EVALUATION OF DRYLAND COTTON CROPPING SYSTEM EFFECTS ON YIELDS AND RETURNS IN THE TEXAS HIGH PLAINS

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Abstract

Cotton production in the Texas High Plains region constitutes a large part of total cotton production in the United States. Much of the cotton in the region is grown under dryland farming practices. Although much of the cotton in the region is farmed using a conventional tillage cropping system, several alternative cropping systems are becoming increasingly accepted. The net returns to six feasible dryland cropping systems are ranked using stochastic dominance with respect to a function (SDRF). Four conservation cropping systems are confirmed to be superior to the widely accepted conventional cotton cropping system. The adoption of alternative conservation systems can result in increased net revenues to producers. Therefore, conservation cropping systems seem to be practical alternatives for dryland cotton producers in the Texas High Plains.

Introduction

The Texas High Plains (THP) is a twenty-five-county region in northwest Texas with an ideal climate for producing upland cotton. Cotton is the most economically significant agricultural product originating in the area. Around three million acres of cotton are planted each year in the THP. About half the cotton acreage is farmed using dryland production practices. Average returns in the region have historically been greater from cotton than from other feasible crops initiating a gradual shift of most of the agricultural resources toward a conventional tillage cotton monoculture.

Conventional tillage production generally follows the order of operations listed in Table 1. Following harvest, the residual stalks are destroyed, suc-ceeded by a deep tillage operation. Before planting in the spring, herbicide and fertilizer are incorporated. Bedding, planting, and cultivation begin in May. The growing season extends throughout the summer and fall and ends in harvest, typically in October or November. Prior to harvest, about ten operations are characteristically included.

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Table 1. Cropping system practices at the Texas Agricultural Experiment Station, Lubbock, TX.

Cnventl.	Reduced	No till	Term. Wheat/ Cotton	Sorgh./ Cotton	Wheat/ Cotton
Shred stalks	Shred stalks	Apply 2,4-D & diuron	Plant wheat	Apply 2,4-D & diuron	Apply 2,4-D & diuron
Disc					
Disc in trifluralin & fert.	List in trifluralin & fert.			Apply glyphosate & diruon	
Plant	Plant & apply caparol	Plant & apply prometryn, glyphosate, metolachlor, & caparol	Plant & apply prometryn, glyphosate, metolachlor, & caparol	Plant & apply caparol, glyphosate, & dual	Plant & apply caparol, glyphosate, & dual
Rotary hoe	Rotary hoe	Rotary hoe			
Cultivate 3 times	Cultivate 1 time	Cultivate 1 time	Cultivate 1 time	Cultivate 1 time	Cultivate 1 time
Harvest	Harvest	Harvest	Harvest	Harvest	Harvest

Fewer operations are included in the conservation tillage systems. The operations in a representative crop season are listed in Table 1. The crop is planted into the residue of the previous harvest, and herbicides are used in place of mechanical weed control, eliminating some of the tillage practices. Through the elimination of many of these operations, production costs are lowered by way of reductions in labor, fuel, and machinery costs.

Conservation tillage systems generally provide benefits from preservation of soil moisture and reduction of soil erosion from wind and water. Resulting from the increased emphasis on conservation found in government agricultural policy, conservation tillage systems have won attention from producers in the THP. However, like all aspects of business, widespread acceptance of conservation tillage practices for cotton in the region depends on the relative long-term profitability of each system as compared to feasible alternatives. This analysis attempts to address the relative economic performance of the conventional tillage dryland cotton system and several conservation tillage dryland cotton systems on the Texas High Plains.

Approach and Procedure

In 1986, the Texas Agricultural Experiment Station at Lubbock introduced an experiment on cotton cropping systems. Plots farmed under each of six dryland cropping systems have remained in the experiment. The experiment is conducted on 26 ft by 50 ft randomly arranged plots of Amarillo sandy clay loam. The six cropping systems in the experiment consist of a conventional tillage system in continuous cotton and five conservation tillage cropping systems including a reduced tillage system in continuous cotton, a no tillage system in continuous cotton, a reduced tillage cotton system with terminated wheat, a reduced tillage cotton rotation with sorghum, and a reduced tillage cotton rotation with wheat. The cropping and tillage systems were initiated in 1986. The data used in this study were collected for the crop years of 1988 through 1993. Prior to the introduction of the experiment, the plot area had been used in continuous cotton production for five years.

Traditional land preparation, pesticide application, and tillage and harvest practices were used on the plots in conventional tillage continuous cotton. Cropping operations are found in Table 1. On the plots of reduced tillage continuous cotton, deep tilling with a disc plow was eliminated from the system and trifluralin was applied during the listing operation. On the plots of no tillage continuous cotton, planting was completed directly into the residual stalks from the previous crop, precluding any tillage operations after harvest and before planting. Winter weeds were controlled in the no tillage plots with a timely preplant application of 2,4-D and diuron. Glyphosate for burn down of existing weeds and metolachlor and prometryn as pre-emergence herbicides were applied at or directly following planting. In the terminated wheat-cotton rotation, wheat as a winter cover, was drilled into the residual stalks following harvest. In April, prior to listing, the wheat was terminated using .38 lb/acre of glyphosate. The sorghum-cotton rotation and the wheat-cotton rotation were cropping systems based on the annual rotation of crops planted. The land was planted to cotton one year and to wheat(sorghum) the following year. These rotations used the same tillage and herbicide practices as the no tillage system.

Fertilizer was applied according to results of annual soil tests of each plot. Nitrogen application ranged from 20 lb N/acre to 40 lb N/acre. Yield was calculated by the lint production from a strip of each plot thirteen feet long and two rows wide. The total cost of production was separated into preharvest costs and harvest costs. Harvest costs varied with respect to yield, therefore, these costs varied across cropping systems. Variable input costs reflect local prices of seed, fuel, fertilizer, and pesticides. Costs of mechanical operations were taken from the Texas Crop Enterprise Budgets (TAES, 1989). The Index of Prices Paid (USDA, Prices paid, 1993) by farmers for all production groups was used to inflate (deflate) these costs to the later (earlier) years.

Behavior and patterns of average yields and returns provide the producer with useful tools for production planning, however, only the variability of yields and returns allows the producer to examine the relative risk associated with particular cropping practices. To accommodate the need for a valuation of relative risk, the stochastic dominance with respect to a function (SDRF) technique was used. The SDRF is a valuative criterion which orders variable alternatives for a defined set of decision makers who have an absolute risk aversion coefficient which falls between specified upper and lower bounds. The absolute risk aversion coefficient (ARAC), defined as the negative ratio of the second derivative of a von Neumann-Morgenstern utility function to the first derivative of the same function, is a measure of the degree of con-vexity or concavity of the decision maker's utility function. Since the slope of a utility function is accepted to be positive, a positive ARAC suggests the second derivative is negative, indicating a concave utility function. Accord-ingly, the ARAC serves as a suggestion of the risk preference of the decision maker. Because the absolute risk aversion coefficient is a unique measure which holds across preferences and the utility function is unique only to a positive linear transformation, the former provides a less restrictive measure of risk preference. A major advantage of SDRF as a valuation criterion is that it imposes no limitations on the upper or lower bounds of the absolute risk aversion interval. The interval can be specified as small or large as nec-essary to account for the uncertainty in the approximation of the coefficient.

Yield data points were taken from three plots of each cropping system for each of the six sample years. Therefore, eighteen yield data points were used along with costs of production and revenues specified in 1993 values to find eighteen net revenue calculations for each cropping system. Following King and Robison (1981), the SDRF technique was used to compare the net rev-enues given alternative absolute risk aversion intervals. Three risk aversion intervals were specified. The intervals span the range of the absolute risk aversion coefficient from -.0003 to .0006. SDRF was performed for each interval.

Results and Discussion

Dryland cotton lint yields exhibit wide fluctuation relative to rainfall patterns during the growing season. Table 2 summarizes the overall average and standard deviation of cotton yields for each of the six cropping systems.

Table 2. Average cotton yields on dryland cropping systems at Lubbock, TX, 1988-1993.

Cropping System	Mean	Std.Deviation
	.... pounds per acre	
Conventional tillage	227	106
Reduced tillage	281	111
No-till	255	93
Terminated wheat-cotton	181	144
Sorghum-cotton reduced	330	91
Wheat-cotton reduced	463	94

Monthly rainfall for each year is found in Table 3. Rainfall in four of the six years is below the 75 year average, with three of those years enduring a below average measure of at least three inches. Regardless of low rainfall in 1988, yields were above average for all systems except the sorghum-cotton rotation, resulting from acutely dry conditions throughout most of the rest of the sample period bringing down the overall average.

Table 3. Monthly rainfall at Lubbock, Texas, 1988-1993.

	1988	1989	1990	1991	1992	1993	75 yr
				.... inches			
Jan	0.30	0.45	0.48	1.20	1.32	1.03	0.52
Feb	0.42	1.04	1.73	0.43	2.01	0.39	0.67
Mar	0.25	0.68	0.61	0.07	1.36	0.37	0.85
Apr	1.41	0.28	1.32	0.00	1.26	1.16	1.22
May	2.29	0.40	0.82	1.76	5.25	2.06	2.69
Jun	1.56	4.91	0.20	4.05	4.40	3.78	2.63
Jul	3.35	0.31	5.81	2.34	1.71	0.82	2.21
Aug	0.42	3.37	1.48	2.08	1.56	1.78	2.03
Sep	2.48	3.51	1.06	5.79	0.69	0.24	2.49
Oct	0.10	0.00	2.08	0.35	0.00	0.49	1.96
Nov	0.22	0.00	1.27	1.14	1.47	0.30	0.64
Dec	0.51	0.22	0.41	2.54	1.36	0.33	0.65
Total	13.31	15.17	17.27	21.75	22.39	12.75	18.5

Severely dry conditions in 1988 and 1989 lead to below average yields in 1989 for all systems except the wheat-cotton rotation. Rainfall for 1990 was below average, however, timely rains in April and through the last part of the summer lead to above average yields for all systems except reduced tillage in that year.

Annual rainfall in 1991 exceeded the long-run average by over three inches resulting from heavy rains in September. The September measure was over three inches above the 75-year average leading to extremely wet conditions during a period of the growing season when excessively wet conditions are detrimental to yield. As a result, the yields for all systems in 1991 were below the sample average. However, average yields for all the cropping systems were well above the sample average, resulting from significant and timely rainfall throughout the growing season in 1992.

Cotton yields in 1993 for the continuous cotton systems were significantly below sample averages, while yields for the two cotton rotations were higher than average. Above average precipitation during the last two months of 1992 resulted in good residue moisture on the rotation systems and accounted for the yield differential.

Average net revenues for each system for the six year sample are found in Table 4. Revenues in Table 4 do not reflect government deficiency payments. Slight variations in the price of cotton existed across systems resulting from differences in fiber quality. The values in Table 4 are rendered in 1993 dollars. The inflated values for the production costs were calculated using the Index of Prices Paid by farmers for production of all commodities as calculated by the USDA. The inflated values for the revenues were arrived at using the Index of Prices Received by farmers for cotton (USDA, Prices received, 1993).

Table 4. Net revenues above total costs in 1993 prices for dryland cotton systems at Lubbock, TX, 1988-1993.

Cropping System	Mean	Std. Deviation
	...... net revenue per acre......	
Conventional tillage	21.69	44.19
Reduced tillage	56.25	39.23
No-till	31.55	29.57
Terminated wheat-cotton	-0.11	49.99
Sorghum-cotton reduced	38.68	33.24
Wheat-cotton reduced	52.03	26.25

The reduced tillage cropping system outperformed the other systems on the basis of mean net revenue above total costs. However, the wheat-cotton rotation showed a comparable value. The net revenue of these two systems far exceeded those of the remaining four. In order, the systems ranked according to net revenue above total cost in the following way:

1 Reduced tillage continuous cotton
2 Wheat-cotton reduced tillage
3 Sorghum-cotton reduced tillage
4 No-till continuous cotton
5 Conventional tillage continuous cotton
6 Terminated wheat-cotton

The cropping systems were next ranked using SDRF to determine if the order would change from that found using average net revenues when the standard deviations of those net revenues are considered. Likewise, the SDRF provides insight in determining if the ordered systems might change given alternative levels of producer risk preference represented by the absolute risk aversion coefficient.

The results from the SDRF are found in Table 5. A "1" to the right of any pair of cropping systems indicates that the first cropping system dominated the second. A "-1" to the right of any pair indicates that the second system dominated the first. For example, a "-1" is found to the right of the first pair of systems, CONVTILL-REDTILL, indicating that REDTILL distribution of net revenues dominated CONVTILL distribution of net revenues.

Table 5. Results from SDRF applied to dryland cropping systems.

Dryland cropping systems*			
CONVTILL-REDTILL	-1	TWC-CONVTILL	-1
CONVTILL-NOTILL	-1	TWC-REDTILL	-1
CONVTILL-TWC	1	TWC-NOTILL	-1
CONVTILL-SORGCOT	-1	TWC-SORGCOT	-1
CONVTILL-WHEATCOT	-1	TWC-WHEATCOT	-1
REDTILL-CONVTILL	1	SORGCOT-CONVTILL	1
REDTILL-NOTILL	1	SORGCOT-REDTILL	-1
REDTILL-TWC	1	SORGCOT-NOTILL	1
REDTILL-SORGCOT	1	SORGCOT-TWC	1
REDTILL-WHEATCOT	1	SORGCOT-WHEATCOT	-1
NOTILL-CONVTILL	1	WHEATCOT-CONVTILL	1
NOTILL-REDTILL	-1	WHEATCOT-REDTILL	-1
NOTILL-TWC	1	WHEATCOT-NOTILL	1
NOTILL-SORGCOT	-1	WHEATCOT-TWC	1
NOTILL-WHEATCOT	-1	WHEATCOT-SORGCOT	1

* CONVTILL - Conventional tillage cotton, REDTILL - Reduced tillage cotton, NOTILL - No-till cotton, TWC - Terminated wheat-cotton, SORGCOT - Conservation tillage sorghum-cotton, and WHEATCOT - Conservation tillage wheat-cotton.

Examination of the results in Table 5 indicate that reduced tillage dominated all other systems. The overall ranking implied by the results in the table is:

1 Reduced tillage continuous cotton
2 Wheat-cotton reduced tillage
3 Sorghum-cotton reduced tillage
4 No-till continuous cotton
5 Conventional tillage continuous cotton
6 Terminated wheat-cotton

Upon comparison of the ranking of systems using SDRF to the ranking using average net revenues, the two techniques concluded the same order of systems. However, when the distributions under consideration are more similar, the two techniques often confirm different rankings. In which case, the results from the SDRF are preferred to the results from the average net revenue ranking because the SDRF accounts not only for the average net revenues of the systems, but also the variability of the net revenues.

Conclusion

The stochastic dominance with respect to a function analysis of six dryland cotton cropping systems revealed that four of the five conservation tillage systems exhibited a distribution of net revenues favorable to that of the conventional tillage system for all likely producer risk preference levels. These four conservation systems displayed increased stability and profitability over the conventional tillage system, and hence are workable options that producers should consider. Conservation tillage systems in dryland cotton production may be better suited to producer risk preferences than conventional practices. Although conservation systems are being used by increasing numbers of farmers, many producers are reluctant to change from conventional practices.

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