for weighted factor scores. Greater agreement with the former statement was associated with increases in odds ratios for having planted GM crops in the past, and having planned to plant GM crops in 2003. Greater agreement with the latter statement was associated with increases in odds ratios for having planned to not plant GM crops in 2003 and having discontinued planting GM crops.

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Appendix: Frequency Tables for Likert-Scale Responses

Q11. Biotechnology will be beneficial to world agriculture.

	Frequency	Percent
Strongly Agree	72	53.7
Moderately Agree	51	38.1
No Opinion	6	4.5
Moderately Disagree	2	1.5
Strongly Disagree	3	2.2

Q12. Biotechnology will be beneficial to U.S. agriculture.

	Frequency	Percent
Strongly Agree	67	50.0
Moderately Agree	52	38.8
No Opinion	4	3.00
Moderately Disagree	9	6.7
Strongly Disagree	2	1.50

Q13. Biotechnology will be beneficial to Illinois agriculture.

	Frequency	Percent
Strongly Agree	67	50.0
Moderately Agree	49	36.6
No Opinion	8	6.0
Moderately Disagree	7	5.2
Strongly Disagree	3	2.2

Q14. Biotechnology will help find new uses for agricultural products.

	Frequency	Percent
Strongly Agree	50	37.3
Moderately Agree	54	40.3
No Opinion	23	17.2
Moderately Disagree	5	3.7
Strongly Disagree	2	1.5

Q15. Biotechnology will lead to surpluses of agricultural products.

	Frequency	Percent
Strongly Agree	15	11.2
Moderately Agree	30	22.4
No Opinion	43	32.1
Moderately Disagree	34	25.4
Strongly Disagree	12	9.0

Q16. Many of the problems encountered in conventional agriculture (e.g., insect and weed problems) are eliminated by biotechnology.

	Frequency	Percent
Strongly Agree	25	18.7
Moderately Agree	74	55.2
No Opinion	14	10.4
Moderately Disagree	17	12.7
Strongly Disagree	4	3.0

Q17. Introduction of GM crops has made farm management easier.

	Frequency	Percent
Strongly Agree	34	25.4
Moderately Agree	63	47.0
No Opinion	16	11.9
Moderately Disagree	15	11.2
Strongly Disagree	6	4.5

Q18. Biotechnology benefits large farm operations more than small operations.

	Frequency	Percent
Strongly Agree	18	13.4
Moderately Agree	27	20.1
No Opinion	26	19.4
Moderately Disagree	41	30.6
Strongly Disagree	22	16.4

Q19. Biotechnology makes me more dependent upon large corporations for farm inputs.

	Frequency	Percent
Strongly Agree	28	20.9
Moderately Agree	38	28.4
No Opinion	34	25.4
Moderately Disagree	21	15.7
Strongly Disagree	13	9.7

Q20. GM crops enable me to depend less on agricultural chemicals.

	Frequency	Percent
Strongly Agree	21	15.7
Moderately Agree	64	47.8
No Opinion	19	14.2
Moderately Disagree	24	17.9
Strongly Disagree	6	4.5

Q21. Technology fees affect my GM crop planting decisions.

	Frequency	Percent
Strongly Agree	33	24.6
Moderately Agree	62	46.3
No Opinion	20	14.9
Moderately Disagree	13	9.7
Strongly Disagree	6	4.5

Q22. Restrictions on saving GM seed affect my GM crop planting decisions.

	Frequency	Percent
Strongly Agree	29	21.6
Moderately Agree	36	26.9
No Opinion	34	25.4
Moderately Disagree	26	19.4
Strongly Disagree	9	6.7

Q23. Lawsuits filed by seed companies against farmers affect my GM crop planting decisions.

	Frequency	Percent
Strongly Agree	20	14.9
Moderately Agree	32	23.9
No Opinion	38	28.4
Moderately Disagree	30	22.4
Strongly Disagree	14	10.4

Q24. The StarLink case affects my GM crop planting decisions.

	Frequency	Percent
Strongly Agree	19	14.2
Moderately Agree	32	23.9
No Opinion	39	29.1
Moderately Disagree	28	20.9
Strongly Disagree	16	11.9

Q25. U.S. consumer attitudes toward GM products affect my GM crop planting decisions.

	Frequency	Percent
Strongly Agree	21	15.7
Moderately Agree	42	31.3
No Opinion	30	22.4
Moderately Disagree	29	21.6
Strongly Disagree	12	9.0

Q26. Foreign consumer attitudes toward GM products affect my GM crop planting decisions.

	Frequency	Percent
Strongly Agree	24	17.9
Moderately Agree	58	43.3
No Opinion	18	13.4
Moderately Disagree	21	15.7
Strongly Disagree	13	9.7

Q27. Bt corn generates lower expenses per acre than conventional corn.

	Frequency	Percent
Strongly Agree	5	3.7
Moderately Agree	30	22.4
No Opinion	34	25.4
Moderately Disagree	49	36.6
Strongly Disagree	16	11.9

Q28. Herbicide tolerant corn generates lower expenses per acre than conventional corn.

	Frequency	Percent
Strongly Agree	3	2.2
Moderately Agree	33	24.6
No Opinion	51	38.1
Moderately Disagree	36	26.9
Strongly Disagree	11	8.2

Q29. Herbicide tolerant soybeans generate lower expenses per acre than conventional soybeans.

	Frequency	Percent
Strongly Agree	21	15.7
Moderately Agree	53	39.6
No Opinion	24	17.9
Moderately Disagree	31	23.1
Strongly Disagree	5	3.7

Q30. Bt corn produces higher yields than conventional corn.

	Frequency	Percent
Strongly Agree	15	11.2
Moderately Agree	53	39.6
No Opinion	39	29.1
Moderately Disagree	20	14.9
Strongly Disagree	7	5.2

Q31. Herbicide tolerant corn produces higher yields than conventional corn.

	Frequency	Percent
Strongly Agree	3	2.2
Moderately Agree	19	14.2
No Opinion	77	57.5
Moderately Disagree	24	17.9
Strongly Disagree	11	8.2

Q32. Herbicide tolerant soybeans produce higher yields than conventional soybeans.

	Frequency	Percent
Strongly Agree	6	4.5
Moderately Agree	34	25.4
No Opinion	46	34.3
Moderately Disagree	36	26.9
Strongly Disagree	12	9.0

Q33. Bt corn generates more profit per acre than conventional corn.

	Frequency	Percent
Strongly Agree	11	8.2
Moderately Agree	45	33.6
No Opinion	53	39.6
Moderately Disagree	18	13.4
Strongly Disagree	7	5.2

Q34. Herbicide tolerant corn generates more profit per acre than conventional corn.

	Frequency	Percent
Strongly Agree	3	2.2
Moderately Agree	19	14.2
No Opinion	77	57.5
Moderately Disagree	27	20.1
Strongly Disagree	8	6.0

Q35. Herbicide tolerant soybeans generate more profit per acre than conventional soybeans.

	Frequency	Percent
Strongly Agree	9	6.7
Moderately Agree	51	38.1
No Opinion	35	26.1
Moderately Disagree	31	23.1
Strongly Disagree	8	6.0

Q36. Market segregation of GM crops from non–GM crops is practical.

	Frequency	Percent
Strongly Agree	16	11.9
Moderately Agree	38	28.4
No Opinion	29	21.6
Moderately Disagree	40	29.9
Strongly Disagree	11	8.2

Q37. Market segregation of GM crops from non–GM crops is necessary.

	Frequency	Percent
Strongly Agree	39	29.1
Moderately Agree	52	38.8
No Opinion	26	19.4
Moderately Disagree	15	11.2
Strongly Disagree	2	1.5

Q38. As a farm producer, I am concerned about increased regulation of GM crops in international trade.

	Frequency	Percent
Strongly Agree	45	33.6
Moderately Agree	71	53.0
No Opinion	13	9.7
Moderately Disagree	3	2.2
Strongly Disagree	2	1.5

Q39. As a farm producer, I am concerned about receiving lower prices for GM crops.

	Frequency	Percent
Strongly Agree	54	40.3
Moderately Agree	56	41.8
No Opinion	14	10.4
Moderately Disagree	9	6.7
Strongly Disagree	1	0.7

Q40. As a farm producer, I am satisfied with the benefits of biotechnology.

	Frequency	Percent
Strongly Agree	26	19.4
Moderately Agree	70	52.2
No Opinion	17	12.7
Moderately Disagree	16	11.9
Strongly Disagree	5	3.7

Q41. Biotechnology will be beneficial to consumers.

	Frequency	Percent
Strongly Agree	41	30.6
Moderately Agree	62	46.3
No Opinion	20	14.9
Moderately Disagree	8	6.0
Strongly Disagree	3	2.2

Q42. Biotechnology improves the overall quality and nutritional values of food products.

	Frequency	Percent
Strongly Agree	27	20.1
Moderately Agree	37	27.6
No Opinion	53	39.6
Moderately Disagree	12	9.0
Strongly Disagree	5	3.7

Q43. Food that contains GM ingredients should be labeled as such.

	Frequency	Percent
Strongly Agree	19	14.2
Moderately Agree	40	29.9
No Opinion	43	32.1
Moderately Disagree	24	17.9
Strongly Disagree	8	6.0

Q44. Consumers concerns about food products made from GM crops are exaggerated.

	Frequency	Percent
Strongly Agree	39	29.1
Moderately Agree	49	36.6
No Opinion	31	23.1
Moderately Disagree	11	8.2
Strongly Disagree	4	3.0

Q45. As consumer, I am satisfied with the benefits of biotechnology.

	Frequency	Percent
Strongly Agree	37	27.6
Moderately Agree	59	44.0
No Opinion	21	15.7
Moderately Disagree	13	9.7
Strongly Disagree	4	3.0

Q46. Growing GM crops is ethical.

	Frequency	Percent
Strongly Agree	49	36.6
Moderately Agree	56	41.8
No Opinion	23	17.2
Moderately Disagree	3	2.2
Strongly Disagree	3	2.2

Q47. Utilization of biotechnology in animal production is ethical.

	Frequency	Percent
Strongly Agree	27	20.1
Moderately Agree	45	33.6
No Opinion	45	33.6
Moderately Disagree	11	8.2
Strongly Disagree	6	4.5

Q48. Farmers in general have a sufficient knowledge of biotechnology.

	Frequency	Percent
Strongly Agree	7	5.2
Moderately Agree	56	41.8
No Opinion	27	20.1
Moderately Disagree	34	25.4
Strongly Disagree	10	7.5

Q49. I am well informed about biotechnology.

	Frequency	Percent
Strongly Agree	25	18.7
Moderately Agree	62	46.3
No Opinion	23	17.2
Moderately Disagree	19	14.2
Strongly Disagree	5	3.7

Q50. I can easily obtain objective information about biotechnology.

	Frequency	Percent
Strongly Agree	26	19.4
Moderately Agree	63	47.0
No Opinion	24	17.9
Moderately Disagree	15	11.2
Strongly Disagree	6	4.5