Valuing Transgenic Cotton Technologies Using a Risk/Return Framework

Kelly J. Bryant, Jeanne M. Reeves, Robert L. Nichols, Jeremy K. Greene, Christopher H. Tingle, Glenn E. Studebaker, Fred M. Bourland, Charles D. Capps, Jr., and Frank E. Groves

Stochastic Efficiency with Respect to a Function (SERF) is used to rank transgenic cotton technology groups and place an upper and lower bound on their value. Yield and production data from replicated plot experiments are used to build cumulative distribution functions of returns for nontransgenic, Roundup Ready, Bollgard, and stacked gene cotton cultivars. Analysis of Arkansas data indicated that the stacked gene and Roundup Ready technologies would be preferred by a large number of risk neutral and risk averse producers as long as the costs of the technology and seed are below the lower bounds calculated in this manuscript.

Key Words: cotton, financial risk, market value, SERF, transgenic

JEL Classifications: Q12, Q16

Transgenic cotton cultivars provide growers with additional management options for weed and insect control. Growers now have the option to plant Bollgard cultivars that express an organic toxin synthesized by the bacterium *Bacillus thuringiensis* (*Bt*) in the foliage, bracts, and carpels. When certain lepidopteran pests, notably the heliothine insects, tobacco budworm *(Heliothis virescens)*, and bollworm *(Helicoverpa zea)* feed on Bollgard cotton, the *Bt* toxin paralyzes the mid-gut of susceptible insects and they die as small caterpillars (Benedict). Other transgenic cultivars have been developed that have the ability to tolerate the nonselective herbicide glyphosate (Roundup Ready) or the broad-leaf herbicide, bromoxynil (BXN) (Collins; Stewart). Newer cultivars have incorporated both the herbicide resistance and *Bt* expressions in order to provide both insect and weed management capabilities. These seed technology options are summarized in Table 1.

Producers now have more options for managing production risks associated with lepidopteran insects and weeds. The Bollgard gene acts as an insurance policy. In the event of heavy infestation by lepidopteran larvae, the cotton plant has built-in protection. In

Kelly J. Bryant is professor and center director, Southeast Research and Extension Center, University of Arkansas Division of Agriculture, Monticello, AR. Jeanne Reeves and Bob Nichols are director and senior director, respectively, Cotton Incorporated, Cary, NC. Jeremy Greene is associate professor, Edisto Research and Education Center, Clemson University, Blackville, SC. Chris Tingle is weed control group leader, Syngenta Crop Protection, Vero Beach Research Center, Vero Beach, FL. Glenn Studebaker and Fred Bourland are Extension entomologist and director/professor, respectively, Northeast Research and Extension Center, University of Arkansas Division of Agriculture, Keiser, AR. Charles Capps, Jr., is county extension agent (agriculture), University of Arkansas Division of Agriculture, Monticello, AR. Frank Groves is area agronomist (cotton), Southeast Research and Extension Center, University of Arkansas Division of Agriculture, Monticello, AR.

Table 1. Seed Technology Options Available to Cotton Producers

Seed Technology	Built-in Lepidoptera Control?	Ability to Broadcast Glyphosate Herbicide?
No transgenic traits	No	No
Roundup Ready gene	No	Yes
Bollgard gene	Yes	No
Stacked gene	Yes	Yes

addition, insecticide sprays for heliothine or other insects can also be applied, if necessary. The Bollgard gene comes at a price that is the sum of a premium for the transgenic seed and an annual license to use the trait, the latter called the technology fee.

The Roundup Ready gene adds efficiency and convenience to weed control in cotton. Broadcast sprays of glyphosate are quick and easy to apply, and the herbicide is off-patent and inexpensive. In most cases glyphosate is very effective for weed control. Thus, weed management with glyphosate in glyphosate-resistant crops is reliable, low-cost, and saves the operator fuel and time. In addition, herbicides other than glyphosate may still be applied to Roundup Ready cultivars, if necessary, for a complete weed management program. Such convenience and flexibility also comes at a price equal to a premium for the seed and an annual fee for licensed use of the transgenic technology.

Since transgenic technologies are inherent in the seed when purchased, the producer must decide before planting what level of flexibility, insurance, and time-saving he or she desires. With the advent of pest-managing transgenic traits, the decision to purchase a cultivar and the choice of pest control are complicated. A good means of comparing the relative advantages of cultivars is by costs and returns (Nichols, May, and Bourland). Hurley, Mitchell, and Rice point out that risk is important when making the decision to plant a *Bt* crop because farmers make planting decisions before knowing the severity of insect infestations.

Another variable in the production decision equation is the expected yield of the cultivar chosen. Since yield is an important component of net returns, a cultivar could be chosen for its yield potential alone regardless of its technology traits. The authors presume that for some or all of the reasons above, cotton cultivars containing the Roundup Ready gene, the Bollgard gene, or both have been widely adopted.

The purpose of this study is to determine a range of economic values for four mutually exclusive technologies in cotton production. In a single field a producer can plant a conventional cultivar, a cultivar containing the Roundup Ready gene, a cultivar containing the Bollgard gene, or a cultivar containing both genes (referred to as "stacked"). Once the value of each technology is determined, we can compare that information to its market price and make inferences as to their expected adoption.

The demand for a transgenic cotton cultivar is a function of expected yield, production cost, and production risk associated with the cultivar. Different production regions have different production risks. Thus, these transgenic cultivars are expected to have different values in different markets (production regions) due to different growing environments in those markets. This study determines the value of four transgenic cotton technology groups in two production regions important to Arkansas cotton producers.

Previous Research

Some studies have compared a single technology with conventional cotton and have not addressed risk in the decision-making process. Cooke et al. obtained field level agronomic data from 12 to 15 farms in the Mississippi Delta from 1997 to 2000 to measure the entomological and economic impact of *Bt* cotton when compared with conventional cotton. On each farm, paired or split fields were selected for a side-by-side per acre cost and return comparison. A 4-year average of costs and yields for the two technologies showed only 8 pounds of lint per acre difference in average yields and $2.66 per acre

difference in average production cost. The authors conclude that the profitability of *Bt* cotton is a function of the severity and duration of tobacco budworm infestations in any given year and that growers should most likely always plant some *Bt* cotton based on the history of tobacco budworm infestations associated with the producer's farm.

Karner, Hutson, and Goodson seek to determine the economic impact of *Bt* cotton on Oklahoma's cotton industry. They collected 4 years (1996–1999) of replicated agronomic data from 51 irrigated cotton trials. They then constructed per acre cost and return estimates for *Bt* and non-*Bt* cotton for each year and a 4-year average. The authors conclude that *Bt* cotton was the best yielder and had higher returns per acre in all 4 years. The *Bt* profit advantage ranged from $40.06 per acre in 1999 to $83.53 per acre in 1996, even after accounting for a technology fee associated with the *Bt* technology.

Other studies have utilized a risk/return framework when comparing a single technology to conventional cotton. Johnson and Blackshear evaluate the cost of production and profitability of Roundup Ready cotton compared to conventional cotton in the Southern High Plains of Texas. They used on-farm observations of costs and returns from 1998–2000. The methodology consisted of financial analysis, stochastic simulations, and stochastic dominance with respect to a function. The authors conclude that Roundup Ready cultivars had higher net incomes than the conventional varieties over the time period studied. Also, for all levels of absolute risk aversion ranging from 0 to 0.05, the Roundup Ready cultivars dominated conventional cotton cultivars.

Frisvold and Pochat report on differences in means and variances of pest damage, insecticide use, and pest control costs between *Bt* and non-*Bt* cotton acreage using state-level survey data. Simple one-tailed *t*-tests were used to test differences in means and an *F*-test was used to test differences in variances. The authors were not able to reject the hypothesis that means or variances of overall pest control costs, including *Bt* fees, were equal on *Bt* and non-*Bt* acreage. However, the variance of yield losses from target pests was lower for *Bt* cotton.

Still other studies have compared multiple technology groups simultaneously, but have ignored the risk component. Bryant et al. (2003) examine the cost and returns associated with alternative pest control systems using transgenic and nontransgenic cotton cultivars in an effort to identify the most economical alternatives. Agronomic data from replicated research plots at two locations in 1998, 1999, and 2000 served as the basis for per acre cost and return calculations for each cultivar at each location in each year. The authors conclude that yield was the factor most closely associated with profitability at each site in each year. In three of the five site-years, yields were not statistically different for most or all of the cultivars tested, so the least expensive treatment would also be the most profitable treatment. Comparisons among the cultivars tested in this research indicate that the currently available cultivars offer ample opportunities to identify high-yielding cultivars and profitable systems regardless of transgenic traits.

Jost et al. followed a procedure similar to Bryant et al. (2003) to evaluate the yield and returns of cotton cultivars in Georgia. They utilized field experiments from 2001–2004 to compare production systems utilizing cotton cultivars possessing a wide variety of transgenic technologies. The authors conclude that profitability was most closely associated with yield and not with technology and that no system, transgenic or otherwise, consistently provided the greatest return across year and location.

All of the studies cited above (with the exception of Frisvold and Pochat) begin their methodology with agronomic data from field trials making them site and time period specific. This study does the same. The studies cited above have treated the market price of seed and technology for the various cultivars as a given and then compared net returns among the cultivars. This study seeks to solve for the value of the technologies. This is accomplished by fixing the price of seed and technology at zero for all the cotton cultivars considered and then using a risk/return framework to determine the value of one

technology group over the others. Multiple technology groups are included simultaneously, thus better reflecting the set of choices a producer faces.

Still other studies have utilized nationwide farm-level survey data and econometric models to measure the effects of adopting genetically engineered crops on the U.S. farm sector (Fernandez-Cornejo, Klotz-Ingram, and Jans; McBride and El-Osta). Hurley, Mitchell, and Rice utilize county average yields, on-farm field trials, and simulation techniques to evaluate how planting *Bt* corn affects farmer risk and welfare in Iowa. This study uses a more direct methodology to determine the relative value of mutually exclusive technologies for a specific region of production.

Methods

Field studies were conducted in 2001, 2002, and 2003 at the Northeast Research and Extension Center (NEREC) at Keiser, Arkansas, and the Southeast Branch Experiment Station (SEBES) at Rohwer, Arkansas. Cotton was planted on May 15, 2001; May 31, 2002; and May 28, 2003 at NEREC and on June 7, 2001; May 21, 2002; and May 12, 2003 at SEBES. Plot size was four rows 0.9 m by 15 m long. The experimental design was a randomized complete block with four replications. The plots at NEREC were managed under a no-till system. The plots at SEBES were managed using a more conventional system of spring tillage and mechanical cultivations when appropriate. Roundup Ready, Bollgard, and Roundup Ready plus Bollgard cultivars were chosen based on their performance in the University of Arkansas Official Variety Tests (Benson et al.) and percentage of acreage planted in Arkansas (USDA-AMS 2001). The cultivars included in the study by year are displayed in Table 2.

All plots were managed to maximize yields according to University of Arkansas Cooperative Extension Service recommendations. Herbicide systems were chosen based on the genetic capabilities of each cultivar and the weeds present. For example, Roundup Ultra-Max was the primary herbicide used with the

Roundup Ready and Roundup Ready plus Bollgard cultivars, and cotton-selective herbicides were used with nontransgenic cultivars. After emergence, plots were scouted for insects weekly. As with the herbicide systems, insecticide applications were based on the genetic capabilities of each cotton cultivar and weekly scouting to determine the insect populations that were present. At both locations, the two center rows of each plot were machine harvested.

Each cotton cultivar represents a cotton production system. Once the cultivar is selected, the weed and insect management programs are fixed. The remaining production practices, such as tillage, fertilizer, and irrigation, are independent of the cultivar choice and in this study those production factors were constant across all cultivars for a given location and year. Therefore, the only factors causing a difference in returns among the cultivars are yield, weed control cost, and insect control cost.

Returns over weed and insect control were calculated for each cultivar as

$$(1) \quad R_{ijkl} = Y_{ijkl} * P_l - WC_{mkl} - IC_{nkl},$$

where

R = return over weed and
   insect control in dollars per acre.

Y = cotton lint yield in pounds per acre.

P = cotton lint price in dollars per pound.

WC = weed control cost,
   material plus application, in dollars per acre.

IC = insect control cost,
   material plus application, in dollars per acre.

i = cultivar (see Table 2).

j = replication 1 to 4.

k = location (NEREC or SEREC).

l = year (2001, 2002, or 2003).

m = herbicide technology group inherent
   in i (Roundup Ready or not).

n = insecticide technology group inherent
   in i (*Bt* or not).

Table 2. Cotton Cultivars Serving as Treatments by Year

Seed Technology	2001	2002	2003
No transgenic traits	ST 474	ST 474	ST 474
	PSC 355	PSC 355	PSC 355
	FM 966	FM 966	FM 966
Roundup Ready gene	ST 4793R	ST 4793R	ST 4793R
	PM 1199 R	PM 1199 R	SG 521 R
Bollgard gene	ST 4691 B	ST 4691 B	ST 4691 B
	DP 20 B	DP 20 B	FM 958 B
Stacked gene	ST 4892 BR	ST 4892 BR	ST 4892 BR
	SG 215 BR	SG 215 BR	SG 215 BR
		PM 1218 BR[a]	ST 5599 BR

[a] The Paymaster PM 1218 BR cultivar was only grown at the Northeast Arkansas location in 2002.

Return measured in this way is the amount of money available to cover all the remaining costs of production, including the cost of the seed and technology. Since all the remaining production practices were held constant across the cultivars, any difference in return between two cultivars as calculated in Equation (1) is attributable to the production system (dictated by the seed and technology employed) and therefore is a measure of the value of one cultivar over the other.

Plot yields were multiplied by the base Arkansas Commodity Credit Corporation loan rate to arrive at gross returns for each treatment. The base loan rate was $0.5230/lb in 2001, $0.524/lb in 2002, and $0.5235/lb in 2003. Treatment costs including herbicide, insecticide, and application costs were determined for each cultivar using a computerized budget generator (Laughlin and Spurlock) and input prices from the University of Arkansas cotton budgets. Specific information on yields and costs by cultivar, year, and location are published in Bryant et al. (2004). While seed costs and technology fees differ across technology groups, these costs were omitted from this analysis for the purpose of estimating the value of one technology group over the others.

A total of thirteen cultivars were grown over the 3-year period (Table 2). The thirteen cultivars were divided into four technology groups: conventional cultivars, Roundup Ready cultivars, Bollgard cultivars, and stacked gene cultivars. Each cultivar tested contained four replications in each year. Thus, a minimum of 24 observations on returns exist for each technology group at each location when combined across years. Means and standard deviations were calculated for each technology group. Empirical cumulative distributions were constructed for each technology group assuming an equally likely probability of occurrence for each observation.

Hardaker et al. outline a methodology for analyzing risky investment alternatives, which they call Stochastic Efficiency with Respect to a Function (SERF). "SERF orders alternatives in terms of certainty equivalents (CE) as a selected measure of risk aversion is varied over a defined range" (Hardaker et al., p. 255). This procedure requires specifying a form of the utility function and a range of Absolute Risk Aversion Coefficients (ARAC). For this study we chose the negative exponential utility function as suggested in Hardaker et al. We calculated appropriate ARAC for each location by dividing two extreme values for relative risk aversion with respect to wealth of 0.5 and 4.0 by an approximate overall average of wealth for the alternatives at each location (Hardaker et al.). For Southeast Arkansas we calculated the certainty equivalent for each alternative using ARACs ranging from zero to 0.01. For Northeast Arkansas we calculated the certainty equivalent for each alternative using ARACs ranging from zero to 0.015.

Subtracting the CE for a less preferred alternative from the CE of the preferred alternative yields a measure of preference for

Table 3. Returns for Four Cotton Seed Technology Options

Technology	Southeast Arkansas		Northeast Arkansas	
	Average Returns ($/acre)	SD of Returns ($/acre)	Average Returns ($/acre)	SD of Returns ($/acre)
Conventional	567	273	306	122
Roundup Ready gene	529	266	350	119
Bollgard gene	580	273	327	108
Stacked gene	614	191	346	124

the preferred alternative at a given risk aversion level (Hardaker et al.) We calculated the difference in CE at each ARAC level. The software developed by Richardson, Schumann, and Feldman was used to apply the SERF method and graph the results.

Results

"The CE of a risky prospect is the sure sum with the same utility as the expected utility of the prospect. In other words, for a given utility function, it is the point mass at which the decision maker is indifferent between the value and the risky outcome. For a rational decision maker who is risk averse . . . , the estimated CE is typically less than the expected money value and greater than or equal to the minimum value." (Hardaker et al., p. 257)

Southeast Arkansas

Means and standard deviations of returns over weed and insect control in Southeast Arkansas for each technology group are displayed in Table 3. The seed costs and technology fees are not included. The stacked gene technology has the greatest expected value and the smallest standard deviation. This indicates a good choice for risk neutral and risk averse decision makers provided the seed and technology are acceptably priced. The Roundup Ready technology has the smallest expected value but also has one of the smallest standard deviations.

The certainty equivalents for each alternative production technology and each ARAC ranging from zero to 0.01 are displayed in Figure 1. The stacked gene technology has the

greatest certainty equivalent for each ARAC considered. Thus, the stacked gene technology would be preferred over the other technology alternatives by all risk adverse decision makers represented by the ARACs considered as long as the price and technology fee is equal across technology groups. Following the stacked gene technology in preference is the Bollgard technology, then the conventional technology, and last the Roundup Ready technology. However, at higher levels of risk aversion, the Roundup Ready technology is preferred over the conventional technology.

A per acre value of the stacked gene technology over the alternative technologies was determined by subtracting the CEs of the alternative from the stacked gene technology at each ARAC level (Figure 1). The per acre values of the stacked gene technology at the lower and upper bounds of the ARACs are displayed in Table 4. During the study period, the stacked gene technology cost a producer approximately $9.00/acre more than the Bollgard technology, $27.00/acre more than the Roundup Ready technology, and $37.00/acre more than the conventional technology. All of these are below the lower bound of the value of the stacked gene technology (Table 4). Thus, we would expect to see widespread adoption of stacked gene cotton in Southeast Arkansas.

Northeast Arkansas

Means and standard deviations of returns over weed and insect control in Northeast Arkansas for each technology group are also displayed in Table 3. Again, the seed costs and technology fees are not included. The Round-
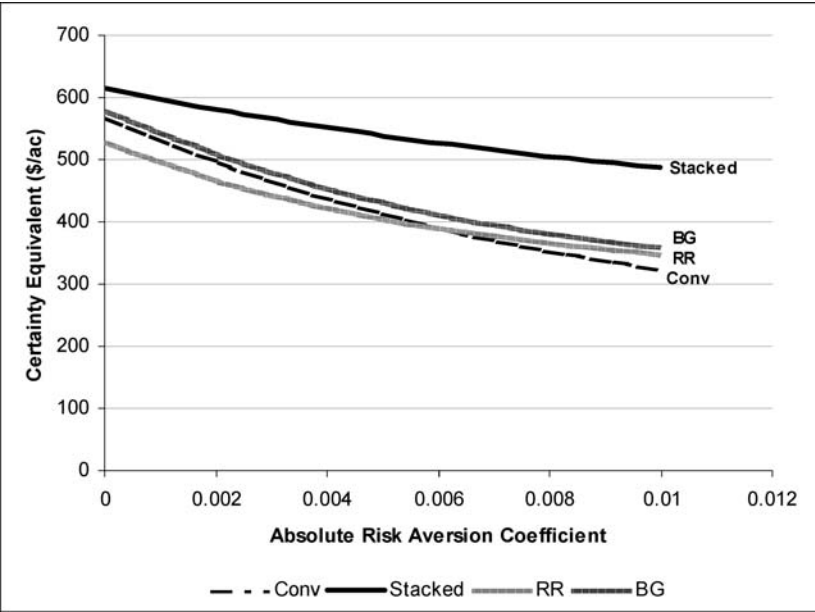
Figure 1. Certainty Equivalents Across Absolute Coefficients for Each of Four Cotton Production Technology Alternatives in Southeast Arkansas Assuming a Negative Exponential Utility Function

up Ready technology has the greatest expected value. The Bollgard technology has the smallest standard deviation. The means and standard deviations for the three genetically modified technologies are similar to each other. The CDFs of these technologies were entwined. Only the CDF of the conventional technology appeared to be substantially different from the other three.

The certainty equivalents for each alternative production technology across ARACs ranging from zero to 0.015 are displayed in Figure 2. The Roundup Ready technology has the greatest certainty equivalent for each ARAC considered. Thus, the Roundup Ready technology would be preferred over the alternatives by all risk averse decision makers represented by the ARACs considered provided the seed costs and technology fees were the same across the technology groups. Following the Roundup Ready technology in terms of preference is the stacked gene technology, then the Bollgard technology, and finally the conventional technology.

Table 4. Value of the Dominant Cotton Seed Technology over the Dominated Technologies

| Value of the Stacked Gene Technology in Southeast Arkansas		
Dominated Technology	Lower Bound ($/acre)	Upper Bound ($/acre)
Bollgard gene	34.10	127.56
Conventional	47.30	163.72
Roundup Ready gene	85.60	138.65
Value of the Roundup Ready Gene Technology in Northeast Arkansas		
Dominated Technology	Lower Bound ($/acre)	Upper Bound ($/acre)
Stacked gene	3.15	9.61
Bollgard gene	22.56	23.47
Conventional	43.70	41.58
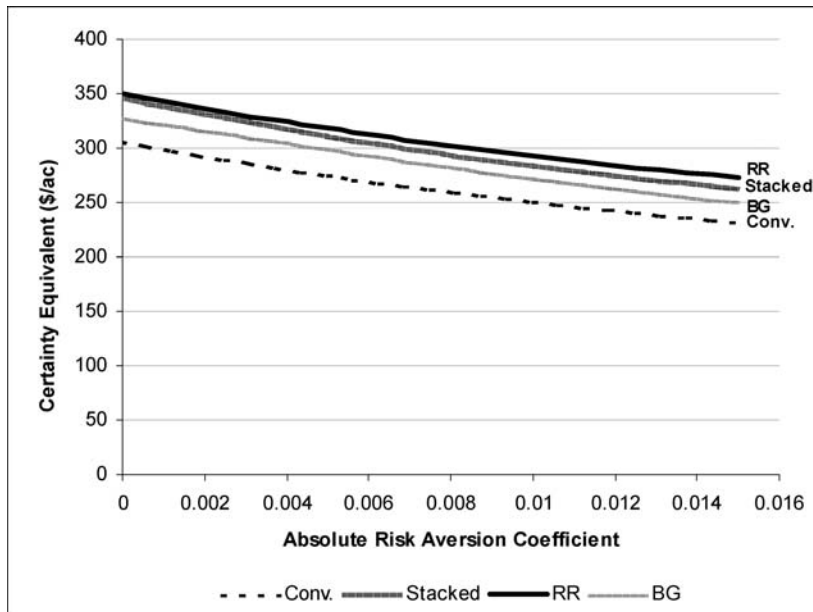
Figure 2.   Certainty Equivalents Across Absolute Risk Aversion Coefficients for Each of Four Cotton Production Technology Alternatives in Northeast Arkansas Assuming a Negative Exponential Utility Function

A per acre value of the Roundup Ready technology over the alternative technologies was determined by subtracting the CEs of the alternative from the Roundup Ready technology at each ARAC level. The per acre value of the Roundup Ready technology over that of the other technologies at the lower and upper bounds of the ARACs are also displayed in Table 4.

During the study period, the Roundup Ready technology cost a producer less than both the stacked gene and Bollgard technologies, and approximately $9.00/acre more than the conventional technology. This is well below the lower bound in Table 4. Thus, we would expect to see widespread adoption of Roundup Ready cotton in Northeast Arkansas. This analysis suggests that low pest pressure during the period of this study in this northern portion of the cotton belt made the Bollgard technology unwarranted.

Conclusions

A large number of risk neutral and risk averse producers would prefer the stacked gene technology in Southeast Arkansas and the Roundup Ready technology in Northeast Arkansas provided the costs of the technology and seed for these technologies relative to that of the other technologies are below the lower bounds listed in Table 4. The price differences in these respective markets have in fact been below these lower bounds and cotton producers in Arkansas have widely adopted stacked gene cotton and Roundup Ready cotton since its development (USDA-AMS 2006). If the price difference between the technologies changes, a farmer's preference for that technology will change depending on his attitude toward risk. Segmenting the market is important. This study shows that the preferred technology is different for the two markets in Arkansas.

This study uses an accepted methodology to place upper and lower bounds on the value of a dominant cotton technology with respect to a set of dominated technologies. Multiple technologies are compared simultaneously and risk is appropriately considered. This approach can be used to assess the value of newer transgenic crop technologies as they are

developed. The information is of interest to crop producers also as it measures the yield, production cost, and risk of the technologies in their production region.

References

Benedict, J.H. "*Bt* Cotton: Opportunities and Challenges." *Proceedings of the Beltwide Cotton Conference*, P. Dugger and D.A. Richter eds., pp. 25–29. Memphis, TN: National Cotton Council, 1996.

Benson, N.R., F.M. Bourland, W.C. Robertson, J.M. Hornbeck, and F.E. Groves. *Arkansas Cotton Variety Tests—2001*. Fayetteville, AR: Arkansas Agricultural Experiment Station, Research Series 491, 2001.

Bryant, K.J., R.L. Nichols, C.T. Allen, N.R. Benson, F.M. Bourland, L.D. Earnest, M.S. Kharboutli, K.S. Smith, and E.P. Webster. "Transgenic Cotton Varieties: An Economic Comparison in Arkansas." *Journal of Cotton Science* 7,4(2003):194–204.

Bryant, K., J. Greene, C. Capps, F. Groves, C. Tingle, G. Studebaker, F. Bourland, B. Nichols, and J. Reeves. "An Economic Comparison of Transgenic and Non-Transgenic Cotton Production Systems in Arkansas." *Proceedings of the Beltwide Cotton Conference*, P. Dugger and D.A. Richter eds., pp. 534–48. Memphis, TN: National Cotton Council, 2004.

Collins, J.R. "BXN Cotton: Marketing Plans and Weed Control Programs Utilizing Buctril." *Proceedings of the Beltwide Cotton Conference*, P. Dugger and D.A. Richter eds., p. 201. Memphis, TN: National Cotton Council, 1996.

Cooke, F.T., Jr., W.P. Scott, S.W. Martin, and D.W. Parvin Jr. "The Economics of *Bt* Cotton in the Mississippi Delta." *Proceedings of the Beltwide Cotton Conference*, P. Dugger and D.A. Richter eds., pp. 175–77. Memphis, TN: National Cotton Council, 2001.

Fernandez-Cornejo, J., C. Klotz–Ingram, and S. Jans. "Farm-Level Effects of Adopting Herbicide-Tolerant Soybeans in the U.S.A." *Journal of Agricultural and Applied Economics* 34,1(2002):149–63.

Frisvold, G., and R. Pochat. "Impacts of Bt Cotton Adoption: What State-Level Data Can and Can't Tell Us." *Proceedings of the Beltwide Cotton Conference*, P. Dugger and D.A. Richter eds., pp. 555–57. Memphis, TN: National Cotton Council, 2004.

Hardaker, J.B., J.W. Richardson, G. Lien, and K.D. Schumann. "Stochastic Efficiency Analysis with Risk Aversion Bounds: A Simplified Approach." *The Australian Journal of Agricultural and Resource Economics* 48,2(2004):253–70.

Hurley, T.M., P.D. Mitchell, and M.E. Rice. "Risk and the Value of Bt Corn." *American Journal of Agricultural Economics* 86,2(2004):345–58.

Johnson, P.N., and J. Blackshear. "Economic Analysis of Roundup Ready Versus Conventional Cotton Varieties in the Southern High Plains of Texas." *The Texas Journal of Agriculture and Natural Resources* 17(2004):87–96.

Jost, P., D. Shurley, S. Culpepper, P. Roberts, R. Nichols, J. Reeves, and S. Anthony. "Economic Comparison of Transgenic and Nontransgenic Cotton Production Systems in Georgia." *Agronomy Journal* 100,1(2008):42–51.

Karner, M., A.L. Hutson, and J. Goodson. "Bollgard—Impact and Value to Oklahoma's Cotton Industry 1996–1999." *Proceedings of the Beltwide Cotton Conference*, P. Dugger and D.A. Richter eds., pp. 1289–93. Memphis, TN: National Cotton Council, 2000.

Laughlin, D.H., and S.R. Spurlock. *User's Guide for the Mississippi State Budget Generator Version 6.0 for Windows*. Starkville: Department of Agricultural Economics, Mississippi State University, Internet site: www.agecon.msstate.edu/laughlin/msbg.php (Accessed June 19, 2007).

McBride, W.D., and H.S. El-Osta. "Impacts of the Adoption of Genetically Engineered Crops on Farm Financial Performance." *Journal of Agricultural and Applied Economics* 34,1(2002):175–91.

Nichols, R.L., L.O. May, and F. Bourland. "Introduction to the Symposium—Transgenic Pest-Managing Cultivars: Status and Testing Issues." *Crop Science* 43(2003):1582–83.

Richardson, J.W., K. Schumann, and P. Feldman. *Simulation and Econometrics to Analyze Risk*. College Station: Department of Agricultural Economics, Texas A&M University, Internet site: www.afpc.tamu.edu/courses/643/downloads.php?dir=5 (Accessed June 19, 2007).

Sherrick, S. "Roundup Ready Cotton: Marketing Plans and Weed Control Programs using Roundup Ultra." *Proceedings of the Beltwide Cotton Conference*, P. Dugger and D.A. Richter eds., p. 201. Memphis, TN: National Cotton Council, 1996.

U.S. Department of Agriculture–Agricultural Marketing Service. *Cotton Varieties Planted—2006 Crop*. Memphis, TN: Author, September 2006.

———. *Cotton Varieties Planted–2001 Crop*. Memphis, TN: Author, 2001.