Factors Influencing Farmers' Decision to Produce Biotech Crops: Results of a Survey

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Background and Problem Statement

Worldwide, in 2003, about 58.7 million hectares (145 million acres) were planted to genetically modified or transgenic crops compared to only 1.7 million hectares in 1996. The United States, Argentina and Canada have a commanding lead in the countries with the largest number of hectares devoted to genetically modified soybean, corn and cotton (ISAAA, 2003). Sales of genetically modified crops rose from $75 million in 1995 to almost $2.3 billion in 1999. Despite the high adoption rate, many countries are still opposed to legislation that would allow modified crops in their food system (Prideaux, 2000; Vidal, 2000). This makes the farmer's decision on whether or not to adopt biotech crops all the more important.

There are numerous controversies surrounding the use of genetically engineered crops in foods processed for human consumption. These controversies concern issues such as food safety and nutrition, environment, religion, and legal (ownership and liability), among others. Concerns and fears about genetically modified inputs raise questions about the possibilities of widespread consumer rejection of foods containing modified ingredients. These possibilities, although difficult to estimate, pose real threats to the food distribution/processing system and food trade among nations. As the debate continues, many countries grapple with policies and rules that acknowledge the challenges facing the world food system. In order to safeguard or protect their consumers, policy-makers have used results of surveys to justify their often-controversial stance on genetic modification in agricultural production. One of the ways to resolve the on-going controversies has been labeling. This approach would not solve all problems, and there are ample examples of supporters and opponents of labeling (Runge and Jackson, 2000; Caswell, 2000; Unnevehr and Hasler, 2000).

Although much information is available on consumer preferences for food with biotech ingredients (Hallman, et al., 2002; Krueger, 2001; Pew Initiative on Food and Biotechnology, 2001; and Onyango et al., 2003), there is limited information on factors explaining farmer preferences for producing genetically modified crops. One of the few studies that have examined the adoption of genetically modified crops is the work of Fernandez-Cornejo and McBride (2002). The foregoing discussion highlights some of the issues that have fueled the controversy surrounding genetically modified crops. The remaining sections of the paper provide a brief discussion of the theoretical framework, objectives, source of data and procedures used for analyses and finally the results and conclusions of analyses of a three-state producer survey conducted in 2003.

Theoretical Framework

The following discussion of the theoretical framework is drawn from the work of Silberberg (1990). A competitive firm maximizes profits, which are given by, Π = total revenues – total cost. Mathematically, the function can be represented as:

Maximize Π = TR – TC, where TR is total revenue, $p * f(x_i)$ and TC, $\sum_{i=1}^{n} w_i * x_i$, represents total cost, and w are factor input prices. The profit equation can be written as:

$$\Pi = pf(x_i) - \sum_{i=1}^{n} w_i * x_i \quad \text{..........(1)}$$

The maximum difference between total revenue and total cost can be achieved when the total cost, TC, of producing an output level is minimized. The cost function can be derived as:

$$C = C^*(y, w_i) \quad \text{..........(2)}$$

It is important to note here that y enters the cost function as a parameter rather than as an argument (Silberberg, 1990, p. 224). The factor demand curves for the profit-maximizing firm can be expressed in equation (3) as:

$$x_i = x_i^*(w_i, p) \ldots\ldots(3)$$

and the output supply curve as:

$$y = y^*(w_i, p) \ldots\ldots(4)$$

Equation (4) is the supply curve of a profit maximizing firm and shows how much output will be produced for various output prices. Since a profit-maximizing firm changes output y only if some factor or output price changes, it is difficult to use equation (1) to derive a firm's cost function. Cost functions must be derived in models where output, y, enters as a parameter. The following problem can be re-stated to satisfy the profit maximization formulation:

Minimize $C = \sum_{i=1}^{n} w * x_i$ ……(5)

Subject to $f(x_i) = y^0$ ……(6)

where, y^0 is an assigned level of output. Technology is one of the important factors that can shift the supply curve, although not the only one. Other factors, including producer attitudes, entry of firms into the market, can shift the supply curve. Equation (4) can be slightly modified to capture shifts in the supply function. The shifts can be incorporated into the equation and presented as follows:

$$y^{new} = y^*(w_i, p; \Phi) \ldots\ldots(7)$$

where, Φ represent shift factors such as listed above. This paper examines the influence of producer attitudes toward biotechnology as one of the factors that can shift the supply curve.

<u>Objectives of the Paper</u>

This paper, (1) identifies some of the characteristics of the farmers surveyed using a mail survey administered in three states – Arkansas, North Carolina and Tennessee and, (2) analyzes factors influencing farmers' decision to produce genetically modified crops using their responses to the survey.

Data and Procedures

Data from government and private publications are used to discuss important issues in the debate on genetically modified ingredients in the food system. Qualitative and quantitative techniques are used in analyzing the results of a mail questionnaire survey conducted for Tennessee State University by the National Agricultural Statistics Service (NASS), Tennessee office, during the summer of 2003. Mail questionnaire surveys were sent to producers in Arkansas, North Carolina, and Tennessee. The surveys were sent from NASS through the Tennessee office, under a cooperative agreement between the two institutions. Tennessee State University, the University of Arkansas, Pine Bluff, the University of Arkansas, Fayetteville, and North Carolina A&T State University jointly developed the questionnaire used for the survey. The questions in the survey were developed based on the information obtained from focus group meetings held with producers and consumers in the three states participating in the study. One hundred and sixty-three useable questionnaires were analyzed for this paper. Out of the twenty-two questions developed for the survey, three subcategories of factors that influenced farmers' decision to produce biotech crops were used in collecting the specific responses reported in this paper. The three categories were related to production (10 items), marketing (5 items), and policy (4 items). These questions will be discussed in detail later on in this paper. The Statistical Package for the Social Sciences (SPSS) was used in analyzing 163 useable survey responses. Chi-square tests of independence (measures of association) are used in relating producer demographic/economic information to factors that may influence their decision to adopt biotech crops.

Results and Discussion

General Demographic Information: One hundred and thirty-seven or 91.9% of survey participants were male producers compared to twelve (8.1%) who were female. While most of the producers in the study (56.9%) were between 45 and 64 years of age, about 30.0% were 65 years or older. Only 13.1% were 44 years or younger. Concerning income, while 4.8% of the producers had household incomes of less than $10,000 about 38.4% earned between $10,000 and $49,000 in 2002. A total of 39.8% earned between $50,000 and $99,999 while only 12.4% earned between $100,000 and $199,999. Only seven producers or 4.8% earned more than $200,000 in 2002, according to the survey. When asked what percentage of their income came from their current farming enterprises, 18.6% of the farmers indicated that 100% of their incomes were derived from this source. Thirty-six producers (23.0%) indicated that 51 - 99% of their income came from their current farming operations. About 51.9% of the producers surveyed indicated that between 1% and 50% of their incomes were derived from their current enterprise (Table 1). With regard to educational attainment, only 3.7% of farmers participating in the survey had less than 9^{th} grade education, 5.6% had 9^{th} to 12^{th} grade education with no diploma. About 21.7% of the farmers in the survey had high school or high school equivalency certificate. Almost 6% had vocational or trade school certification, 21.7% had some college with no degree. A total of 24.9% of respondents had associate or bachelor's degrees and 16.8% held graduate or professional degrees. As expected, about 88.2% of the farmers lived in communities with less than 2,500 people, while only 1.2% lived in communities with 100,000 people to over 500,000 people.

Areas Planted to Biotech Crops: On average, farmers in the survey planted an average of 513.42 acres in 2002. An average of 196.87 or 38.34% acres were planted to biotech crops. A summary of the biotech and non-biotech crops planted in Arkansas, North Carolina is presented in

Table 2. Consistent with the national trend, the top three crops planted to biotech varieties were: soybeans, corn, and cotton. From the survey, 36.2% of the farmers responded that they had produced soybeans in the last three years, 16.0% indicated they had planted corn while 11.0% said yes to having planted cotton. Biotech rice, peanuts, tobacco and sugar crops had a zero percent adoption rate by farmers in Arkansas, North Carolina and Tennessee. In the United States, in 2003, 81% of soybeans were genetically engineered covering almost 60 million acres. Genetically modified (GM) corn accounted for 40% of all corn grown in the country covering 32 million acres while modified cotton, covering 10.2 million acres accounted for 73% of all cotton crop planted in the United States during the 2003 planting year (http://pewagbiotech.org/resources/factsheets/crops). According to the same source, farmers in every state planted some genetically modified corn crop in 2001. While South Dakota was the top adopter of modified corn (75% GM varieties) and soybeans (91% GM varieties) in 2003, Arkansas, with 95% of acres planted to GM cotton varieties, was the top adopter of GM cotton in the United States. Although there are no recorded statistics, other genetically modified crops planted in the United States include canola, squash, and papaya. Although commercially available in the United States marketplace, these crops have not yet been widely adopted by U.S. farmers (http://pewagbiotech.org/resources/factsheets/display.php3?FactsheetID=2).

Much is known about what factors influence consumer acceptance of food biotechnology while there is little information on how producer preferences develop. This study will provide insights into how selected factors may affect the farmer's decision to adopt biotech crops. Isolating these factors could provide useful implications for production, marketing, and policy which can be used in establishing relationships among variables driving farmers' decisions to adopt biotech crops.

Farmers' Attitudes toward biotech crop production: In order to elicit farmers' reactions toward adoption of biotech crops, farmers were asked to respond to some specific production, marketing and policy questions. They were asked how selected considerations would affect their decision to produce biotech crops. The specific question was, "… how would the following considerations influence your decisions regarding biotech crop production?" Responses to the question are presented in Table 3. Respondents were given three options to select from: positive influence (Positive), no influence (None), and negative influence (Negative). Selecting the "None" option indicated an indifferent attitude toward biotechnology crop production, given the particular consideration. Respondents in this case were indicating that the situation described had neither negative nor positive influence on their decision. The three production considerations that would elicit the most positive attitudes by farmers toward biotech crop production seemed to be farm profitability (55.8%), crops' yield potential (53.8%), and adaptability of crop to farmer's growing condition (50.0%). For marketing, harvested product quality, consumer health, and handling/storage were the three considerations that would elicit the most positive response toward growing biotech crops. It is interesting to note that many of the farmers had rather indifferent attitudes toward biotechnology in many of the marketing categories. Considerations of agri-chemical company regulations biotech crop production and guidelines on biotech crop marketing would elicit positive attitude in 33.8% and 32.5%, respectively, among the farmers surveyed. About 29.7% of the farmers surveyed indicated that consideration of governmental regulation of biotech crop production would elicit positive attitudes toward biotech crop production. These responses would seem to suggest that farmers would welcome some sort of regulation to encourage them in producing biotech crops. The figures do not, however, present clear evidence as to whether they would prefer governmental or private involvement in the regulation.

Testing for Significant Differences in Attitudes by gender, ethnicity, age, educational attainment, and place of residence

Chi-square tests were used in testing for difference in attitudes toward biotech crop production to see what, if any, gender, ethnicity, age, education, and place of residence had on observed attitudinal differences. The following general null hypotheses relating k = 5 characteristics (gender, ethnicity, age, education, and place of residence) were tested:

H_{0k}: A farmer's selected characteristic is not related to his/her attitude toward biotech crop production

H_{1k}: A farmer's selected characteristic is related to his/her attitude toward biotech crop production

The following Pearson chi-square statistic used for testing the null, H_{0k}, can be written as:

$$\chi^2 = \sum \{(O_{ij} - E_{ij})^2 / O_{ij}\} \qquad (8)$$

Where, O_{ij} = observed frequency, E_{ij} = expected frequency, computed using standard procedures (Agresti, 1996). All estimations were conducted the Statistical Package for the Social Sciences. Place of residence was a significant factor explaining difference in attitude of producers toward biotech crop production in all the production considerations. The level of educational attainment was significantly related to only three considerations: yield potential ($\chi^2 = 24.93$, $p \leq 0.05$), landlord preferences ($\chi^2 = 32.65$, $p \leq 0.005$), and lender preferences ($\chi^2 = 34.78$, $p \leq 0.005$). Age, ethnicity and gender were significant variables explaining difference in attitudes towards biotech crop production. Farmer's ethnicity was a significant factor explaining differences in attitude toward biotechnology when considering crop yield potential, farm profitability, and labor health considerations (Table 4). As expected, while selected farmer characteristics were related to their attitudes toward biotechnology crop in production-related considerations, very few marketing and policy consideration showed any kind of relationship. Ethnicity, educational attainment, and place of residence showed significant relationships to consumer health and harvested product quality considerations. As was expected, farmers' characteristics did not seem to be significantly related to their attitudes given the policy considerations in the questionnaire.

Summary and Conclusions

This paper provided much needed information on factors influencing farmer attitudes toward biotech crop production. Using information collected from farmers in Arkansas, North Carolina, and Tennessee, and the Statistical Package for the Social Sciences, the paper shows that gender, ethnicity, age, education, and place of residence influenced farmers' attitudes toward biotech crop production. Farmers' attitudes toward biotech crop production were more significantly related to gender, ethnicity, age, education, and place of residents than market and policy considerations. Of the approximately 513.42 average acres planted by farmers in the three states, about 196 acres or 38.3% were dedicated to biotech crops. The survey also shows that while biotech soybeans and corn, others included sorghum corn and cotton. With the limited availability of information to map producers' preference for producing biotech crops, this study will contribute to fill an important gap in the literature by providing preliminary results that could motivate further research on the issues.

Table 1. Descriptive Statistics on Selected Survey Variables

Variable	Respondents (%)
<u>Gender</u>	
Male	91.9
Female	8.1
<u>Age</u>	
≤44 years old	13.1
45 – 64	56.9
≥65 years	30.0
<u>2002 Household Income</u>	
Less than $10,000	4.8
$10,000 - $49,000	38.4
$50,000 - $99,999	39.8
$100,000 – $199,999	12.4
$200,000 or more	4.8
<u>% Household Income from farming</u>	
0%	6.4
1% - 50%	51.9
51% – 99%	23.0
100%	18.6

Table 1. Descriptive Statistics on Selected Survey Variable (Continued)

<u>Ethnicity</u>	**Respondents (%)**
Black or African-American	1.3
White	96.2
Asian	0.6
Native Hawaiian or other Pacific Islander	0.6
Other	1.3
<u>Educational Attainment</u>	
Less than 9th grade	3.7
9th to 12th grade, no diploma	5.6
High School graduate, including GED holders	21.7
Trade or vocational school	5.6
Some college, no degree	21.7
Associate/Bachelors degree	24.9
Graduate or professional degree	16.8
Place of Residence	
<u>Community with less than 2,500 people</u>	88.2
2,500 – 49,999	8.8
50,000 – 99,999	1.9
100,000 – 499,999	0.6
500,000 or more	0.6

Table 2. Biotech and Non-Biotech Crops Planted by Farmers, 2000 - 2003

	Response to whether crop had been planted in last three years (%)			
	Biotech Crop		**Non-biotech Crop**	
Crop	Yes	No Response*	Yes	No Response
Soybean	36.2	63.8	22.1	77.9
Corn	16.0	84.0	31.3	68.7
Sorghum	0.6	99.4	12.3	87.7
Rice	0.0	100.0	12.9	87.1
Cotton	11.0	89.0	7.4	92.6
Wheat	0.6	99.4	32.5	67.5
Hay/Forage	0.6	99.4	28.2	71.8
Peanuts	0.0	100.0	31.9	68.1
Fruits	0.6	99.4	0.6	99.4
Potatoes	0.6	99.4	14.7	85.3
Vegetables	2.5	97.5	23.3	76.7
Tobacco	0.0	100.0	17.8	82.2
Sugar Crops	0.0	100.0	1.8	98.2

* Although "no response", may not necessarily mean that no such crops were planted, they will be interpreted as such in this paper.

Table 3. Considerations Influencing Biotech Crop Production Decisions

Consideration	Effect of Consideration on Biotech Crop Production Decision (%)		
	Negative	No Effect	Positive
Production			
Farm size/acres farmed	11.4	54.4	34.2
Management/Planning efficiency	7.6	45.9	46.5
Adaptability of crop to farmer's growing conditions	6.4	43.6	50.0 (3)
Environmental impacts of production practices	9.6	45.2	45.2
Farmer's yield potential	5.1	41.0	53.8 (2)
Farm profitability	6.4	37.8	55.8 (1)
Labor health considerations	8.4	53.5	38.1
Brand loyalty	6.4	78.2	15.4
Landlord preferences	7.8	81.7	10.5
Lender preferences	7.3	81.5	11.3
Marketing			
Availability of marketing outlets	14.2	53.5	32.3
Handling/Storage consideration	9.1	55.8	35.1 (3)
Harvested product quality	9.7	46.8	43.5 (1)
Consumer health consideration	11.7	52.6	35.7 (2)
Consumer product preferences	14.4	57.5	28.1
Policy			
Government regulations on biotech production practices	18.7	51.6	29.7 (3)
Agri-chemical company regulations on biotech product production practices	21.4	44.8	33.8 (1)
Agri-chemical company guidelines on biotech crop marketing	19.5	48.1	32.5 (2)
Ethical/moral/religious consideration	11.0	61.9	27.1

(•) Ranking based on % indicating positive influence; ranking done separately for the three categories: Production, Marketing, and Policy.

Table 4. Chi-Square Test of Significance for Production, Marketing, and Policy Considerations and Selected Variables

Consideration	Chi-Square Value and Level of Significance				
Consideration	Gender	Ethnicity	Age	Education	Place of Residence
Production					
Farm size/acres farmed	6.46*	13.64	25.99***	11.65	25.10***
Management/Planning efficiency	3.04	16.54*	25.42***	22.29	33.88***
Adaptability of crop to farmer's growing conditions	4.32	23.96***	17.17	19.97	41.12***
Environmental impacts of production practices	8.84**	16.14*	17.49	14.38	22.71**
Farmer's yield potential	6.23*	23.91***	23.95**	24.39*	30.74***
Farm profitability	3.74	20.88**	22.89**	17.34	21.28*
Labor health considerations	12.67***	14.31**	23.93	13.90	30.84***
Brand loyalty	15.65	21.49**	18.64*	18.42	31.76***
Landlord preferences	1.73	12.47	20.00*	32.65***	26.21***
Lender preferences	2.07	13.45	16.17	34.78***	26.67***
Marketing					
Availability of marketing outlets	0.56	10.30	9.32	26.24*	11.07
Handling/Storage consideration	1.61	12.99	9.53	11.82	15.06
Harvested product quality	1.76	15.65*	12.07	14.36	25.66***
Consumer health consideration	2.78	11.92	11.19	31.73***	22.20**
Consumer product preferences	0.63	9.66	14.15	12.75	10.35
Policy					
Government regulations on biotech production practices	0.05	8.91	11.00	7.66	9.00
Agri-chemical company regulations on biotech product production practices	0.70	10.31	12.68	16.46	11.63
Agri-chemical company guidelines on biotech crop marketing	0.92	11.33	7.37	17.96	13.91
Ethical/moral/religious consideration	0.91	20.20**	16.14	18.86	15.11

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.005$

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