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Changes in Cultural Practices of Farmers in Southeast Nebraska as a Result of Their Adoption of Transgenic Crops

Abstract
How do cultural practices change as producers adopt transgenic crops? A group of progressive producers in southeast Nebraska were surveyed to learn how practices changed as RR soybeans were adopted. These producers were found conservative in changing their management practices to use transgenic crops most efficiently. Tillage and planting practices were unchanged from conventional crops. Seed dealers and on-farm research were the top educational resources used in determining which varieties of soybeans to plant. Based on this study, on-farm research offers Extension an avenue for providing needed information to producers.

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Introduction

The adoption of transgenic soybean *(Glycine max, L..)* varieties has been extremely rapid in the North Central U.S. The initial release of these transgenic soybean varieties occurred in 1996, and they accounted for 47% of total area planted to soybeans in 1999 (Harlander, 2000). The most widely used transgenic soybeans were varieties with tolerance to the broad-spectrum, low-toxicity herbicide glyphosate (hereafter referred to as Roundup) These varieties are called Roundup Ready® soybeans, (hereafter referred to as RR soybean).

The rapid adoption of RR soybeans suggests that farmers perceive these transgenic varieties to be cost-effective. (Fernandez-Cornejo, 2000). RR soybeans have several advantages. They can be planted in fields with severe weed problems because the most common weed species are readily controlled by Roundup (Wait, 1999). The ease and large window of application make it easier for producers to control weeds, especially when wet or dry weather inhibits the effectiveness of conventional herbicides (Hartzler, 1997). Other advantages include the low toxicity and rapid decomposition of Roundup compared with the most commonly used alternative soybean herbicides.

Despite these advantages, RR soybean have several disadvantages. The first is that these varieties cost more than conventional seed. A second disadvantage is the uncertainty about marketing transgenic crops. Concerns about food safety and environmental issues surrounding the use of transgenic crops present the possibility of trade restrictions on their export to the European Union,

Japan, and other major importing countries (Fernandez-Cornejo, 2000).

Because Europe and East Asia represent the largest markets for U.S. soybeans, any trade restrictions on transgenic crops would have a negative impact on prices farmers receive for these products. Other disadvantages include the inability to re-use saved seed from a RR soybean crop because of patent protection, and the limited number of widely adapted RR soybean varieties.

Given the disadvantages and potential marketing risks, as well as the rapid rate of adoption, a key issue is whether farmers are taking full advantage of the potential benefits in crop management that result from use of transgenic soybeans. The goal of our research was to investigate the degree to which farmers modified crop management in the initial years after adoption of transgenic soybeans, and whether these changes would allow them to fully benefit from their use. In addition, we were interested in knowing the sources of information that farmers utilized in making decisions on crop management when using transgenic crops.

Methods

As a part of an exploratory study, a survey was developed to elicit responses from farmers about crop management practices used on conventional and transgenic soybean varieties. Although the initial survey included both RR soybeans and Bt Corn, for the sake of brevity, this article focuses on the findings concerning RR soybeans. The primary purpose of the survey was to determine what changes, if any, these producers were making in their crop management practices when adopting RR soybeans. In addition, the survey included questions regarding farming experience and farm size as well as questions about their reasons for using transgenic crops and concerns they had about using them in the future.

Rather than using a random sample, the study was intentionally selective, specifically seeking respondents from among the population of early adopters of transgenic crops. Essentially a cluster sample, this design is limited in its ability to support extrapolation to the general population. However, it does provide information about the specified population that might be missed in a broader sample, and it is useful in developing theoretical understanding that can guide future research.

The survey was sent out in the fall of 1997 and again in 1998 to selected farmers located in a 21-county area of southeast Nebraska. In selecting the producers to be surveyed, Cooperative Extension Educators in the 21 counties were sent packets containing 12 envelopes. Each of the 12 envelopes contained the survey and a cover letter explaining how to complete and return the survey. These Extension Educators were asked to send the letter to 12 producers in their county whom they believed would be using RR soybeans.

A total of 252 surveys were sent out both in 1997 and in 1998. In 1998, the instructions to Extension Educators asked that the survey be sent to those same individuals who had received the survey in 1997. Because many Extension Educators did not record the names of farmers who were sent the survey the previous year, those surveyed in 1998 included both producers surveyed and not surveyed in 1997. Twenty-five percent of those producers returning surveys in 1998 indicated that they had been surveyed in 1997.

Of the 252 surveys sent out in the fall of 1997, 43% (n = 109) were completed and returned. In 1998, only 23% (n = 59) of surveyed producers returned completed surveys. The reduction in the rate of return in 1998 may reflect survey "fatigue," particularly among those who had completed the survey in the previous year. Data from both the 1997 and 1998 surveys were analyzed. The questions were structured such that producers could indicate either a positive or negative response.

The percent of positive responses for each question were then calculated for both years. Non-parametric measures of association were calculated using the Pearson Chi Square test often used as a measure of statistical significance for nominal and ordinal data. Chi Square indicates the probability values for the relationship between two dichotomous variables and measures the difference between the data observed and the data expected under an assumption of independence.

This test identified statistically significant differences in responses to the same questions asked in1997 and 1998 survey. Thus, time was treated as an independent variable, and a given cultural practice as a dependent variable in this study. Significant differences were calculated at the 0.1, 0.05, and 0.01 probability levels.

The purposive sample design and variations in sample size and composition in this study represent violations of the assumptions underlying the Chi Square statistic, and results should therefore be interpreted with caution. The measures are presented for those readers accustomed to including them in their interpretation of marginal statistics.

In addition, while we failed to achieve a true panel study, with one-to-one correspondence between the 1997 and 1998 respondents, the study provides some interesting insights into the relationship between the adoption of new technologies and the adoption of related cultural practices among some of Nebraska's larger and presumably more successful agricultural producers.

Results

Farmers completing the survey had similar characteristics in both 1997 and 1998. Mean length of time involved in farming was 22 years in 1997, with a range of 5 to 55 years, and 24 years in 1998, with a range of 7 to 40 years. Average farm size was 1,311 acres in 1997, with a range of 300 to 3,800 acres, and 1,411 acres, with a range of 320 to 4,000 acres in 1998. Because average farm size in southeast Nebraska is 414 acres (Census of Agriculture, 1997), these results indicate that the surveyed farmers had large operations and were likely to be full-time farmers. The proportion of producers growing transgenic crops increased significantly between 1997 and 1998 (Table 1). Only 3% of the surveyed producers did not plant Bt corn or RR soybean in 1998 versus 19% in 1997.

Table 1.
Type of Genetically Engineered Crop Grown: Percent of Responding Producers

Crops	**1997 %**	**1998 %**
RR Soybeans	65	92*
Bt Corn	52	78*
Did Not Use	19	3*

*Significant at P<0.01 respectively

The reasons stated for using RR soybean were remarkably similar in both years, although simple curiosity about how RR soybean would perform was a greater factor in 1997 than in 1998 (Table 2). Apparently, farmers who were surveyed were satisfied with performance of transgenic soybeans as indicated by the significant increase in rate of adoption of RR soybean in 1998 compared to 1997 (Table 1). A large majority of surveyed farmers indicated that the main reason for using transgenic soybean varieties was to solve a weed problem and to reduce weed-control costs. Yield and planting method were not important drivers of adoption among the surveyed farmers in this study.

Table 2.
Cultural Reasons that RR Soybeans Were Planted in 1997 and 1998: Percent of Responding Producers

Cultural Reasons	**1997 %**	**1998 %**
Time Savings	18	28
Yield Goal Raised	11	7
Curiosity	49	31*
Allows Drilled Beans	11	20
Save Money	76	65
Solve a Weed Problem	87	89

*Significant at P<0.01 respectively

Did producers change fertilization practices with the adoption of RR soybeans? Evidently not, as 90% of those surveyed in both years indicated that they made very few changes in their fertilization practices (data not shown).

Tillage practices also changed very little during the transition from conventional to RR soybeans in both 1997 and 1998 (Table 3). Although the survey did not ask producers whether they used no-till practices prior to the adoption of the RR soybeans, Natural Resource Conservation Service records show that only 27% of farmers in the 23 counties making up the Southeast District have adopted no-till practices (Kanable, personal communication, 2000).

Thus, we could assume the majority of the producers surveyed were not practicing no-till prior to the adoption of RR soybeans, nor did they practice it with their adoption of the RR soybeans. Although this is surprising because of the advantages of RR soybeans in no-till systems to control weeds, it is apparent that farmers were in no hurry to change tillage practices when adopting RR soybeans.

Table 3.
Effect of RR Soybeans on Tillage Practices in 1997 and 1998: Percent of Responding Producers

Tillage Practices	**1997 %**	**1998 %**
Remained the Same	90	87
Less to More Tillage	3	2
More to Less Tillage	17	13

The elimination of most pre- and post-emergence herbicides other than Roundup highlighted the change regarding weed control practices (Table 4). Almost 90% of those responding in 1997 and 70% in 1998 indicated that they had eliminated pre-plant and pre-emergence herbicides following the adoption of RR soybeans. It would be expected that a high percentage of those adopting RR

soybeans would eliminate other types of herbicides for their soybeans. It is interesting to note that there was a significant decrease in the proportion of producers who eliminated pre-plant or post-emergence herbicides in 1998 from 1997, which may indicate some dissatisfaction with the degree of weed control when only Roundup was used in 1997.

Table 4.
Weed Control Practices That Were Eliminated Following the Adoption of RR Soybean Crops in 1997 and 1998: Percent of Responding Producers

Weed Control Practices	**1997 %**	**1998 %**
Pre-plant and Pre-emergence Herbicides	89	69*
Post Emergence Herbicides	89	76**
Rotary Hoe or Cultivation	21	30
Other	7	2

*Significant at P<0.01.
**Significant at P <0.10.

Planting practices essentially remained the same. Over 90% of those responding in both years had not changed their planting practices. Less than 10% reduced row width, increased seeding rates, or reduced the speed of their planter as a result of using RR soybeans (data not shown). The relatively small proportion of those surveyed who reported decreasing their row width with the adoption of RR soybeans is surprising because adoption of RR soybeans should improve weed control in narrow-row systems and narrow rows often result in higher yields (Elmore, 1998).

The survey also inquired about the educational resources producers used when selecting varieties. A large majority of those surveyed used their seed dealers as their primary source of information for both RR and conventional varieties (Tables 5, 6, 7, and 8). In 1998, survey respondents indicated that they relied upon seed dealers more often in selecting RR soybeans than for conventional beans, and the difference was significant (P<0.05). Most of those who responded to the survey also used information obtained from on-farm research as a basis for selecting their varieties, both with RR and conventional soybeans. Less than half of those surveyed indicated that farm magazines, Cooperative Extension, or chemical dealers were used as source of information for variety selection.

Between 1997 and 1998, the influence of chemical dealers fell dramatically for both RR soybeans and conventional beans (Tables 5 and 6). In 1998, less than 10% of those responding to the survey used chemical dealers for variety information, while in 1997 this ranged from 23% to 28% for RR and conventional soybeans.

Table 5.
Educational Resources in 1997 to 1998 for Conventional Beans Varieties: Percent of Responding Producers

Educational Resources	**1997 %**	**1998 %**
Seed Dealers	82	74
Farm Magazine Ads	7	4
Variety Testing	55	56
Cooperative Extension	24	28
On-farm Research	59	54
Chemical Dealers	23	9*
Other	7	4

*Significant at P<0.05.

Table 6.
Educational Resources in 1997 and 1998 for RR Soybeans Varieties: Percent of Responding Producers

Educational Resources	**1997 %**	**1998 %**
Seed Dealers	85	87
Farm Magazine Ads	10	6
Variety Testing	49	59
Cooperative Extension	23	26
On-farm Research	61	61
Chemical Dealers	27	7
Other	10	4

Table 7.
Education Resources Comparing Normal and RR Soybeans Varieties in 1997: Percent of Responding Producers

Educational Resources	Normal Bean %	RR %
Seed Dealers	82	85
Farm Magazine Ads	7	10
Variety Testing	55	49
Cooperative Extension	24	23
On-farm Research	59	61
Chemical Dealers	23	27
Other	7	10

Table 8.
Educational Resources Comparing Normal and RR Soybeans Varieties in 1998: Percent of Responding Producers

Educational Resources	Normal Bean %	RR %
Seed Dealers	74	87
Farm Magazine Ads	4	6
Variety Testing	56	59
Cooperative Extension	28	26
On-farm Research	54	61
Chemical Dealers	9	7
Other	4	4

Better weed control, reduced crop injury, and ease of application were cited by more than 50% of those surveyed as reasons for using RR soybeans (Table 9). Eight out of ten producers reported better weed control as a reason for using RR soybeans (Table 9). Significantly fewer producers felt there was a cost advantage to using RR beans in 1998 compared with 1997.

Table 9.
Benefits of Planting RR Soybeans in 1997 and 1998: Percent of Responding Producers

Benefits	1997 %	1998 %
Better Weed Control	83	87
Less Crop Injury	80	76
Cost Advantage	76	54*
Ease of Application	51	65
Other	10	7

*Significant at P<0.01.

A majority of respondents in 1997 and 1998 cited the expense of RR soybean varieties as a disadvantage to their use (Table 10). The percentage of producers expressing concern over the fear of the ban of transgenic crops by foreign governments doubled from 1997 to 1998, from 18% to 39%, which was indicative of the ongoing discussion in the popular press regarding transgenic crops. It also was evident that those responding to the survey in 1998 were far less concerned about the lack of well-adapted RR soybean varieties than they were in 1997 (Table 10).

Although not a significant trend, more farmers reported concerns about a yield reduction with RR soybeans in 1998 than in 1997. In 1998, half of those replying to the survey indicated they were concerned about a possible yield reduction while only one-third of the respondents had such concerns in 1997. These concerns are consistent with results from research conducted by University of Nebraska agronomists who found a significant yield drag from RR soybeans compared with sister-lines of conventional soybeans (Elmore et al., in press). It is likely, however, that the yield drag will diminish and perhaps disappear as commercial seed companies increase efforts to incorporate the RR trait into the current, elite germplasm.

Table 10.
Disadvantages of Using RR Beans in 1997 and 1998: Percent of Responding Producers

Disadvantages	1997 %	1998 %
Cannot Use Bin Run Seed	38	31
Expense	54	63
Fear of Ban by Foreign Govt.	18	39*
Reduction in Yield	37	50
Limited Variety Selection	34	17*

*Significant at P<0.05.

Conclusions

Selected producers in southeast Nebraska were surveyed regarding changes in cultural practices (e.g., changes in fertilization, planting rates, herbicide use, etc.) when adopting RR soybean and Bt

corn varieties, their reasons for adoption, and concerns about use of this new technology. The study respondents could be characterized as progressive, full-time, experienced producers who managed large operations that were approximately 3.0 times larger than the regional average farm size.

From this study, we conclude that producers in southeast Nebraska who would be described as early adopters of new technologies were conservative in making changes in management that would allow them to take full advantage of the benefits from use of transgenic crops. Although those responding to the survey indicated that they had eliminated most pre-plant and post-emergent herbicides on RR soybean, tillage and planting practices basically remained unchanged in 1997. The same was true in 1998, when producers expanded their use of RR soybeans. Taken together, these finding suggest that Extension efforts should be directed towards improving farmer understanding of the management practices that maximize returns from their investment in transgenic crops.

It was surprising to the authors that relatively few producers switched to no-till or narrow row practices as they adopted RR soybeans. Because weed control is clearly much easier with the RR soybeans, a greater shift to some form of conservation tillage and narrow row production systems may occur in the future as equipment changes occur on the farm. In the first years of adoption such changes were not evident.

Reasons for planting these transgenic crops varied with the type of crop. For those planting RR soybeans, improved weed control was a major motivating factor. A second reason cited by the majority was reduced cost. In 1997, curiosity provoked many in this group of growers to try these transgenic crops. However, by 1998, this curiosity factor was not cited by a majority of those surveyed. The majority of respondents cited seed expense as a major disadvantage to using RR soybeans. The fear of foreign governments banning the import of RR soybeans increased significantly from 1997 to 1998, most likely as the result of the increasing coverage in the popular press.

Implications for Extension

Studies of the adoption and diffusion of innovative new technologies have a long tradition in rural sociology (Rogers, 1983). The classic "S-curve" that characterizes innovators, early adopters, majority adopters, and laggards has been well documented. This relationship between time and the diffusion of new technologies has historically grounded Extension's educational philosophy, especially in agriculture, and is apparently reaffirmed in this model.

In this study, farmers planting RR beans in 1997 were heavily motivated by curiosity and can be characterized in classical terms as innovators or early adopters. Farmers adopting this technology in 1998 are likely to have made their decision at least in part based upon observation of the results obtained by their more innovative neighbors in the previous year.

The more interesting implication of this study is that changes in cultural practices that would presumably give additional benefits in terms of yield or profit when used in combination with the transgenic crops lagged behind. This would appear to provide fertile ground for Extension education, because realizing the full economic and environmental benefits from transgenic crops dictates that appropriate cultural practices be adopted as well.

Is Cooperative Extension realizing the potential impact of educational programs in this area? Probably not. It was very evident from this study that seed dealers were the major source for information on selecting both RR soybean and conventional varieties, and it is likely this influence also extends to the cultural practices that accompany their planting.

How can Cooperative Extension capitalize on our position as a provider of objective information and education with regard to use of transgenic crops? On-farm trials were an important educational tool for many of those being surveyed. While such applied research is a proven educational method, the value of which is clearly indicated by years of research on the adoption and diffusion of innovation, it is the observation of the authors that on-farm trials have fallen from favor in the Extension programs of many states.

Time and opportunity costs for researchers under growing pressure to achieve national and international visibility for their work underlie this tendency away from on-farm trials, as does the inescapable fact that the private sector has achieved great success in introducing new technologies to today's producers. However, this study suggests that new technologies create a teachable moment of great potential impact in the cultural arena, and they offer county-based faculty members the opportunity to advance Cooperative Extension's educational mission by facilitating such demonstrations. It is the conclusion of the authors that the emergence of transgenic crops should encourage us to revisit both traditional research on the adoption and diffusion of innovations and Extension's historically successful teaching tool: the on-farm demonstration.

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