An Evaluation of the Organic Cotton Marketing Opportunity

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The prospects and demand for organic farming products are on the rise as consumers become more ecologically concerned and health conscious. This is apparent in the steady growth of the organic food market in the U.S. with sales growing at an annual rate of 20.9% in 2006, and the non-food sector closely tracking this trend (Organic Trade Association, 2007). Moreover, a Manufacturer Survey conducted by the Organic Trade Association (OTA) in 2003 showed that the overall US sales growth from organic fiber products are starting to outpace sales growth of organic food. OTA (2004) recorded nearly 23% growth in sales to reach $85 million annually. Such expansion in the organic fiber market is backed by a 35% annual average estimated growth rate in the global retail sales of organic products (Organic Exchange, 2006).

U.S. cotton farmers, particularly those located in the Texas High Plains (THP), have responded by planting more organic cotton, and expanding the amount of land undergoing conversion from conventional farming to organic. In 2001, THP comprised about 73% of the total U.S. certified and transitional cotton fiber acreage (Guerena and Sullivan, 2003), and consistently leads organic cotton production (OTA 2004, 2006). In addition, the organic cotton fiber has established an important market niche for which Texas has developed its capability through state developed certification standards and an organic cotton marketing cooperative.

For cotton to be labeled and sold as organic, it must be certified by an independent organization subject to a set of organic production standards. Elimination of synthetically compounded chemicals such as fertilizers, pesticides, defoliants and other chemical inputs is required under these standards. However, application and certification initially requires substantial costs and time. Cotton growers who decide to convert to organic methods must undergo a three-year transition from conventional production practices before their farms are certified as organic (Hanson et al., 2004).

In spite of the many ecological advantages and farmer health benefits that come from farming organically (Lampkin and Padel 1994; PAN UK 2005; Myers and Stolton 1999), profit is still considered as the best incentive for most farmers to engage in a particular faming system. However, knowledge about profitability of organic cotton enterprise particularly in the U.S. is limited. This limitation is understandable since it is a fairly new area of activity (approximately eighteen years). Although aggregate organic cotton acreage and production data is available from OTA, Organic Exchange, and USDA (figures 1 and 2), pertinent farm-level information specific to organic cotton is warranted.

Given the dominant role played by the Texas High Plains in the US organic cotton industry and the limited literature on the actual performance of the enterprise, it would be useful to assess the profitability of organic production through costs and returns analysis of both organically-produced and conventional cotton. Efforts to provide a basis for any improvement in this segment of U.S. agriculture is also extended to measure the technical efficiency of cotton farmers. Measuring the degree of organic cotton growers' success in attaining maximum output given the resources available to them is explored to prop up the economic competitiveness, or otherwise, of adopting organic techniques. Tzuovelekas, Pantzios, and Fotopoulos (1997) has noted that determining farm efficiency would also allow for determining farm potentials for raising productivity and improving resource use. Hence, profitability and efficiency measurements allow us to evaluate the viability of organic method of producing cotton as an alternative system.

This article aims to produce a comprehensive analysis of the potential economic costs, and returns of organic cotton production in Texas High Plains; to estimate the technical efficiency of the sample organic and conventional cotton farms in Texas High Plains; and, to identify the factors contributing to farm efficiency.

The availability of this information will support better informed decisions by current producers and users of this organic fiber. Furthermore, understanding of the production and marketing aspects of the organic cotton industry, particularly the cost structures, also allow non-organic producers and consumers to more clearly see the potentials of growing and consuming organic cotton.

Data and Descriptive Statistics

Survey questionnaires were mailed-in to certified organic cotton farmer-members of the Texas Organic Cotton Marketing Cooperative (TOCMC) in August 2008[1]. Given the relatively small number of TOCMC members, whom are believe to comprise majority of the organic cotton growers in the THP, a complete enumeration was employed. The survey obtained primary data that includes input costs, volume of production, and market prices received by the producers during cotton crop year 2007. The questionnaire is designed to elicit separate information from the producers' irrigated and dryland cotton farms. It is noteworthy however, that secondary data on custom rates are also utilized[2].

Among the twenty-one questionnaires that were targeted, only eleven were completely filled-out and returned by the organic farmers. These producers are responsible for the production of 11,752 (79%) of the 14,878 organic and transitional bales produced by cooperative members who grew organic cotton in 2007 (Pepper, Ph. Interview, 2008).

A group consisting of twenty-one non-organic control producers also situated in Texas High Plains was randomly selected from a list of cotton farmers provided by the Texas Agri-Life Research Station–Lubbock. This allowed the profitability and technical comparison of the organic and conventional cotton farming systems. Most of survey questionnaires returned are properly filled out except for two conventional cotton producers who did not plant cotton in the period under study. This reduced the usable conventional questionnaires into seven.

Socio-Demographic Profile of Sample Farmers

All but one conventional farmer utilized both irrigated and dryland acreage to produce cotton in crop year 2007, while less than half of the organic sample devoted both their irrigated and dryland portions to organic cotton. The rest have chosen to produce cotton under one ecosystem only. Irrigated farms that produced cotton have average size that range from 348 to 438 acres across farming systems, while farms under dryland conditions were planted to an average of 508 to 627 acres (table 1). An important caveat if that combining the data collected on irrigated and dryland farm sizes does not depict the aggregate agricultural landholding per farmer[3].

On average, sample organic farmers have 10 years of experience under organic farming method. Prior to engaging in organic practices, these farmers have been growing cotton using non-organic methods with a mean of 23 years while conventional farmer sample has started a bit earlier with 26 years mean cotton farming experience. Farmer's mean ages across cotton farming methods ranged from 47 to 52 years. In addition, majority of the organic producers have attained a Bachelor's Degree (64%), about 27% have reached some college, and 9% got a high school diploma. Likewise, much of the conventional cotton growers acquired a Bachelor's Degree (43%), leaving the rest equally divided into those who have attended college (29%) and had a Graduate Degree (29%).

Measuring Organic and Conventional Cotton Costs and Returns

The production costs and yield (pounds) of organic and conventional composite farms used in the analysis are directly supplied by the sample farmers on a per acre basis[4]. To account for the effects of ecosystems, the data used in the enterprise budgets are organized into four groups: (1) Organic-Irrigated; (2) Organic-Dryland; (3) Conventional-Irrigated; and (4) Conventional-Dryland.

Costs incurred by organic and conventional producers are divided into two categories, total direct expenses and total fixed expenses. Total direct expenses include seeds, fertilizers, herbicides, insecticides, other chemicals (which may include fungicide, etc.), harvest aid (chemical defoliants), Crop Consulting Service fee, crop insurance, energy costs (consummated by irrigation), Organic Certification Fee, interest on capital, labor, and repair and maintenance. The last two mentioned components are further subdivided into several activities that are most common in cotton (organic and non-organic) production. Labor is the aggregate custom rate per acre of performing different labor farm operations. Repair and maintenance is the sum of costs per acre of implements, tractors, pick-up, and center pivot[5]. The total specified expenses are computed by combining the total direct expenses and total fixed expenses, and correspond to total farm costs per acre.

Gross value of cotton produced is the quantity of harvested organic or conventional cotton per acre multiplied by the market price (US$) per pound received by the cotton farmer. Returns above direct expenses are computed as gross value less total direct expenses, while returns above total specified expenses is the difference between gross value and total specified expenses. The latter is equivalent to the cotton farms' net profit per acre.

Survey Results

The budgets developed in this article serve as an initial step in analyzing the competitiveness of the organic cotton enterprise. Table 2 summarizes this information, and tables 3 and 4 supplement such information by providing the result of test of means of costs and returns of organic and conventional cotton operations, under irrigated and dryland ecosystems.

Revenue

On average, sample organic farmers produced 976 lbs/acre cotton from irrigated acres, a significantly lower volume than 1395 lbs/acre cotton harvested by conventional producers under the same ecosystem. Organic cotton produced from dryland farms is about 649 lbs/acre, while 772lbs/acre are obtained by conventional producers. Dryland cotton farm yields, on average, are not significantly different across farming systems. This implies a 30% and 16% lower average cotton yield for irrigated and dryland organic farmers, respectively. Further inspection of table 2 reveals higher actual market prices received for organic cotton ($1.27/lb and $1.15) compared with conventional cotton prices ($0.64/lb and $0.63/lb) during crop year 2007.

The gross value earned by organic farmers from cotton harvested in irrigated and dryland acreage in 2007 are $1237/acre and $743/acre, respectively. Conventional cotton farmers have made $895/acre and $489/acre from irrigated and dryland portions. Evidently, the average revenue earned by conventional farmers in 2007 is reduced by the lower prices received from their cotton whereas the average price premium received by organic producers ($0.63/lb and $0.51/lb) allowed them to obtain significantly higher gross returns.

Patterns and Costs of Input Use

The organic method of producing cotton is based on a system of farming that protects the long-term fertility of soils without the use of toxic and persistent pesticides and fertilizers (Lampkin and Padel, 1994). This is indicative of the principles and practices that can be expected in producing and handling the fiber.

Seeds

Sample organic farmers incurred considerably lower seed costs per acre in irrigated (about 85% lower) and dryland cotton farms (about 82% lower). Under the USDA National Organic Standards, organic producers are only allowed to use cotton varieties that are not genetically-modified/enhanced, or more commonly referred to as Non-GMs. Consequently, the use of "Roundup Ready" and similar varieties that are popular to West Texas conventional cotton producers are not permitted under organic practices. This GM cotton known to be herbicide tolerant and relatively pricey given that: (a) technology fees are included in the price and (b) farmers are required to buy new seeds every planting season contrary to customary seed saving practices (Myers, 2001). However, proponents of this type of seeds claim that producers could save on herbicides and labor costs incurred in controlling weeds, and expect higher yield.

Non-GM seeds, sourced from the Texas Organic Cotton Marketing Cooperative (TOCMC) or from independent seed companies, allowed for lower average seed costs per acre under organic method of farming despite higher seeding rate. As indicated in the data provided by the surveyed farms, organic farming demands for higher amount of seeds per acre than conventional counterparts. A mean of 18lbs/acre and 14lbs/acre seeds are sown in irrigated and dryland organic grounds, respectively, while conventional farmers placed 11lbs and 8lbs on irrigated and dryland grounds. In spite of this, sample organic producers spent an average of only $8/acre (irrigated) and $6/acre (dryland) on seeds relative to $51.7/acre and $34.3/acre expended by conventional producers. In addition, the fact that organic producers are allowed to catch their own seed and have it delinted for planting may have contributed to lower average seed costs.

Fertilizer

As shown in table 2, fertilizer average costs per acre in irrigated and dryland organic farms are $78/acre and $42/acre, respectively. Conventional producers on the other hand incur $65/acre mean fertilizer costs in irrigated acres, and $25/acre was expended on fertilizers applied to dryland portions. Inspection of tables 3 and 4 shows, that the means among organic and conventional cotton producers' fertilizer costs are not significantly different across production systems. However, the types of fertilizer applied under organic practices differ from what conventional farms use to maintain the proper amount of nutrients in the soil. Survey data and personal field visit relate that organic farmers abide by the USDA-National Organic Program (NOP) standards that eliminate synthetic fertilizers in organic production. Most organic farmers in the sample feed the soil with compost that is mostly from animal waste. Some use green manure, particularly rye, while one farm use concentrated liquid chicken compost[6]. With conventional practice, chemical fertilizers are commonly used to enhance soil quality. The majority of the sample conventional producers apply purely chemical fertilizers except for one, who used digested chicken manure as a supplement.

Chemical costs

The literature on organic cotton production contends that the absence of pesticides and other chemicals, such as chemical defoliants used as harvest aids, partly distinguishes the product from cotton grown conventionally. Inspection of the budgets presented by the article denotes the strict compliance of organic farmers to federal standards and principles of the farming system they have adopted. Conversely, application of synthetically compounded chemicals is paramount under the conventional approach of producing cotton. This concurs with the sample conventional producer's recorded chemical costs.

The average costs of herbicide treatment of sample irrigated cotton farms is \$24/acre, and \$14/acre in dryland farms. Such costs account for 4% and 5% of the total direct expenses of conventional irrigated and dryland cotton farms, respectively (table 5). Moreover, the average insecticide costs in irrigated (\$5/acre) and dryland acres (\$1/acre), relatively lower than herbicide costs, constitute 0.8% and 0.4% of the irrigated and dryland productions' direct expenses, respectively. It is noteworthy that the lower mean insecticide cost in dryland ecosystem is due to few conventional farmers in the sample who did not use insecticide to wring out insects in crop year 2007. The survey further reveals that other chemicals add up to the producer's direct expenses. However, such cost (\$5.9/acre) is only present in the sample farmer's irrigated farms. The harvest aid cost component, contributed 3% (\$17/acre) to the irrigated cotton production direct expenses, and 4% (\$12/acre) to dryland cotton expenditures. Overall, chemical costs constitute 8% and 9% of the total direct expenses in irrigated and dryland conventional cotton production, respectively.

Crop Insurance

Crop insurance policy in farming organic cotton is not mandatory, just like in any conventional cotton production, but the majority of sample organic farms insure their crops. Organic producers have their entire dryland cotton acreage and 94% irrigated acreage covered. Likewise, most conventional cotton producers in the sample purchase coverage as part of their risk management strategies. About 92% of the total irrigated conventional acres are insured, while one farmer-respondent cultivating a significantly large dryland area did not purchase crop insurance, pulling down the total dryland area coverage to only 36%. The means of crop insurance paid per acre by organic and conventional producers have no significant difference, but components of such costs incurred by producers from both farming systems may differ. The survey does not provide information with regard to the specific type and number of crop insurance policies held by the organic and conventional farmer-respondents. However, a personal interview with one organic famer belonging to the sample offers a general idea about such information. As related, Multi-Peril Crop Insurance (MPCI) that provides a safety net against losses from a number of uncontrollable causes is very popular among organic cotton farmers. Other farmers prefer Hail Insurance over MCPI despite its limited coverage, but some farmers have both.

Energy

Several studies comparing energy input use in organic and conventional farm systems (Shearer et al. 1981; Pimentel, 2005; Gundogmus, 2006) found less energy use in organic farming. Comparing the means of energy cost per acre under the two cotton farming systems reveal a significantly higher energy costs per acre paid out by organic producers.

Although reports from organic and conventional cotton farmers in the sample only involve energy input costs in irrigation activities, the article found results that is consistent with findings from a profitability study of organic soybean production in several states in the U.S., where McBride (2008) reported a significantly higher energy costs per acre (throughout the production process) in the organic soybean fields.

The reported mean energy costs used in irrigation by sample organic cotton farmers ($91/acre) from Texas High Plains are reasonably higher as farmers would not risk their crop's yield by minimizing use of water. Given that organic cotton market prices are found to be significantly higher than conventional cotton, organic farmers would desire to maximize the yield potentials of their cotton and thus use more water.

Organic Certification Fee

Adopting the organic technique of growing cotton requires farms to undergo a certification process that is considered costly. However, the measures and processes provided for by the Texas Department of Agriculture bring credibility to the organic fiber as it is transmitted into the market. Certification allows building consumer confidence in organic products and to sustain and stimulate growth of the industry as a whole. The strict standards set forth by the organic certifier open markets for the final product.

Labor

Total labor costs remarkably dominate the total direct expenses incurred by the organic and conventional sample farmers. The average labor costs for irrigated organic and non-organic farms are not on the average significantly different whereas dryland mean labor costs for organic farms are significantly higher than their conventional counterparts. About 62% (irrigated) and 65% (dryland) of the organic farms' total direct expenses went to labor payments. Under conventional practices, 52% and 57% were paid-out to custom operations in irrigated and non-irrigated farms, respectively. Apparently, hand hoeing (54% in irrigated, 33% in dryland) and harvesting through stripping and/or picking method (18% in irrigated and 24% in dryland) have magnified the organic producers' labor costs. On the other hand, conventional farmers have spent a lot on scouting for insects with about 25% (irrigated) and 15% (dryland) of labor costs allotted to these activities.

Repair and Maintenance

The costs of implements, tractors, pick-up, and center pivot are assumed the same under both organic and conventional farming techniques. TOCMC organic farmer-members relate through field visit and personal conversations that they did not buy additional equipments after deciding to switch to organic farming. The same assumption holds for interest on capital and fixed expenses incurred by both farming systems. Budgets show that irrigated farms has total repair and maintenance expenses of about $49/acre, while non-irrigated farms spent $26/acre.

Empirical Estimation of the Stochastic Frontier Production Model

A production frontier provides the standards against which the performance of a producer can be evaluated in respect to technical efficiency. Producers who employ the optimal combination of activity operate on their production frontier. Often however, producers do not succeed as optimizers due to unusually favorable environment that is beyond their control. Thus, it is unlikely that producers operate at their frontier and in effect, they are not able to maximize their output.

The stochastic production frontier approach to measuring technical efficiency is employed in this article considering the random variations in the sample farm operations being studied. A general stochastic production frontier model is specified by Kumbhakar and Lovell (2000) as:

$$y_i = f(x_i;\beta)\cdot \exp\{v_i\}\cdot TE_i , \qquad (1)$$

where y_i is the scalar output of farmer i, $i = 1,......,I$, x_i is a vector of N inputs used by farmer i, $f(x_i;\beta)$ is the deterministic production frontier common to all farmers, and β is a vector of technology parameters to be estimated, $TE_i = \exp\{-u_i\}$ is a one-sided non-negative error representing output-oriented technical inefficiency of farmer i. Higher values of u_i indicate greater technical inefficiency. Equation (1) decomposes the error term ε_i into two components as compared with the deterministic production frontier model, $y_i = f(x_i;\beta)\cdot \exp\{u_i\}$, that attributes the entire shortfall of observed output y_i solely to technical inefficiency. Two-sided stochastic noise error component, v_i, captures the effects of farmer-specific random events that are likely associated with unmeasured production factors. Rearranging terms,

$$TE_i = \frac{y_i}{f(x_i;\beta)\cdot \exp\{v_i\}}, \qquad (2)$$

defines technical efficiency as the ratio of the observed output to maximum feasible output in an environment characterized by $\exp\{v_i\}$. In equation (2) a farmer is technically efficient if its output level is on the frontier, which implies that $TE_i = 1$. Otherwise, $TE_i \le 1$ provides a measure of the shortfall of observed output from maximum feasible output in an environment that accommodates white noise allowed to vary across producers.

Assuming that the production frontier that takes a Cobb-Douglas functional form, the stochastic production frontier model expressed in natural logarithmic form can be specified as:

$$\ln y_i = \beta_o + \sum_n \beta_n \ln x_{ni} + v_i - u_i \,, \qquad (3)$$

where the white noise component v_i is assumed to be *iid* and symmetric. This is independently distributed with u_i .Maximum Likelihood Estimation (MLE) yields consistent estimates of the production technology parameters, β and variance parameters, $\sigma = (\sigma_u^2 + \sigma_v^2)^{1/2}$ and $\lambda = \sigma_u / \sigma_v$ [7].

According to Jondrow et al. (1982), subsequent to this a farmer-specific inefficiency term is generating by the conditional distribution $f(u \mid \varepsilon)$. As efficiency varies across producers, it is useful to determine the factors that contribute to variations. The literature provides two approaches in finding these determinants, the single and two-stage approach. However, the former which is developed by Battese and Coelli (1995) is mostly preferred in the efficiency literature. Battese and Coelli (1995) pointed out that the model specification in the second stage under the latter procedure conflicts with the assumption that u_i is independent.

Under the single-stage approach, the technical inefficiency effects are hypothesized to be a function of the explanatory variables related with farm-specific characteristics. The inefficiency term u_i is specified as:

$$u_i = \delta z_i + w_i$$

where w_i is a random variable assumed to be *iid*, defined by the truncation of the normal distribution with mean zero and variance σ^2 (such that $w_i \geq -\delta z_i$); and z_i is a vector of farm-specific inefficiency variables.

Empirical Specification

Following Battese and Coelli (1995), empirical estimation in this article is conducted using the technical inefficiency model. Estimation using the cross-sectional data set from sample organic and conventional cotton farms, already described in the previous sections, is carried out using the computer program FRONTIER 4.1. The program, developed by Coelli (1995) is used to obtain ML estimates of the parameters of stochastic production models. A Cobb-Douglas functional form is assumed given its simplicity and the small amount of data available. The model to be estimated is:

$$\ln Y_i = \beta_0 + \beta_1 \ln Materials_i + \beta_2 \ln Water_i + v_i - u_i \text{, and} \quad (4)$$

$$u_i = \delta_0 + \delta_1 Exp_i + \delta_2 Educ_i + \delta_3 Area + W_i \quad (5)$$

where Y is the total value (US Dollars) of cotton produced by the *i*th farm; Materials refer to the value of seeds, fertilizers applied, chemicals (herbicide, insecticide, chemical defoliants, and other chemicals) used during the production; Water is the combined amount of applied water and rainfall (acre-inch); Exp (years) is the number of farming experience of the cotton grower; Educ is a dummy variable that has a value of 1 if the farmer has at least went to college; and Area refers to land area (acres) devoted to cotton.

Estimation Results

Table 6 presents the result of stochastic production frontier estimation based on (4). The maximum likelihood estimate for the ratio parameter γ (1.000) denotes that farm-specific technical efficiency is of considerable importance in explaining the total variability of organic and conventional cotton produced. As regards to the maximum likelihood parameters of the explanatory variables considered in this article, both *materials* and *water* have positive coefficients as expected. In addition, these two variables are statistically significant in both models. The elasticity of output for *water* in organic and conventional farming has registered higher values relative to the elasticity of output for *materials*. This suggests that *water* as an input to cotton production has major impact under both farming systems, although the elasticity value (0.4306) in conventional farms are relatively higher than organic farming (0.3588). This comes as no surprise given that conventional farmers are able to apply more water to increase cotton yield, without risking the growth of unwanted weeds. Unlike in organic farming where use of 'round-up ready' seeds and weed control chemicals is not permitted, non-organic farms commonly use herbicide to control weeds without damaging the cotton. Conventional farms also exhibit a higher responsiveness to *materials* (0.3810) relative to organic counterparts (0.2475). Clearly, chemicals are important under non-organic techniques of farming.

Technical Efficiency and Inefficiency Effects

Interpreting technical efficiency scores of two different methods of farming always come with an important caveat, i.e. the higher scores exhibited by one farming system with respect to the other does not indicate that the former are more efficient by some degree than the latter (Tzuovelekas, Pantzios, and Fotopoulos 2001, 2002; Oude Lansink et al. 2002, 2005). The sample farms considered in this article are facing different production technologies. As these authors have always pointed out, higher technical efficiency score of one sample farmer relative to their counterpart means that, on average, the former lay closer to their specific production frontier than the sample counterpart does with their respective production frontier.

On average, the estimated technical efficiencies of sample organic and conventional cotton farms are 46 % and 78%, respectively. This reveals that in general, the sample organic and conventional farms have not been successful in maximizing the level of output attainable given their production technology. Given the estimated efficiency scores, it is still possible for organic farmers to increase their production by as much as 54% given their current technology and without using more resources than are actually available. Conventional farmers are situated relatively closer to their production frontier, but output can still be stretched to 22%. Furthermore, investigating the variation of farm efficiency scores indicates that all conventional farmers recorded efficiency rates from 50% to 100%, while only 27% of the organic farms are in the said range. Interestingly, most organic farms (67%) were found to have an efficiency level between 30% and 50%.

Table 6 also shows the coefficients of the explanatory variables in the inefficiency model (5). The sign of the coefficients in the model used to estimate inefficiency in the organic farming sample are as expected. Experience, education, and area show positive effect on efficiency. Estimated experience coefficient suggests that the longer years of growing cotton organically, the less technically efficient organic farmers are. The estimate for the coefficient of education implies that organic cotton farmers who have at least started college are less inefficient. However, these relationships are weak given that *exp* and *educ* are not significant. Evidently, *area* is positively related to organic farms' efficiency level. On the contrary, the estimated coefficient of *area* in conventional farms is positive suggesting diseconomies of scale. Education is positively related to technical efficiency in non-organic farms, although found to be insignificant. Finally, experience shows strong negative relationship with technical efficiency, which indicates that farmers who have longer experience growing cotton conventionally are less efficient.

Conclusion

This article evaluated the profitability and technical efficiency of organic cotton farming using sample data from organic and conventional cotton growers Texas High Plains. In comparative terms, analysis of costs and returns reveals significantly higher average returns above total specified expenses in organic farming relative to their conventional counterparts. Evidently, significantly lower average yields in organic irrigated and dryland farms relative to non-organic farms have been compensated by the price premium received by the organic producers, making higher profits possible. It is noteworthy however, that total labor costs appear to dominate among the other components of total direct expenses under both organic and conventional practices.

In spite of the higher profitability recorded by sample organic farms, empirical estimation reveals that, in general, organic farmers have not been successful in attaining the maximum output given the resources available to them. On average, the current efficiency level of organic cotton farms can still be stretched up to 54% with the existing technology, and without using more resources than are actually available. Conventional cotton farms are found to exhibit a relatively closer position with their respective production frontier, although increasing production by 22% is still feasible. The relatively lower technical efficiency of sample organic farms is fairly reasonable. As pointed out in the first section, organic cotton production as an alternative to U.S. conventional cotton practices is a relatively new area of activity that began in the U.S. in 1991.

The opportunities presented by developing a non-traditional production system in organic cotton in West Texas appear to be substantially more profitable than conventional cotton over the years studied. However, organic acreage is still only a very small fraction of total production acres. This profitability is in large part the result of successful group marketing efforts by the Texas Organic Cotton Marketing Cooperative that consistently achieves much higher prices for their organic cotton. The ability to maintain those premiums and overall returns to organic cotton production will be a key challenge in the current economic climate.

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Table 1. Socio-economic Characteristic of the Sample Farmers, 2007

Characteristics	Organic				Conventional			
	Min	Max	Mean	Mode	Min	Max	Mean	Mode
Farm Size (Acre)								
Irrigated Acres	60	1000	348		125	1800	438	
Dryland Acres	95	1430	508		281	5700	627	
Farmer's Farming Experience								
Cotton Farming	55	44	23		6	38	26	
Organic Farming	1	17	10		0	0	0	
Farmer's Age (Years)	24	64	47		39	66	52	
Farmer's Education								
High School				1				0
Some College				3				2
Bachelors Degree				7				3
Graduate Degree				0				2

Table 2. Estimated Costs and Returns per Acre, Organic and Conventional Cotton

	Organic		Conventional	
Items	**Irrigated**	**Dryland**	**Irrigated**	**Dryland**
Yield	976	649	1,396	772
Price	1.27	1.15	0.64	0.63
Gross value	**1,237**	**743**	**895**	**489**
cost/lb	0.88	0.7	0.5	0.5
Total Direct Expenses	**786**	**380**	**616**	**308**
Seeds	7.8	6.2	51.7	34.3
Fertilizers	77.5	41.9	64.5	25.0
Herbicides	0.0	0.0	23.7	14.2
Insecticides	0.0	0.0	4.7	1.3
Other chemicals	0.0	0.0	5.9	0.0
Harvest aid	0.0	0.0	16.8	12.3
Crop Consulting Services	3.8	0.4	0.0	0.0
Crop Insurance	25.0	14.9	11.8	9.7
Energy for irrigation	91.4	0.0	50.8	0.0
Organic Certification Fee	29.0	34.9	0.0	0.0
Labor	**482.9**	**246.7**	**318.1**	**176.8**
Stalk shredding/cutting	8.4	8.4	7.8	5.7
Chiseling	4.0	16.1	1.3	1.6
Disking	7.2	1.2	1.2	0.0
Listing	8.1	8.1	5.8	5.4
Rod weeding	7.5	8.6	3.2	2.5
Fertilizer app.	6.0	3.7	10.2	5.1
Insecticide app.	0.0	0.0	2.5	0.7
Herbicide app.	0.0	0.0	12.3	8.3
Planting	8.8	8.8	8.8	8.8
Scouting	12.8	0.6	80.0	26.7
Rotary hoeing	13.6	4.8	4.8	0.9
Sandfight	8.7	7.4	10.5	13.0
Cutivating	23.9	23.9	5.0	3.5
Hand hoeing	260.4	82.5	8.6	5.0
Harvest Aid app.	0.0	0.0	5.9	2.8
Other activities	1.3	0.0	3.6	4.2
Harvesting-Strip/Pick	87.9	57.9	117.3	65.7
Ginning	24.5	14.7	29.3	17.0
Repair and Maintenance	**48.9**	**26.4**	**48.9**	**26.4**
Implements	12.5	13.8	12.5	13.8
Tractors	11.8	12.4	11.8	12.4
Pick-up	0.3	0.2	0.3	0.2
Center Pivot	24.4	0.0	24.4	0.0
Interest on Op. Capital	19.6	8.7	19.6	8.7
Returns Above Direct Expenses	**451**	**363**	**279**	**180**
Fixed Expenses				
Implements	22.4	24.4	22.4	24.4
Tractors	19.9	20.9	19.9	20.9
Pick-up	0.5	0.3	0.5	0.3

Center Pivot	33.6	0.0	33.6	0.0
Total Fixed Expenses	**76**	**46**	**76**	**46**
Total Specified Expenses	**862**	**426**	**693**	**354**
Returns Above Total Specified Expenses	**374**	**318**	**203**	**135**

Table 3. Comparison of Means on Production Costs and Returns of Irrigated Organic and Conventional Cotton Operations, 2007

Items	Organic	Conventional	Pr > |t|[a]	Pr > |t|[b]
	Irrigated		Pooled	Satterthwaite
	(N=8)	(N=7)		
Yield	976	1,396	0.0061***	0.0095***
Price	1.27	0.64	<.0001***	<.0001***
Gross Value	**1,237**	**895**	**0.0089*****	**0.0080*****
cost/lb	0.88	0.5	0.0004***	0.0005***
Total Direct Expenses	**786**	**616**	**0.2625**	**0.3034**
Seeds	7.8	51.7	<.0001***	<.0001***
Fertilizers	77.5	64.5	0.4431	0.4653
Herbicides	0.0	23.7	0.0002***	0.0028***
Insecticides	0.0	4.7	0.0315*	0.0662*
Harvest aid	0.0	16.8	0.0009***	0.0075***
Other chemicals	0.0	5.9	0.0192**	0.0475**
Crop Insurance	25.0	11.8	0.2009	0.1895
Crop Consulting Services	3.8	0.0	0.3688	0.3506
Energy for irrigation	91.4	50.8	0.0156**	0.0142**
Organic Certification Fee	29.0	0.0	<.0001***	0.0004***
Labor	**482.9**	**318.1**	**0.1697**	**0.2131**
Stalk shredding/cutting	8.4	7.8	0.5349	0.5748
Chiseling	4.0	1.3	0.2364	0.2284
Disking	7.2	1.2	0.0228**	0.0209**
Listing	8.1	5.8	0.1197	0.1723
Rod weeding	7.5	3.2	0.0594*	0.0598*
Fertilizer application	6.0	10.2	0.1044	0.1460
Insecticide application	0.0	2.5	0.0006***	0.0056***
Herbicide application	0.0	12.3	0.0594*	0.1030*
Planting	8.8	8.8	.	.
Scouting	12.8	80.0	0.1331	0.1789
Rotary hoeing	13.6	4.8	0.0613*	0.0793*
Sandfight	8.7	10.5	0.9527	0.9519
Cutivating	23.9	5.0	<.0001***	<.0001***
Hand hoeing	260.4	8.6	<.0001***	<.0001***
Harvest Aid application	0.0	5.9	0.0011***	0.0082***
Other activities	1.3	3.6	0.5407	0.5686
Harvesting - Strip/Pick	87.9	117.3	0.0710*	0.0924*
Ginning	24.5	29.3	0.3056	0.3082
Repair and Maintenance	**48.9**	**48.9**	.	.
Implements	12.5	12.5	.	.
Tractors	11.8	11.8	.	.
Pick-up	0.3	0.3	.	.
Center Pivot	24.4	24.4	.	.
Interest on Op. Capital	**19.6**	**19.6**	.	.
Returns Above Direct Expenses	**451**	**279**	**0.0428****	**0.0396****
Fixed Expenses				
Implements	22.4	22.4	.	.
Tractors	19.9	19.9	.	.
Pick-up	0.5	0.5	.	.
Center Pivot	33.6	33.6	.	.
Total Fixed Expenses	**76**	**76**	.	.
Total Specified Expenses	**862**	**693**	**0.2625**	**0.3034**
Returns Above Total Specified Expenses	**374**	**203**	**0.0428****	**0.0396****

[a-b]*significant at 10% level; **significant at 5% level; ***significant at the 1%level

Table 4. Comparison of Means on Production Costs and Returns of Dryland Organic and Conventional Cotton Operations, 2007

Items	Organic Dryland (N=7)	Conventional Dryland (N=6)	Pr > |t|[a] Pooled	Pr > |t|[b] Satterthwaite
Yield	649	772	0.3554	0.3888
Price	1.15	0.63	<.0001***	<.0001***
Gross Value	**743**	**489**	**0.0504***	**0.0460***
cost/lb	0.7	0.5	0.0354**	0.0318**
Total Direct Expenses	**380**	**308**	**0.1550**	**0.1641**
Seeds	6.2	34.3	<.0001***	0.0003***
Fertilizers	41.9	25.0	0.4471	0.4350
Herbicides	0.0	14.2	0.0010***	0.0094***
Insecticides	0.0	1.3	0.2997	0.3632
Harvest aid	0.0	12.3	0.0067***	0.0281***
Other chemicals	0.0	0.0	.	.
Crop Insurance	14.9	9.7	0.1854	0.1784
Crop Consulting Services	0.4	0.0	0.3774	0.3559
Energy for irrigation	0.0	0.0	.	.
Organic Certification Fee	34.9	0.0	<.0001***	<.0001***
Labor	**246.7**	**176.8**	**0.0348****	**0.0500****
Stalk shredding/cutting	8.4	5.7	0.0258**	0.0643**
Chiseling	16.1	1.6	0.0326**	0.0340**
Disking	1.2	0.0	0.3774	0.3559
Listing	8.1	5.4	0.1132	0.1747
Rod weeding	8.6	2.5	0.0380**	0.0347**
Fertilizer application	3.7	5.1	0.5754	0.5809
Insecticide application	0.0	0.7	0.0068***	0.0284***
Herbicide application	0.0	8.3	0.2997	0.3632
Planting	8.8	8.8	.	.
Scouting	0.6	26.7	0.1053	0.1656
Rotary hoeing	4.8	0.9	0.1124	0.1030
Sandfight	7.4	13.0	0.1854	0.1946
Cutivating	23.9	3.5	<.0001***	<.0001***
Hand hoeing	82.5	5.0	0.0002***	0.0003***
Harvest Aid application	0.0	2.8	0.0522*	0.1019*
Other activities	0.0	4.2	0.2997	0.3632
Harvesting - Strip/Pick	57.9	65.7	0.5535	0.5856
Ginning	14.7	17.0	0.4188	0.4413
Repair and Maintenance	**26.4**	**26.4**	.	.
Implements	13.8	13.8	.	.
Tractors	12.4	12.4	.	.
Pick-up	0.2	0.2	.	.
Center Pivot	0.0	0.0	.	.
Interest on Op. Capital	8.7	8.7	.	.
Returns Above Direct Expenses	**363**	**180**	**0.0703***	**0.0640***
Fixed Expenses				
Implements	24.4	24.4	.	.
Tractors	20.9	20.9	.	.
Pick-up	0.3	0.3	.	.
Center Pivot	0.0	0.0	.	.
Total Fixed Expenses	**46**	**46**	**.**	**.**
Total Specified Expenses	**426**	**354**	**0.1550**	**0.1641**
Returns Above Total Specified Expenses	**318**	**135**	**0.0703***	**0.0640***

[a-b]*significant at 10% level; **significant at 5% level; ***significant at the 1%level

Table 5. Input Costs Share to Total Direct Expenses in Organic and Conventional Cotton Operations, 2007

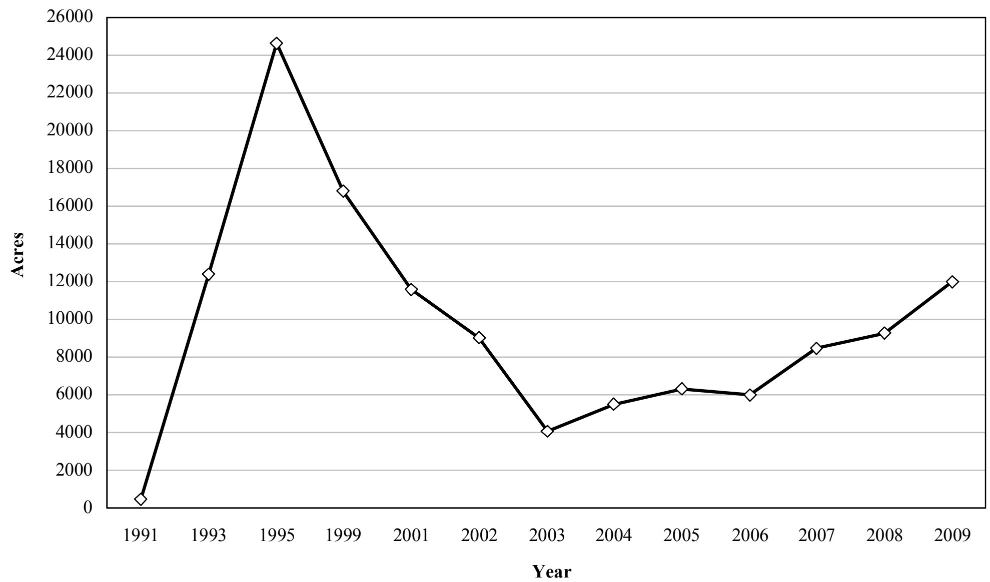
Items	Organic		Conventional	
	Irrigated	Dryland	Irrigated	Dryland
Total Direct Expenses	**786**	**380**	**616**	**308**
Seeds	**1.0%**	**1.6%**	**8.4%**	**11.1%**
Fertilizers	**9.9%**	**11.0%**	**10.5%**	**8.1%**
Herbicides	**0.0%**	**0.0%**	**3.8%**	**4.6%**
Insecticides	**0.0%**	**0.0%**	**0.8%**	**0.4%**
Other chemicals	**0.0%**	**0.0%**	**1.0%**	**0.0%**
Harvest aid	**0.0%**	**0.0%**	**2.7%**	**4.0%**
Crop consulting services	**0.5%**	**0.1%**	**0.0%**	**0.0%**
Crop insurance	**3.2%**	**3.9%**	**1.9%**	**3.1%**
Energy for irrigation	**11.6%**	**0.0%**	**8.2%**	**0.0%**
Organic Certification Fee	**3.7%**	**9.2%**	**0.0%**	**0.0%**
Labor	**61.46%**	**64.90%**	**51.61%**	**57.30%**
Stalk shredding/cutting	1.7%	3.4%	2.5%	3.2%
Chiseling	0.8%	6.5%	0.4%	0.9%
Disking	1.5%	0.5%	0.4%	0.0%
Listing	1.7%	3.3%	1.8%	3.1%
Rod weeding	1.6%	3.5%	1.0%	1.4%
Fertilizer app.	1.2%	1.5%	3.2%	2.9%
Insecticide app.	0.0%	0.0%	0.8%	0.4%
Herbicide app.	0.0%	0.0%	3.9%	4.7%
Planting	1.8%	3.6%	2.8%	5.0%
Scouting	2.6%	0.2%	25.1%	15.1%
Rotary hoeing	2.8%	1.9%	1.5%	0.5%
Sandfight	1.8%	3.0%	3.3%	7.3%
Cutivating	4.9%	9.7%	1.6%	2.0%
Hand hoeing	53.9%	33.4%	2.7%	2.8%
Harvest Aid app.	0.0%	0.0%	1.9%	1.6%
Other activities	0.3%	0.0%	1.1%	2.4%
Harvesting-Strip/Pick	18.2%	23.5%	36.9%	37.2%
Ginning	5.1%	6.0%	9.2%	9.6%
Repair and Maintenance	6.22%	6.93%	7.93%	8.54%
Implements	25.48%	52.26%	25.48%	52.26%
Tractors	24.09%	47.13%	24.09%	47.13%
Pick-up	0.57%	0.61%	0.57%	0.61%
Center Pivot	49.86%	0.00%	49.86%	0.00%
Interest on Op. Capital	2.49%	2.29%	3.18%	2.83%

Table 6. Maximum-Likelihood Estimates for Parameters of the Cobb-Douglas Stochastic Production Frontiers

		Organic Cotton		Conventional Cotton	
Variable	Parameter	Estimate[a]	t-ratio	Estimate	t-ratio
Constant	β_0	5.8198***	14.10	3.9167***	24.82
		(0.4127)[b]		*(0.1578)*	
log(Materials)	β_1	0.2475**	2.28	0.3810**	3.65
		(0.1086)		*(0.1045)*	
log(Water)	β_2	0.3588*	1.82	0.4306**	5.68
		(0.1976)		*(0.0759)*	
Constant	δ_0	1.3822***	5.21	-0.5402	-1.35
		(0.2651)		*(0.4007)*	
Experience	δ_2	-0.0024	-0.15	0.0253***	10.27
		(0.0159)		*(0.0025)*	
Education	δ_3	-0.2991	-1.48	-0.5402	-1.35
		(0.2015)		*(0.4007)*	
Area	δ_1	-0.0006**	-2.54	0.0003***	8.89
		(0.0002)		*(0.00003)*	
$\sigma^2 = \sigma_u^2 + \sigma_v^2$		0.0504**	2.81	0.1637***	11.26
		(0.0180)		*(0.0145)*	
$\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$		1.0000***	107.60	1.0000***	3207.15
		(0.0093)		*(0.0003)*	
Log likelihood		1.6001			5.0800
Mean Technical Efficiency		0.46			0.78

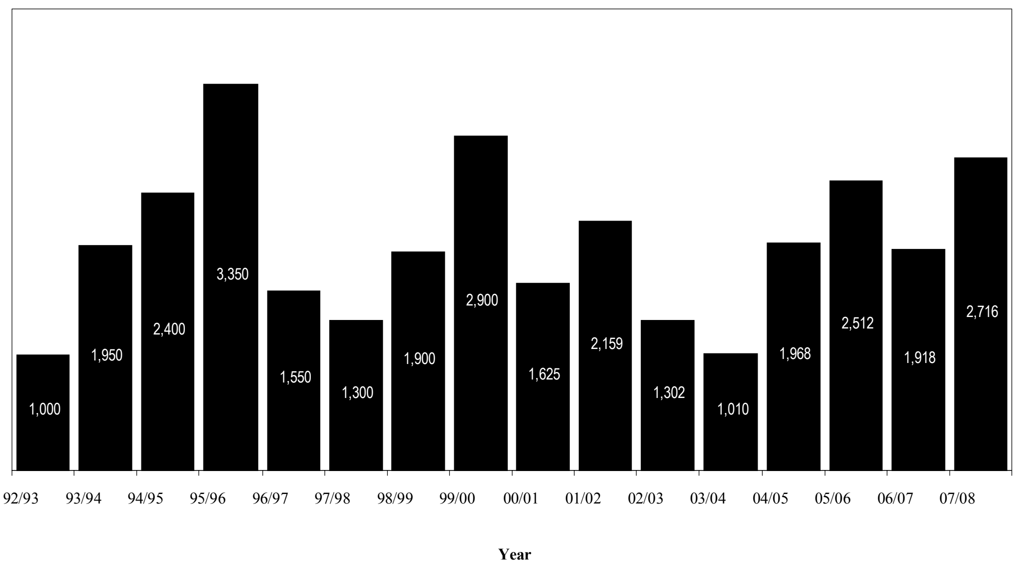
[a]*Significant at 10% level; **significant at 5% level; ***significant at the 1%level

[b]Figures in the parenthesis are standard errors



Note: Actual area planted to organic cotton in 2009 is not available yet. Thus, presented above is OTA's acreage projection.
Source: Organic Trade Association (2004); Organic Trade Association (2006); and http://www.ota.com

Figure 1. Estimated U.S. organic cotton area, 1991 – 2007



Source: Organic Trade Association (2004) and Organic Exchange (2008)

Figure 2. Estimated U.S. organic cotton production (MT), 1992/1993 to 2007/2008

Notes

[1] Access to this group of farmers was allowed through coordination with the cooperative. Hence, we would like to acknowledge the support provided by the Texas Organic Cotton Marketing Cooperative, as well as Dr. Jackie Smith of Texas Agri-Life Research Station–Lubbock, in making this article possible.

[2] Information taken from the 2004 Custom Rates Statistics handbook about rates on different operator labor under cotton farming activities are converted into equivalent dollar amounts in 2007.

[3] For instance, besides the organic cotton acreage declared in the survey, a fraction of land were cultivated by three sample organic cotton producers during the above-mentioned crop year using conventional techniques as well. One of three farmer-respondents who has not yet considered full conversion of their whole cotton acreage to organic farming systems, has 3% of his cotton field apportioned to conventionally-grown cotton. The other two farmers indicated 34% and 18% of respective total cotton acreage cultivated under organic techniques and equivalently, bigger portions remain under conventional system of farming.

[4] A composite of farms is described by the AAEA Task Force on Commodity Costs and Returns (2000) as a simple or weighted average of enterprise budgets for some period or for some group of individual or representative farms.

[5] The components of repair and maintenance and fixed expenses are provided for by the Texas Agri-life Research Station's projected budget for 2007 cotton production.

[6] Green manure is a type of cover crop grown not for its food value but to provide ground cover to hold the soil in place to prevent soil erosion. Rye cover feeds the micro-organisms in the soil when turning the cover crop back into the soil by disking or plowing, thereby providing natural nutrients for future plants grown on that soil (Sullivan, 2002).

[7] The parameter λ is an indicator of the relative variability of the two sources of variations. If λ is close to zero, the discrepancy between the observed and the maximum attainable levels of output is dominated by random factors outside the control of the farmer. Otherwise, the more λ is greater than one the more the production is dominated by variability emanating from technical inefficiency.