Factors Affecting Farmers' Knowledge of Agricultural Biotechnology: Survey Results

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Biotechnology includes genetic engineering, which involves the development of new products through DNA manipulation of living organisms and has been applied to agriculture, medicine, and other fields. Investment in biotechnology research has been made by both the public and private sectors. The former has historically focused on basic research while the private sector develops the technology for use by producers. However, in recent years private companies have made significant investment in both basic and applied research working in collaboration with government research institutions and universities. This trend has been observed both in the developed and developing countries (Pray 2001; Kalaitzandonakes 2000).

According to James (2001), global planting of genetically engineered crops grew by 4 million acres between 1996 and 2000 in more than 12 countries. The U.S. and Canada lead the world with over 75% of acreage planted with such crops. Phillips (2002) provides the most recent list of biotech crops that have been approved for production both in developed and in some developing countries.

Proponents of agricultural biotechnology maintain that its benefits include the production of crops that are cheaper, have higher yields, are resistant to insects and disease, and are more nutritious (Falck-Zepeda et al. 2000; Feldman et al. 2000). Others, such as Barkema, (2000) assert that agricultural biotechnology could play an important role in rural development. However, there are concerns about risks that biotechnology may bring about, such as exposure to potential allergens in biotech foods, the effect of pollen from biotech crops on cross pollination of non-biotech crops, and the effect of some insecticide toxins in insect-resistant biotech crops on beneficial insects (Ervin et al. 2000). These concerns have raised debate on the use of regulatory measures involving such crops through labeling and application of the precautionary principle to establish that there are no risks to the environment or to human health (Lofstedt et al. 2002; Schupp and Gillispie 2001; Institute of Food Technologists 2000).

Economic issues involving biotechnology, including the impact of adopting bioengineered crops have been considered by Fernandez-Cornejo and McBride (2002), Shoemaker et al. (2001), and Falck-Zepeda et al. (2000). The latter provided an estimate of the surplus distribution arising from the introduction of Bt corn in the U.S. among farmers, the company that developed the gene, U.S. consumers, and the rest of the world. Estimates by Hubbell et al. (2000) show subsidy levels associated with adoption of Bt cotton and reduction in the level of insecticide application. They emphasize the importance of such assessment to provide input for policy making. Makki et al., (2000) underscore the importance of considering expected level of returns to farmers adopting biotechnology. Sparling et al. (1999) argue that in addition to farmers, lenders must be considered, since they provide the financial resources. Van der Sluis et al. (2002) maintain that it is important to compare the costs, benefits, and risks of biotechnology, involving all stakeholders including consumers to effectively take into account any concerns in making choices both by farmers and by policy makers. All of the above issues have primarily been considered in relation to large farmers.

Objective

The objective of this paper was to analyze factors that affect small farmers' knowledge of agricultural biotechnology in selected Tennessee counties and to derive policy implications.

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Data and Methodology

Data was collected using a mail survey of randomly selected small farmers including those located in under-served communities in the following counties: Tipton and Bolivar (West Tennessee), Lawrence and Robertson (Middle Tennessee), and Cocke (East Tennessee). These counties are predominantly rural and agricultural, with per-capita income lower than the state average. The survey was conducted by the Alabama Agricultural Statistical Service using an instrument developed by a consortium of eleven 1890 land-grant universities on a project titled "Southern Agricultural Consortium for Under-served Communities (SACUC)." A total of 307 completed responses were received from Tennessee farmers. Of these, 200 came from counties in under-served communities and the rest from other counties.

The survey covered diverse issues involving farmers' knowledge of agricultural biotechnology, sources of information, their attitudes towards it, socio-economic characteristics, and type of commodities produced. They were also asked to express the extent to which they agree or disagree with a series of statements about the benefits, potential risks, and other issues associated with agricultural biotechnology using the Likert scale. In addition to descriptive statistics, a probit model is used to conduct statistical analysis (Greene 2000).

It is hypothesized that knowledge about biotechnology by small farmers in Tennessee is re-

Table 1: Characteristics of Respondents and the Level of Knowledge About Biotechnology (%).

	Very	Little	None
Gender			
Male	6.8	47.3	45.9
Female 10.7	35.7	53.6	
Race			
White	7.0	46.4	46.7
African American	25.0	25.0	50.0
Hispanic/Latino0	46.4	100	0
Education*			
Less than High School	4.2	25.0	70.8
High School	1.6	41.5	56.9
Some College	8.5	52.5	39.0
College	10.3	69.2	20.5
Graduate School	23.7	55.3	21.1
Off-Farm Work			
None	4.3	44.8	50.9
1–99 days	4.4	48.9	46.7
100–199 days	11.4	51.4	37.1
200+ days	9.9	45.0	45.0
Annual Gross Sale**			
< $1,000	6.7	41.3	52.0
$1,000-$2,499	2.6	48.7	48.7
$2,500-$4,999	3.4	27.6	69.0
$5,000-$9,999	9.1	43.9	47.0
$10,000-$39,000	6.5	54.5	39.0
$40,000-$99,999	16.7	66.7	16.7
$100,000-$249,000	25.0	50.0	25.0

*Significant at 95% level of confidence using chi-square test.
**Significant at 90% level of confidence using chi-square test.

lated both to operator characteristics such as age and education as well as to characteristics of their operations such as farm size and annual gross sale. To the extent that the above hypothesis is not rejected, the results could provide practical insights for designing effective strategies to educate small farmers about agricultural biotechnology.

Results and Discussion

Biotechnology and Tennessee Farmers

A small number of farmers (7.2%) indicated that they are very familiar with the term *biotechnology*. A great majority of them (46.6%) do not have any knowledge about it, while 46.3% have little knowledge about biotechnology. The results also showed that a majority of the under-served farmers (50.5%) do not have any knowledge compared with other farmers (39.9%).

The study revealed a positive relationship between knowledge and education level. About one-fourth of the farmers with graduate-level education are very familiar with the concept, compared with only 4.2% with education less than high school (Table 1). The other significant factor affecting knowledge level was annual gross sale. Farmers with higher gross sales were more knowledgeable about biotechnology, as were farmers who worked full time on their farms. Table 2 shows that about 20% of farmers with 75% or more of their income from farming were very familiar with biotechnology, in contrast to only 4.7% farmers with less than 10% of their income from farming.

Farm size and annual gross sale are directly related to each other. That is, the larger the farm, the higher the gross sale and the more knowledge about biotechnology. Younger farmers were more familiar with the term biotechnology than were older ones. Age group and farm size were also found to be statistically significant.

Biotechnology by Enterprises

Data was analyzed to determine the level of knowledge about biotechnology by different enter-

Table 2: Knowledge About Biotechnology by Age, Farm Size, and Percentage of Income from Farming (%).

	Very	Little	None
Age Group* (years)			
Up to 25	0	0	100
26-35	30.0	30.0	40.0
36-45	13.0	65.2	21.7
46-55	9.8	42.6	47.5
56-65	6.1	50.0	43.9
> 65	3.5	43.0	53.5
Farm Size* (acres)			
Less than 50	5.4	37.6	57.0
50-100	5.6	43.7	50.7
101-250	7.5	46.2	46.2
251-500	10.0	67.5	22.5
> 500	20.0	60.0	20.0
Income from Farming (%)			
< 10	4.7	45.6	49.7
11-25	11.1	42.6	46.3
26-50	7.0	43.9	49.1
51-75	13.3	60.0	26.7
> 75	20.0	70.0	10.0

*Significant at 95% level of confidence using chi-square test.

prises in agriculture. These enterprises range from those producing cash crops to specialty crops and livestock. The results indicated that farmers producing cotton were most likely (25%) to be very familiar with the concept of biotechnology, followed by grain and oilseed producers (20.6%) and dairy farmers (20.0%). On the other hand, a very small percentage of farmers in nursery; greenhouse and floriculture; and fruits, nuts, and berries know about biotechnology. The level of knowledge about biotechnology by enterprise is shown in Table 3.

Empirical Model

The following model explains the relationship between farmers' knowledge about biotechnology and other factors such as gender, race, education level, farm size, age, and part-time versus full-time farming:

$$BIOKNOW_i = \beta_0 + \beta_1 GEND + \beta_2 RACE + \beta_3 EDU + \beta_4 PERINC + \beta_5 UNDCAT + \beta_6 FARSIZ + \beta_7 AGE + e_i$$

Where the dependent variable is
BIOKNOW = 1 if farmer has any knowledge about biotechnology
= 0 otherwise.

And the independent variables are
GEND = 1 if gender of the farm operator is male
= 0 otherwise.
RACE = 1 if race of the farm operator is white
= 0 otherwise.
EDU = Farmer's education level.
PERINC = Percentage of income from farming operation
UNDCAT = 1 if farmer belongs to under-served category
= 0 otherwise,
FARSIZ = Farm size (acreage) including cropland, idle land, pastures, woods, and waste land, both owned and rented from others.
AGE = Farmer's age in years.
e_i = error term.

Empirical Results

Probit analysis was used to estimate the model shown in Table 4. The estimated coefficients explain various factors that affect farmers' knowledge about biotechnology in agriculture. The factors included were gender, race, age, education, dependence of household income on farming, and farm size.

Table 3: Knowledge About Biotechnology by Type of Enterprise Operated (%).

	Very	Little	None
Grain & Oilseed	20.6	50.0	29.4
Nursery, greenhouse & floriculture	0	66.7	33.3
Vegetable & melons	15.0	35.0	50.0
Cotton	25.0	37.5	37.5
Fruits, nuts & berries	4.2	62.5	33.5
Garden & home use	5.6	44.9	49.5
Hay	7.5	46.8	45.7
Other crops	3.4	44.8	51.7
Beef cattle	7.0	47.0	46.0
Poultry & eggs	7.1	50.0	42.9
Sheep, goat, wool & mohair	5.0	55.0	40.0
Dairy	20.0	40.0	40.0
Hogs	0	0	100
Aquaculture	0	100	0
Timber	10.8	60.2	29.0
Equine	14.0	60.5	25.6
Other livestock & poultry	0	54.5	45.5
Land is idle	0	25.0	75

The results indicated that age, education level, percentage of income from farming, and farm size were significant factors in determining farmers' knowledge about biotechnology. The positive sign for the EDU variable suggests that farmers with more education are more likely to have knowledge about biotechnology. Similarly, the same relationship was found between biotechnology knowledge and PERINC. This means that part-time farmers are less likely to know about biotechnology compared with full-time farmers. The other significant variable estimated in this model was farm size. It suggests that the larger the farm, the more likely the farmer is to know about biotechnology. The results also revealed that younger farmers have more knowledge than do their older counterparts. The results also suggest that farmers in underserved communities are less likely to have knowledge about biotechnology. The estimated model also indicates that males have more knowledge about biotechnology than do females, although the difference is not significant.

Conclusion

The main objective of this study was to evaluate the current level of knowledge about biotechnology and to determine various factors that contribute to it. The results showed that very few farmers know about biotechnology. Regression results indicated that the main determinants of biotechnology knowledge were a farmer's age, education level, farm size, and percentage of income from farming operations. These results suggest that approaching younger, better-educated farmers will help to enhance adoption of biotechnology. Full-time farmers with large farms also showed more interest in and knowledge of the issue. The study suggests the importance of designing educational programs to educate farmers about biotechnology. It also suggests using appropriate tools to reach farmers efficiently and effectively through magazines, radio, TV, and newspapers. The Extension program and other organizations have an important role to play in providing biotechnology education to farmers.

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Table 4: Probit Coefficients of Factors Affecting Farmers' Knowledge of Agricultural Biotechnology.

Variables	Probit Coefficients	t-value
Intercept	-.47661	-.55857
GEND	.14677	.55149
RACE	-.06046	-.09048
EDU	.34308	5.11218***
PERINC	.00586	1.51890*
UNDCAT	-.15618	-.97117
FARSIZ	.00133	2.31774**
AGE	-.00994	-1.59493*

***Significant at the 99% level of confidence, one-tail test.
**Significant at the 95% level of confidence, one-tail test.
*Significant at the 90% level of confidence, one-tail test.

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