DOES YIELD AND LINT PRICE VARIABILITY AFFECT FEASIBILITY OF TRANSGENIC COTTON IN WEST TEXAS?

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Abstract

A profitability analysis of two production alternatives: 1) GMO or transgenic and 2) conventional non-GMO or brownbag cotton was conducted for dryland cotton in West Texas. Production budgets for both cultivars were constructed. From these budgets a mathematical model was created to compute net profit or loss from both alternatives that includes the sale of lint and cottonseed; government program payments; crop insurance; stochastic prices and yields; and weather anomalies. Using the model, stochastic simulation was performed on the two cultivar alternatives in order to compute net profit or loss both after direct out-of-the-pocket costs were deducted and after total specified costs including a cash rent cost for land were deducted from estimated total revenue. These net revenue values for 500 iterative production periods were graphed as four cumulative distribution functions (CDFs). From this analysis, it may be observed that location, yield differentials, and cotton lint price are all factors in determining which cultivar is the most feasible for West Texas dryland producers.

Introduction

The development of transgenic cotton cultivars gave cotton producers more risk management options for insect control and weed suppression. The insect and weed suppression characteristics of transgenic cotton provide the potential to greatly reduce a common source of production risk for all cotton producers. As production risk is reduced, yield and production costs become less variable and net returns become more predictable and estimable. Studies showing a higher probability of positive net revenues were conducted in Arkansas (Bryant et al., 2002) and Mississippi (Cooke et al., 2001). At the same time producers were learning to enjoy all the benefits of transgenic cotton, seed vendors began to change their product pricing structure in order to profit from this reduced risk. These vendors began to charge technology fees for some portion of the enhanced profit potential brought about by this new genetically customized germplasm. With the built in Bacillus thuringiensis (Bt) gene which expresses one or more endotoxins produced by the soil bacterium, cotton would now be able to defend itself from depredations from pests. Expression of the toxins suppresses feeding by armyworm species (Spodoptera spp.) and is from moderately to highly effective for control of tobacco budworm [Heliothis virescens (F.)] and cotton bollworm [Helicoverpa zea (Boddie)], respectively. However, the Bt endotoxins do not control other major insect pests of cotton, such as the boll weevil (Anthonomus grandis Boheman). In addition, weed control became much more straightforward and less expensive as Roundup® could be applied over the top of the growing cotton plants to kill weedy pests.

However, as time has passed and production costs of cotton have increased relative to cotton revenues net revenues have decreased even as technology fees have increased thus forcing producers to consider the prospect of changing their production strategy back to non-transgenic cultivars. The objective of this research is to determine if yield differentials due to the selection of technology and cotton lint price influence cultivar selection.

Methods

Production budgets for both a generic transgenic Bollguard II Roundup Ready Flex (B2RRF) cultivar and a conventional cotton cultivar, i.e. not genetically modified cotton or brown bag cotton were constructed. An interactive focus group was then formed (one for each of the two separate production areas) to modify and amend these model budgets so they represented the actual cultural practices used by dryland cotton producers in West Texas. These production areas will be known hereafter as Area 1 and Area 2.

These model budgets then became the foundation of a mathematical model which describes both the physical and economic production process for dryland cotton. Once the model was constructed the generating functions for the simulation process were defined. A 25 year data series for Texas cotton yields and prices was obtained for the years 1988 through 2012 (U.S. Department of Agriculture, 2012). After testing to determine which distribution most closely fit the data series it was determined that the best fit was obtained with a multivariate empirical distribution. Both stochastic price and yield generating functions were developed and tested against the mean and standard deviation of the data series to validate their accuracy.

It was further determined from the years of yield data studied that approximately one year out of three resulted in a weather event which reduced the normal yield by some 75% for that production period. A stochastic generating function was developed to simulate this variable that was random and uniform.

An economic model was then developed to describe the dryland cotton production process. This model computed net revenue after direct and total specified costs were deducted from gross revenue. The model considered sales of lint and cottonseed, crop insurance, program payments (direct and countercyclical payments), and deduction for cash cropland rent. The simulation engine then iterated the model through 500 production periods using the Latin Hypercube sampling.

Results

The model was based upon the following assumptions for both production alternatives:

- There is an anomalous weather event every third year.
- A weather event is accompanied by a yield loss of 75%.
- The average yield of the B2RRF cultivar was 450 lbs. of lint per acre.
- Yield differential between conventional and transgenic were selected to be 10 pounds of lint in Area 1 and 0, 25, 50, and 75 pounds of lint in Area 2.
- If market price falls below the 52¢ per lb. loan price then a lint price of 52¢ will be used.
- The APH and FSA yield used to compute both direct payment (DP) and countercyclical payment (CCP) are equal and are 375 lbs. lint per acre per year for transgenic in Area 1 and 500 lbs. of lint in Area 2.
- The Area 1 annual transgenic direct (variable) cost = $206.01 per acre, the annual fixed cost = $45.28 per acre, and the land cash rent charge = $15.00 per acre.
- The Area 1 brownbag annual direct cost = $182.45, annual fixed cost = $52.06, and the land cash rent charge = $15.00 per acre.
- The Area 2 annual transgenic direct (variable) cost = $187.50 per acre, the annual fixed cost = $43.43 per acre, and the land cash rent charge = $15.00 per acre.
- The Area 2 brownbag annual direct cost = $161.54, annual fixed cost = $47.37, and the land cash rent charge = $15.00 per acre.
- The B2RRF and brownbag production budgets apply equally well to every producer in the Glasscock, Reagan, Upton, and Martin County area in West Texas.
- The program payments for cotton are the same each production period, direct payment = $14.67 per acre and the countercyclical payment = $27.67 per acre.
- There were 500 simulated total production periods.

The simulation used a Latin Hypercube rather than a Monte Carlo procedure to sample the probability distributions. The number of iterations a model must simulate can be greatly reduced if the simulations are executed with Latin Hypercube (Inman, Davenport, and Zeigler, 1980). The Monte Carlo procedure randomly selects values from the probability distributions. As a result the procedure samples a greater percent of the random values from the area about the mean and under samples the area under the tails. This technique segments the distribution into N intervals and makes sure that at least one value is randomly selected from each interval. By sampling from each of these N intervals the Latin Hypercube insures that all areas of the probability are considered in the simulation. The Simetar© Simulation Add-in for Excel was used as the simulation engine and for extended statistical functions in this study.

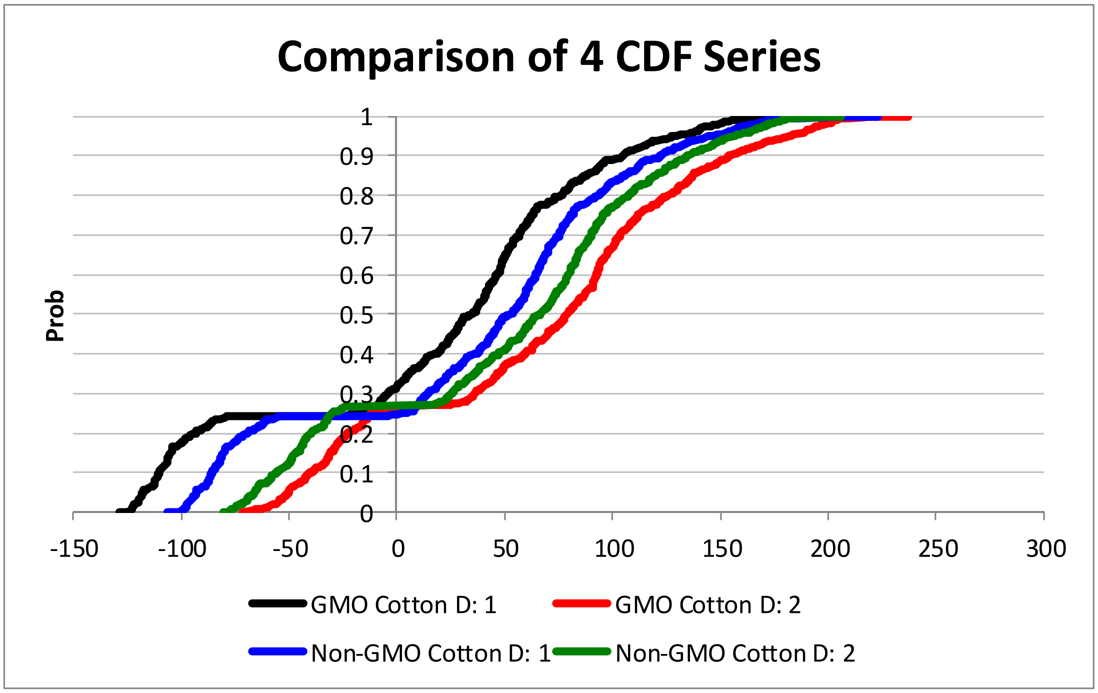

Figure 1. Net Returns after Direct Costs.

Net profit and loss were calculated for each production period with revenue provided from the sale of lint and cottonseed, crop insurance, program payments (direct and countercyclical payments). All profits and losses for the short-term outcome where only direct costs were covered in the B2RRF and brownbag regimes were graphed (Figure 1). Then results were computed for all four yield differentials and the results for that analysis is shown in Table 1. Then the long-term outcome data where total specified costs and land costs were covered was graphed for the B2RRF and brownbag data (Figure 2). These graphs are shown versus their associated probabilities of financial loss.

Table 1. Comparison Of Net Returns After Direct Costs For All Four Yield Differentials.

Conventional-Transgenic Yield Differential	Area	Results
75	Area 1 Area 2	Conventional > Transgenic Transgenic > Conventional
50	Area 1 Area 2	Conventional > Transgenic Transgenic > Conventional
25	Area 1 Area 2	Conventional > Transgenic Transgenic > Conventional
0	Area 1 Area 2	Conventional > Transgenic Transgenic > Conventional

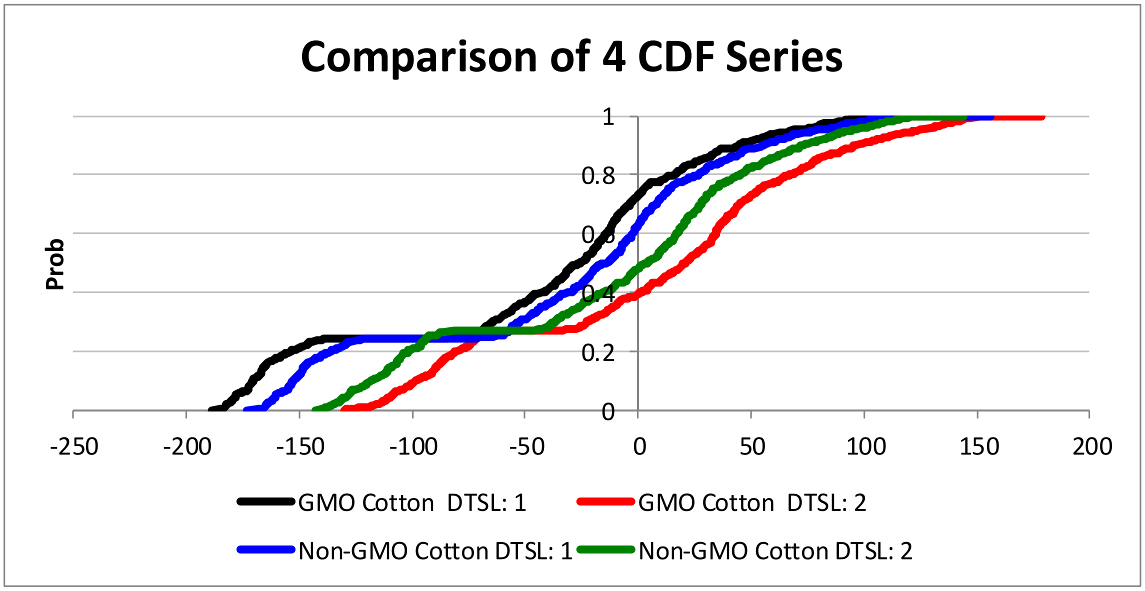

Figure 2. Net Returns After Total Specified Costs and Land Rent.

The data series that appears to the right of its mate is the preferred (more profitable) alternative. For example, look at the short-term outcome pair B2RRF direct (black line) and brownbag direct (blue line) in Figure 1. The blue line lays to the right of the black line, so the brownbag alternative is preferred over the B2RRF alternative in Area 1. Stochastic dominance analysis for the two production alternative scenarios showed that in the short term in Area 1, the brownbag alternative was the dominant solution under both first and second degree stochastic dominance. In Area 2 the red line lies to the right of the green line so the transgenic alternative was stochastically dominant over the conventional alternative. However, our producer can't farm long if only direct costs are covered, so in the long-term—total specified (direct and fixed) and land costs must be covered—the brownbag total cost (blue line) lays to the right of the B2RRF total cost (black line) in Area 1 (Figure 2), brownbag is preferred to B2RRF and in Area 2, the B2RRF total cost line (red) lays to the right of the brownbag total cost line (green), B2RRF alternative is preferred over the brownbag alternative.

Table 2 shows the results if the lint price were allowed to change. In Area 1, conventional production is preferred over transgenic production at every lint price greater than 52¢. In Area 2, the conventional cultivar is preferred over the transgenic at every lint price.

Table 2. Dominance Rankings With Respect To Changing Lint Prices For Risk Averse Producer.

Area 1	Area 2
Conv $1.50 > Transgenic $1.50	Conv $1.50 > Transgenic $1.50
Conv $1.25 > Transgenic $1.25	Conv $1.25 > Transgenic $1.25
Conv 90¢ > Transgenic 90¢	Conv 90¢ > Transgenic 90¢
Conv 75¢ > Transgenic 75¢	Conv 75¢ > Transgenic 75¢
Transgenic 52¢ > Conv 52¢	Conv 52¢ > Transgenic 52¢

Conclusions

Using stochastic simulation to model scenarios of the two production alternatives of the cotton cultivars B2RRF (GMO) and brownbag (non-GMO) using both stochastic dominance analysis and confidence premiums between the probability distributions show the brownbag alternative is preferred most often. In other words, cotton production using conventional or brownbag cultivars is more likely to be the preferred alternative than using the transgenic cultivar. Similarly, the value of technology adoption which results in any yield increase will obviously be influenced by the price of cotton. This simulation used historical price data which might underestimate the current benefits that result in the current environment of relatively high cotton prices.

Acknowledgment

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