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A Preliminary Economic Assessment of Roundup Ready Soybeans in Mississippi*

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Abstract

The advent of genetically altered seed has had a revolutionary effect on the cotton, soybean, and corn seed industries. The basic premise for the use of these seed are to reduce costs through lower applications of chemicals and savings on trips through the field, thus, lowering production costs. Seed companies, however, charge a premium and a fee for use of the seed. This paper compares the costs associated with conventional and roundup ready soybeans. Data were collected from the ACost of Production@ survey of Mississippi producers that is administered by Mississippi State University through the National Agricultural Statistics Service. The survey is a random sample of producers fields that allows for a derivation of the cost of production for each field. The study suggests that while costs reductions can be achieved, the cost savings are offset by the technology fees. The study is based on limited data and points to the need for continued research on the long-run profitability of genetically altered seed to the soybean producers of Mississippi.

Keywords: soybeans, genetically altered seed, roundup ready, costs of production

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Introduction

The advent of transgenic or genetically altered seed has the potential for revolutionizing production agriculture. The general purpose of this technology is to reduce cost through reduced chemical applications, increase resistance to disease or pests, or increase yields through modifications of the genetic code of the plant. Although this technology has been in development for some time, many transgenic technologies have only recently been commercialized. Thus, knowledge of their performance in a commercial setting is limited.

Roundup Ready[1] (RR) technology is one such transgenic development for soybeans, cotton, and corn. The RR gene introduces a resistance to the Roundup herbicide into these crops. Thus, these crops can be sprayed with Roundup, thus killing weeds but not harming the crop. The purpose is to more effectively control weeds, thus reducing overall chemical application costs and cultivation. Recent tests on one farm show that the RR technology has promise in cotton, but that the technology did not always result in a positive return to the producer (Laws). The objective of this study is to assess the potential profitability of the RR technology for soybean producers in Mississippi.

Roundup Ready Technology and Technology Fees

Potential purported benefits of the RR technology include reduced chemical application costs, fewer trips through the field with equipment, and better control of weeds in the crop. In return for capturing these benefits, the producer agrees to pay a technology fee in addition to the cost of the seed. This fee is charged to compensate the developer of the technology for research and development cost (including some premium for taking on the risk of this research), operating expenses, and profit.

With patent rights, the developer of the technology is assumed to have monopoly power (Aoki and Jin-Li) so that the determination of the technology fee can be visualized in Figure 1. In this figure, D is the demand function, MR is the marginal revenue function, AC is the average cost to produce RR seed, and MC is the marginal cost to produce RR seed. The seed company will produce the optimal quantity of RR seed, Q*, and sell at the optimal price, P*, with a cost of C. The difference between P* and C is the monopoly profit. In this case, one would expect that the difference between P*

[1] Roundup Ready is a registered trademark of the Monsanto Corporation.

and C would be approximately equal to the technology fee.[2]

This technology fee can also be seen from the producer's perspective in Figure 2. A producer facing the conventional seed technology is facing a cost structure reflected by MC1 and AC1 (marginal and average costs). Assuming that the RR technology is cost saving and ignoring the technology fee, adoption of that technology would result in a downward shift in production costs (MC2 and AC2). The result is that per unit costs are reduced. Assuming monopoly power, the technology developer will attempt to extract as much of the difference between C1 and C2 as is possible, while still providing some incentive for the producer to adopt the technology. Thus, one hypothesis is that the cost savings (not including the technology fee) resulting from adopting RR technology will be approximately equal to the technology fee.

Methods

The objectives of this analysis were achieved through two primary methods. First, the means of different groups were compared for differences. Second, a regression model was employed to account for the effects of multiple variables. The following describes these techniques.

Data

The data for this analysis were collected from the "Cost of Production" survey of Mississippi producers that is administered by Mississippi State University through the National Agricultural Statistics Service. This survey provides a random sample of agricultural producer's fields for each commodity and provides specific information on chemicals applied, field operations, etc. This allows a derivation of the cost of production for each field in the sample.

Data on chemical applications, chemical costs, seeding rates, seed costs, other costs, yield, growth region, and seed variety were collected from these surveys for the 1997 and 1998 crop years. The data were divided into groups based on year, irrigation/no irrigation, and Roundup Ready/ conventional soybeans. These groupings served as the basis for analysis of the mean values.

Comparing Means

Several questions arise as to the efficacy of Roundup Ready soybeans given the technology fee that is being assessed. First, and most importantly, is there any difference in the chemical costs between Roundup Ready and conventional soybeans? This question was address by using a two-sample t-test, which is given by:

$$t = \frac{\overline{x_1} - \overline{x_2}}{s_p\sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}}},$$

where the $\overline{x}$'s are the mean chemical application costs for the two groups (Roundup Ready and conventional), the n's are the sample sizes of each group, The s^2's are the variances of chemical costs for each group. Using the pooled standard error assumes equality of the population variances of each group. An F-test was used to test for equality of variances. If equal, the above equation was used. If the variances were found

[2] This, of course, is a simplification of the problem. In reality, the seed producer is receiving some benefit from the joint sale of the seed and Roundup Ultra, which is not captured in this simple model. Nevertheless, this model demonstrates how the technology fee may be arrived in the market.

not to be equal, then a modification was made to the denominator of the above equation to account for differences in variances.

To avoid co-mingling potential weather and other effects, this test was performed for each crop year separately. The test was also performed for irrigated and non-irrigated separately. Finally, the average other costs (above chemical and seed costs) were analyzed.

Regression Analysis

Comparing the means as above can provide useful indicators of whether two groups are different. Regression analysis was used to account for the effects of multiple variables. The first regression model is given by:

$$Chem = f(ud, ld, belt, ready, irri, year),$$

where ud is a dummy variable for the upper delta region (ud=1 if the producer is in the upper delta; ud=0 otherwise), ld is a dummy variable for the lower delta, belt is a dummy variable for the black belt region (the coastal plains region is used as the base), ready is a dummy variable for Roundup Ready soybeans (ready=1 if the variety planted by the producer was Roundup Ready; ready=0 otherwise), irri is a dummy variable for irrigation (irri=1 if the field was irrigated; irri=0 otherwise) and year is a dummy variable for the year (year=1 if the year is 1997; year=0 otherwise). Using the regression model, the effects of each variable can be measured while controlling for the other effects.

Results

The means and standard deviations for the data set are shown in Table 1. There were 268 total observations. Approximately 24% of the observations were for Roundup Ready (RR) soybeans. The average yield was 27.9 bushels per acre. Average chemical cost was $27.26/acre and average total cost was $128.36/acre. Approximately 22% of the observations were from the Upper Delta, 27% from the Lower Delta, 31% from the Black Belt, and the remainder from the Coastal Plains. About 51% of the observations were from 1997 and 49% from 1998. Only 10% of the observations were on irrigated soybeans.

The results of the t-tests for equivalence of means are shown in Table 2. Only non-irrigated results are presented because the number of irrigated observations is small and the results were considered unreliable. Results indicate that the specified costs (not including chemical and seed costs) were not significantly different for either 1997 or 1998. The mean cost for RR was higher than conventional soybeans, although not statistically higher, in 1997. This could be because of the small number of observations for RR in 1997 as compared to conventional soybeans.

Chemical costs were significantly lower for RR in both years, suggesting that RR soybeans have the benefit of reducing chemical application costs. In 1997, the cost advantage was $15.19/acre, Given a technology fee assessed by seed companies of approximately $8.50/acre, the RR soybeans generated an average net return of $6.69/acre above chemical costs. In contrast, the average cost savings in 1998 was $4.26/acre, resulting in a net loss to the producer of $(4.24)/acre. One interesting result is the percentage of acres planted to RR increased from about 7% in 1997 to about 46% in 1998. This could be a result of the large net return that was observed in 1997, which induced more producers to plant RR in 1998. In 1998 there was an increased supply of RR seed. Additionally, farmers like the simplicity of the production system.

Results of the regression equations for chemical costs are shown in Table 3. The average chemical cost across all observations, holding all factors at mean levels, is $25.41/acre. Both the Upper and Lower Delta regions observed higher chemical application costs than the Coastal Plains. The differences were $4.97 and $7.93/acre, respectively. The Black Belt region did not exhibit any significant difference in chemical costs from the Coastal Plains. RR soybeans showed significantly lower chemical costs of $6.56/acre as compared to conventional soybeans, other things equal. This suggests that the RR technology did not generate a cost savings if one assumes a technology fee of $8.50/acre. There was no significant difference in chemical application costs for irrigated versus non-irrigated soybeans, and there was no significant difference in chemical costs between years.

The average yield, holding all other factors at mean levels, was 23.42 bushels per acre. The Lower Delta and Black Belt regions exhibited an average 5.96 and 4.32 bushels/acre higher yield than the Coastal Plains, respectively, while the Upper Delta yields were not significantly different from the Coastal Plains. Irrigation increased yields by an average 16.58 bushels per acre, and there was no significant difference in yields between years. Yields were based on farm rather than field yields, therefore any analysis beyond the averages on yields could be biased.

Conclusions

Results of this analysis call into question the efficacy of RR soybeans in reducing costs to Mississippi soybean producers. Readers are cautioned, however, that these results are based on a limited experience with RR soybeans. That is, the results here are based on only two years of observations. There are many questions that have yet to be answered. For example, does RR reduce the variability of yields to the producer? A reduction in yield variability may induce the producer to forgo some revenue to insure more consistent yields. There are also potential environmental benefits to be considered. That is, reduced chemical applications may mean less environmental damage. In a time of increased scrutiny from environmental groups on non-point source pollution, any real reduction in chemical run-off may result in a lower probability of regulation or litigation costs. In addition, the useful life of equipment may be extended if the number of trips through the field is reduced. All of these issues need additional research before conclusions can be drawn.

Nevertheless, this study suggests that while cost reductions can be achieved, those reductions appear to be offset by the technology fees. This points to the need for continued research on the long-run profitability of genetically altered seed to the soybean producers of Mississippi.

References

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Table 1. Means and Standard Deviations of Soybean Cost of Production Data, Mississippi 1997-1998.

Variable	Mean	Standard Deviation
Irrigation	0.104	.3064
Chemical Cost/Acre	27.256	14.6152
Total Specified Cost/Acre	128.355	30.4131
Total Specified Cost Less Chemical and Seed Cost/Acre	81.022	27.5502
Yield	27.903	14.3631
Upper Delta	0.220	0.4151
Lower Delta	0.269	0.4441
Coastal Plains	0.205	0.4046
Black Belt	0.306	0.4617
1997	0.507	0.5009
1998	0.493	0.5009
RR Soybeans	0.235	0.4248

Table 2. Results of t-test for Non-Irrigated RR vs. Conventional Soybeans, Mississippi, 1997-1998.

	N[a]	Mean	Standard Deviation	t-stat
Total Specified Cost Less Chemical and Seed Costs				
1997				
Conventional	110	79.568	25.864[b]	-1.65
RR	8	92.808	32.539	
1998				
Conventional	70	73.453	20.856[c]	0.59
RR	52	73.197	27.206	
Chemical Costs				
1997				
Conventional	110	28.986	15.875[c]	5.06*
RR	8	13.795	7.339	
1998				
Conventional	70	28.708	16.422[c]	1.73*
RR	52	24.450	10.788	

[a] N indicates the number of observations.
[b] Variances are not statically different. T-statistic is based on the assumption of equal variances.
[c] Variances are statistically different. T-statistic is based on the assumption of unequal variances.
* Means are statistically different at the 10% level or better.

Table 3. Results of Regression Analysis on Chemical Costs, Mississippi, 1997-1998.

Independent Variable	Dependent Variable Chemical Cost ($/acre)
Intercept	25.405
	(2.247)*
Upper Delta	4.971
	(2.802)*
Lower Delta	7.933
	(2.592)*
Black Belt	2.986
	(2.498)
RR Soybeans	-6.558
	(2.262)*
Irrigation	-4.332
	(3.041)
Year	-0.580
	(1.916)
R^2	0.068
F-value	3.193*

* statistically significant at the 5% level or better.

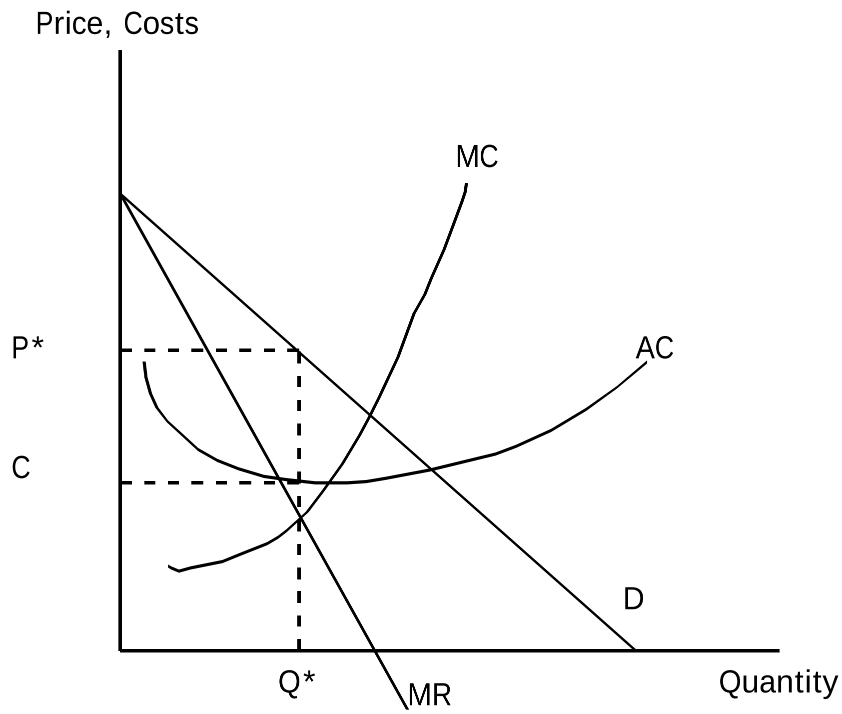

Figure 1. Determination of RR Technology Fee Assuming Monopoly Power.

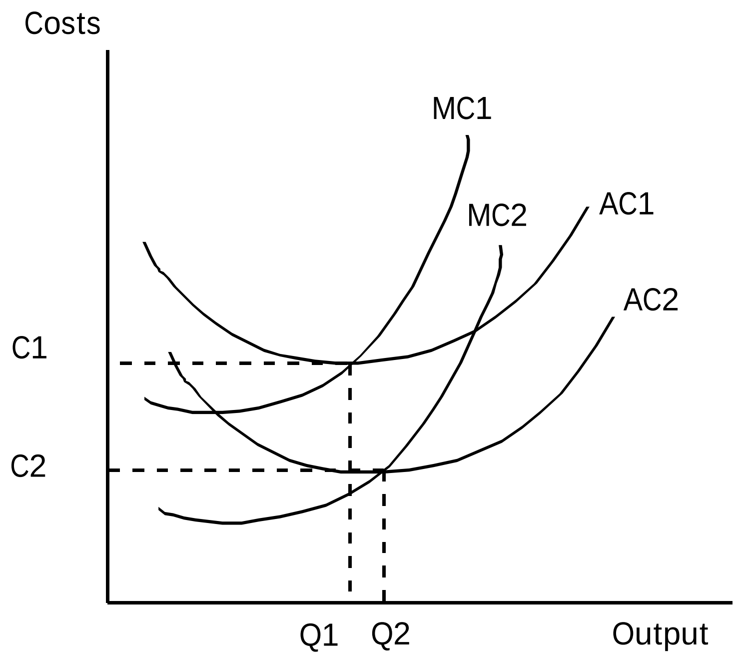

Figure 2. Potential Differences in Producer Cost Structures Between RR and Conventional Seed Technology.