AgBioForum, 5(1): 10-13. ©2002 AgBioForum.

Efficiency of Alternative Technologies and Cultural Practices for Cotton in Georgia

Clayton W. Ward
County Extension Agent, University of Georgia

Archie Flanders
Post-Doctoral Associate, Department of Agricultural and Applied Economics, University of Georgia

Olga Isengildina
Visiting Scholar, University of Illinois at Champaign-Urbana

Fred C. White
D.W. Brooks Distinguished Professor, Department of Agricultural and Applied Economics, University of Georgia

Transgenic cotton varieties and conservation tillage practices are evaluated for technical and allocative efficiency, as well as net returns above variable costs. Data Envelopment Analysis is applied to a survey of Georgia cotton producers. Results support production with transgenic cotton varieties having greater net returns and efficiency rankings than conventional cotton. Net returns and efficiency rankings are greatest with conservation tillage. Conservation tillage benefits are associated with cotton varieties having herbicide resistant technology.

Key words: cotton production, transgenic, genetically modified, Data Envelopment Analysis, efficiency.

Introduction

Developments in production practices and technological advances in seed genetics have given cotton farmers new options to consider in maximizing profits. Besides conventional cotton, farmers have available genetically modified cotton varieties, such as Bt, Roundup Ready (RR), Buctril Resistant (BXN), and stacked gene (BtRR). Transgenic varieties have a built-in resistance to certain pests (Bt cotton is toxic to the cotton bollworm and tobacco budworm) or tolerance to herbicides (Roundup Ready and Buctril Resistant cotton). These varieties allow substitution of current inputs by alternative inputs that are complementary to transgenic seeds. Alternative cultural practices available to farmers are conventional tillage and conservation tillage (strip-till, no-till, or reduced tillage). With the rapid expansion of available technology, it is difficult for farmers to evaluate combinations of inputs in order to maximize profits.

Impact assessments are available for benefits of adopting genetically modified (GM) crops. Fernandez-Cornejo and McBride (2002) apply survey data from US farmers over a two-year period. Production of GM cotton, corn, and soybeans have a consistently positive impact on yields, but only 50% of the reported results have a positive impact for net returns. The level of infestation and the seed premium paid by the farmer determine increased profitability of insect resistant crops. Use of GM crops is correlated with reduced aggregate use of pesticides. Although farmers having previously adopted conservation tillage practices tend to select herbicide tolerant crops, available data does not support herbicide tolerant crops leading to increased adoption of conservation tillage.

Farmers make simultaneous decisions about multiple pest control solutions that are interdependent (Kalaitzandonakes & Suntornpithug, 2001). A survey of cotton producers attempts to determine the reasons that farmers adopt GM cotton varieties. Adoption of GM cotton is primarily due to effective control of pests. This is related to the yield enhancement result of Fernandez-Cornejo and McBride (2002). Other factors for adoption are cost savings and reduction of production risks. Synergies between herbicide resistance and conservation tillage practices are quantified. In this study, adoption of varieties with RR technology leads to adoption of conservation tillage practices.

Other research examines different aspects of growing genetically modified cotton varieties. Wier, Mullins, and Mills (1998) conduct economic analysis of Bollgard (Bt) cotton relative to conventional cotton varieties in Mississippi and conclude that Bollgard is superior to conventional cotton. However, Bachelor, Mott, and Morrison (1998) do not find significant economic benefits of growing Bt cotton in North Carolina and recommend it only for difficult-to-treat fields and environmentally sensitive areas. Limited information exists on comparing costs and benefits across genetically modified varieties. Therefore, there is a need for a more general and conclusive study of economic impacts of growing genetically modified cotton varieties.

An aspect that needs further investigation is the effect of combining different technologies with alternative tillage practices. Bell, Harris, and Wilson (1998) evaluate the implications of conservation tillage (strip tillage in particular) on fertilizer effectiveness for conventional cotton. It has been posited that Roundup Ready technology may enhance the benefits of conservation tillage. Therefore, the objective of this study is to provide an economic analysis of efficiency and profit enhancement from using different cultural practices and technologies for upland cotton in south Georgia.

Data and Procedures

This study is based on the results of a survey of cotton producers in south Georgia. A telephone survey of cotton producers utilizing various combinations of tillage and transgenic technology was conducted in the Fall of 1999. The survey elicited data on production practices, inputs and costs, and yields on a field level. The following types of cotton are compared for conventional tillage and strip tillage: conventional, RR, Bt, BtRR, and Buctril Resistant. The data includes three observations of each of the five types of cotton and two tillage methods. Because only one observation for Buctril Resistant cotton with strip tillage was available, data for this study includes 28 observations.

Farrell (1957) defines technical efficiency as the ability of a firm or industry to produce output from a given set of inputs. Price (allocative) efficiency is the extent to which a firm uses the inputs in the best proportions, given their prices. A linear programming model, specifically data envelopment analysis (DEA), is used to compare output and inputs associated with various combinations of tillage practice and technology. The DEA model forms weighted combinations of inputs for each field in the data set (Thompson & Thore, 1992). The DEA then calculates a composite that represents the most efficient level of each input used relative to its output. Weighted vectors for individual fields are compared to the composite weighted vector of inputs. Each field in the model is ranked in comparison to the fully efficient composite. A field that is considered at least as efficient as the composite receives a rank of 1.0 and is said to be fully efficient. Fields with efficiency rating less than 1.0 are considered less efficient, because their use of inputs could be proportionally reduced by the difference between 1.0 and their efficiency ranking without a reduction in output. Graphically, efficiency is measured from a zero point of origin to an observed production point. These radial measures hold relative proportions of inputs constant. Thus, the efficiency measures are units invariant. Output for the model is production per acre, while inputs for technical efficiency are levels of seed, fertilizer, chemicals, labor, irrigation, and equipment usage. Allocative efficiency measures include respective prices for each input variable. DEAP software is used to analyze the model data.

Results

The summary of allocative efficiency is presented in Table 1. Forty-six percent of fields in the study are ranked fully efficient. The combination of efficient fields consists of 70% strip tillage and 30% conventional tillage. All but one of the 13 efficient fields use transgenic varieties. These results demonstrate that fields utilizing genetically modified cotton varieties and conservation tillage practices dominate the set of efficient fields.

Eighty-three percent of Bt fields (5 of 6) are efficient. All RR fields with strip tillage are in the set of efficient fields, while none of the RR fields with conventional tillage are included. Of the three BtRR fields that are efficient, two are with strip tillage. Consequently, the results show increased efficiency for Roundup Ready technology with conservation tillage, rather than with conventional tillage.

Table 2 shows the average returns of fields utilizing identical combinations of technology and tillage method, ranked by average allocative efficiency. This table indicates that fields with Bt and Roundup Ready technology are more efficient than other fields. The exception is RR with conventional tillage, and this is further evidence that Roundup Ready technology is more efficiently used with strip tillage. Efficiency rankings for Bt and RR show rankings with strip tillage higher than with conventional tillage, while for BtRR the conventional tillage and strip tillage efficiency rankings are nearly identical. In financial terms, each of these three transgenic varieties has greater returns with strip tillage than with conventional tillage. The greatest returns above variable costs are available from the combination of BtRR and strip tillage. Table 2 shows that the selections with the four greatest returns are also in the group with the four highest allocative efficiency rankings. Allocative efficiency ratings (not shown in Table 2), calculated by seed technology and tillage method, support the dominance of transgenics and strip tillage. Measures for seed technology are: Conventional (0.76), Bt (0.95), BtRR (0.91), RR (0.82), and BXN (0.77). Fields with strip tillage have an efficiency rating of 0.90, compared to 0.80 for fields in conventional tillage. Technical efficiency ratings in Table 2 are measures of input usage without regard to price and indicate relative efficiency of physical inputs. Similar to allocative efficiency, the general result is that adoption of transgenic cotton varieties and conservation tillage has potential for increasing technical efficiency as well as financial returns.

Table 1. Sample fields on the efficient frontier. Yield, revenue, variable costs, and returns above variable costs, per acre, by seed technology and tillage method.

Technology	Tillage	Yield (lbs/acre)	Revenue @ 0.65 $/lb ($/acre)	Variable Costs	Returns above Variable Costs ($/acre)
BtRR	strip	950	617.50	160.37	457.13
conv	strip	850	552.50	174.94	377.56
RR	strip	1100	715.00	192.98	522.02
BXN	conv	834	542.10	173.43	368.67
BtRR	strip	1185	770.25	224.00	546.25
RR	strip	975	633.75	186.52	447.23
Bt	strip	1290	838.50	251.33	587.17
Bt	strip	985	640.25	236.86	403.39
Bt	strip	856	556.40	198.16	358.24
BtRR	conv	1100	715.00	281.92	433.08
RR	strip	662	430.30	155.89	274.41
Bt	conv	656	426.40	202.63	223.77
Bt	conv	786	510.90	240.91	269.99
Averages		941	611.45	206.15	405.30

Table 2. Yield, revenue, variable costs (VC), returns above VC per acre, and technical efficiency, across combinations of technology and tillage method, ranked by allocative efficiency.

Technology	Tillage	Yield (lbs/acre)	Revenue @ 0.65 $/lb ($/acre)	Variable costs ($/acre)	Returns above VC ($/acre)	Technical Efficiency	Allocative Efficiency
Bt	strip	1044	678.38	228.78	449.60	0.95	1.00
RR	strip	912	593.02	178.46	414.56	0.86	1.00
BtRR	conv	1068	694.42	265.07	429.35	0.88	0.91
BtRR	strip	1043	677.73	223.78	453.95	0.85	0.90
Bt	conv	754	490.10	224.22	265.88	0.79	0.90
BXN	conv	951	618.37	249.07	369.29	0.71	0.83
conv	strip	731	474.93	206.81	268.12	0.56	0.82
conv	conv	954	620.10	292.79	327.31	0.63	0.71
RR	conv	922	599.30	305.09	294.21	0.54	0.64
BXN	strip	820	533.00	317.81	215.19	0.38	0.59

Conclusion

Data envelopment analysis demonstrates that fields utilizing genetically modified cotton varieties dominate the set of allocatively efficient fields. The number of strip tillage fields substantially surpasses conventional tillage fields, among all fields ranked as efficient. Production methods with transgenic varieties have greater efficiency rankings and financial returns than with conventional cotton. Roundup Ready technology is better utilized with conservation tillage than with conventional tillage.

The results of this analysis may help cotton farmers decide what combinations of tillage and technology to use in their production process. The study is based on data from south Georgia for the 1999 crop year. This study does not take into account the effects of different weather conditions and differences in the soil types. Therefore, a more general study considering these factors may be more exact for determining technology and tillage combinations.

References

Bachelor, J.S., Mott, D.W., and Morrison, D.E. (1998). Large scale evaluation of Bollgard resistance to multiple pests in North Carolina under grower conditions. *Proceedings of the Beltwide Cotton Conferences*, *2*, 961-964. Memphis, TN: National Cotton Council of America.

Bell, D., Harris, G., and Wilson, G. (1998). The effect of banding vs. broadcast N-P-K fertilizer at planting on yield of coastal plains cotton. *Proceedings of the Beltwide Cotton Conferences*, *1*, 613-614. Memphis, TN: National Cotton Council of America.

Coelli, T., Prasada Rao, D.S., and Battese, G.E. (1998). *An introduction to efficiency and productivity analysis*. Boston, MA: Kluwer Academic Publishers.

Farrell, M.J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society*, *series A, 120*, 254-261.

Fernandez-Cornejo, J. and McBride, W.D. (2002). *Adoption of bioengineered crops* (Agricultural Economic Report No. 810). Washington, DC: United States Department of Agriculture Economic Research Service.

Kalaitzandonakes, N.G. and Suntornpithug, P. (2001). Why do farmers adopt biotech cotton? *Proceedings of the Beltwide Cotton Conferences*, *1*, 179-183. Memphis, TN: National Cotton Council of America.

Thompson, G.L., and Thore, S. (1992). *Computational economics: Economic modeling with optimization software*. San Francisco, CA: The Scientific Press.

Wier, A.T., Mullins, J.W., and Mills, J.M. (1998). Bollgard cotton update and economic comparisons including new varieties. *Proceedings of the Beltwide Cotton Conferences*, *2*, 1039-1040. Memphis, TN: National Cotton Council of America.