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PROFITABILITY OF IRRIGATED COTTON-GRAIN SORGHUM ROTATIONS IN THE SOUTHERN HIGH PLAINS OF TEXAS

Jason Blackshear and Phillip Johnson
Department of Agricultural and Applied Economics
Texas Tech University
Lubbock, TX

Abstract

The Standardized Performance Analysis (SPA) method was used to evaluate the profitability of grain sorghum production in the High Plains and Coastal Bend regions of Texas. Grain sorghum was shown to be profitable in the Coastal Bend region for dryland operations under crop share rental agreements in 1999 and 2000. Results for grain sorghum as primary and replacement crops indicated profitability concerns in both the Northern and Southern High Plains. Analysis of cotton yields in a cotton-grain sorghum rotation in the High Plains region indicated an increase of 170 and 142 lbs. per acre following grain sorghum one and two years, respectively. These rotational effects on cotton yields proved to have a significant impact on increased cotton profits and provided evidence for the profitability potential of utilizing grain sorghum in cotton rotations.

Introduction

Grain sorghum has historically been a major field crop in the Southern High Plains (SHP) of Texas, following cotton production. However, total grain sorghum acreage in Texas has steadily decreased since the late 1970s and stabilized at historical lows in the 1990s. This decrease in grain sorghum acreage could possibly be attributed to a reduction of the relative profitability of grain sorghum as compared to other crops. In 2001, grain sorghum represented approximately 12.0% of the total acreage of all Texas field crops (TASS). However, grain sorghum only accounted for approximately 6.1% of the total value of production of all Texas field crops in 2001 (TASS). This reduction of relative profitability may have led to producers planting crops of higher value, thus contributing to the overall decrease in grain sorghum production. Additionally, Texas Cooperative Extension Service crop budgets from the SHP in 2000 projected returns above variable costs of production of $17.65 and $-63.72 per acre for irrigated cotton and irrigated grain sorghum, respectively (TAEX, 2001).

There is some evidence that crop rotation systems may have a positive impact on soil fertility. Bagayoko, Mason, and Sabata (1992) state, “Rotation plays an important role in the maintenance of soil fertility, improvement of soil physical properties, and control of soil erosion” (p. 862). Additionally, there is some evidence that grain sorghum can increase farm net returns and yields under a rotational system with cotton (Keeling, Henniger, and Logan, 1990a). A study by Keeling, Henniger, and Logan (1990a) for irrigated crop rotations in the SHP for 1989-90 found that a grain sorghum-cotton conservation tillage rotation produced net returns above variable costs of $258 per acre compared to $204, $231, and $248 per acre for continuous cotton under conventional tillage, reduced tillage, and no-tillage, respectively.

Reliable information regarding the profitability of grain sorghum produced within crop rotation systems is needed. Therefore, the primary objective of this study was to evaluate the profitability of various irrigated grain sorghum and cotton rotation strategies in the SHP of Texas. There is evidence that grain sorghum has the potential to increase the productivity of other crops produced on a rotational basis. However, producers may recognize grain sorghum as less profitable, and fail to realize the resulting higher yields and additional value received by other crops in a rotation. If grain sorghum production is to be sustainable in Texas, producers need information detailing the effects and benefits in overall profitability and production costs resulting from using grain sorghum in crop rotations. Without this information, grain sorghum is likely to continue to be considered an inferior crop among producers and fail to be included in crop rotations in Texas.

Methods and Procedures

The original Standardized Performance Analysis (SPA) computer software program was developed to provide commercial cow-calf operations with standardized methods to measure, analyze, and report the performance and profitability within cow-calf enterprises (McGrann, Michalke, and Stone, 1996). Following the cow-calf SPA computer program, a program called Standardized Performance Analysis – Multiple Enterprise (SPA-ME) was developed to analyze crop enterprises in multiple enterprise farming operations. The SPA-ME program is an analytical tool that utilizes whole farm financial statements to examine true enterprise performance. SPA-ME allows for specific enterprise assets, liabilities, revenues, and expenses to be separated out from the whole farm financial statements. From this information, cost determination can be made using actual financial statements from producers (McGrann, Michalke, and Stone, 1996). The end result for the producer is a true assessment of their enterprise costs and profitability. Upon completion of all individual analyses, all analyses were compiled into a SPA database designed to generate aggregated results across producers and regions.

Regression Model

The SPA-ME computer program and SPA database were useful in generating results for grain sorghum and cotton as primary crops. However, they were not sufficient to analyze the role that grain sorghum plays in various irrigated cotton-grain sorghum rotations. In order to address rotation strategies, a regression model using ordinary least squares estimation procedures was utilized to estimate the impact of grain sorghum on cotton yields in a rotation in the SHP. The cotton yield function was expressed as:

$$YLD = f(PROD, DC, YR, ICAFS_1, ICAFS_2). \quad (1)$$

Where YLD is cotton yield in pounds per acre, PROD is a set of four binary variables to reflect different levels of management across producers, DC is a binary variable distinguishing between irrigated and dryland cotton, YR is a set of four binary variables reflecting differences in growing seasons between 1997, 1998, 1999, and 2000, $ICAFS_1$ is an index measuring cotton following sorghum one year (CFS_1) as a percentage of total cotton acres, and $ICAFS_2$ is an index measuring cotton following sorghum two years (CFS_2) as a percentage of total cotton acres. In other words, cotton yield per acre is some function of the level of management, irrigated or dryland cotton, growing season, and cotton acres following grain sorghum one and two years in the rotation as a percentage of total cotton acres.

The indices ($ICAFS_1$ and $ICAFS_2$) were developed to capture and differentiate the effect of grain sorghum on cotton yields following grain sorghum one and two years in a rotation, where the $ICASF_1$ ($ICASF_2$) index is calculated as the cotton acres in each field following grain sorghum one (two) year(s) as a percentage of total cotton acres in that field. In other words, if all cotton acres in the field were following grain sorghum one year in the rotation, the $ICASF_1$ index would have a value of one. Suppose a field had a total of 100 acres of cotton with 20 and 40 acres following grain sorghum one and two years, respectively, then the index would be 0.2 and 0.4 for $ICASF_1$ and $ICASF_2$, respectively. For continuous cotton, the $ICASF_1$ and $ICASF_2$ indices would both have a value of zero. Furthermore, this study assumes that there is no positive impact on cotton yields following grain sorghum three years in a rotation. Hence, this study treats cotton following sorghum three years the same as continuous cotton.

Simulation Models

In evaluating the profitability of irrigated cotton-grain sorghum rotations in the SHP, two variations of simulation models were developed. The first set of simulation models (mean simulation models) evaluated the impact of the rotation strategy at mean levels with respect to grain sorghum yields, prices, government payments, and production costs. The second set of simulation models (stochastic simulation models) were developed to account for the variability in prices, yields, and production costs.

Mean Simulation Models. A total of five mean simulation models were set up to evaluate the following rotation strategies for irrigated cotton-grain sorghum operations: (1) 1/3 grain sorghum - 2/3 cotton (Rotation A), (2) 1/4 grain sorghum - 3/4 cotton (Rotation B), (3) 1/5 grain sorghum - 4/5 cotton (Rotation C), (4) 1/10 grain sorghum - 9/10 cotton (Rotation D), and (5) continuous cotton (Rotation E). For simulation purposes, yields for cotton following grain sorghum one year (CFS_1), cotton following grain sorghum two years (CFS_2), and continuous cotton were estimated from the results of the regression model. Government payments, production costs, and lint prices for irrigated cotton were obtained from aggregated SPA database results across those producers in the SHP included in this study. However, irrigated grain sorghum yields, government payments, production costs, and prices were obtained from modified SPA database results for producers included in this study. This was necessary to minimize the impacts of an individual producer that accounted for a large percentage of the irrigated grain sorghum observations and dominated results with above average yields and costs. The modification process involved using the SPA database to generate the per acre average grain sorghum yield, government payments, production costs, and price received for each individual producer. The results for each individual producer were then weighted based on the following equation:

$$W = C_j \quad /TCO, \quad (2)$$

where W, C_j, and TCO represent the weighting factor, irrigated cotton observations for producer j, and total irrigated cotton observations across all producers, respectively. The weighted average was then used to determine the grain sorghum yield, government payments, production costs, and prices utilized in the simulation models. This modification was necessary to utilize yields and production costs relative to grain sorghum and cotton that minimized variations in production costs and yields resulting from different levels of management, soil type, and growing conditions.

The mean simulation models for each rotation strategy (including continuous cotton) were set up on a per acre basis. The appropriate yields were calculated and multiplied by the price to determine the primary product income for each component of the rotation (grain sorghum, CFS_1, CFS_2, and continuous cotton). The primary product income combined with the appropriate government payments for grain sorghum or cotton determined the total revenue for each component of the rotation. The total revenue was then matched with the appropriate costs (cash operating expenses and overhead costs) to determine the net income for each component of the rotation. Finally, the net income from each component was weighted according to the selected rotation strategy to determine the per acre net income for the entire rotation. Upon completion of the mean simulation models, results from these models were evaluated to determine the rotation strategy that produced the highest net income for irrigated operations.

Stochastic Simulation Models. The stochastic simulation models were generated with SIMETAR, a risk analysis software add-in for Microsoft Excel (Richardson, 2002). A total of 500 simulations were generated to evaluate the specified irrigated rotation strategies. The stochastic models were designed to account for the variability associated with yields, prices, and production costs. The means of prices, cash operating expenses, overhead expenses, and yields were derived in the same manner and are equivalent to the mean levels utilized in the mean simulation models. The standard deviations were calculated in the SPA database for those producers included in the study. However, the standard deviations utilized in the stochastic simulation models for CFS_1, CFS_2, and continuous cotton was derived from the SPA database. Since the SPA database does not distinguish between CFS_1, CFS_2, and continuous cotton, the standard deviation provided by the SPA database is for all cotton observations without any considerations of rotation strategies. In an effort to derive the appropriate standard deviation for CFS_1, CFS_2, and continuous cotton yields (given they were calculated from the regression model), the standard deviation across all cotton yields was calculated as a percentage of the mean for all cotton yields. This percentage factor was then multiplied by the appropriate CFS_1, CFS_2, and continuous cotton mean yields (calculated from the regression model) to obtain an approximation of the standard deviations that accounted for CFS_1, CFS_2, and continuous cotton. Additionally, all stochastic variables in the stochastic simulation models were truncated by their absolute minimums and maximums within the dataset for simulation purposes. Furthermore, since government payments have been decoupled, they were not assumed to be stochastic.

Upon completion of the stochastic simulation models, stochastic dominance (STODOM) analysis was utilized to rank the irrigated cropping rotation strategies. STODOM is a mathematically precise valuative criterion to rank actions or choices for classes of decision makers defined by specified lower and upper bounds of their absolute risk aversion coefficient (ARAC). The ARAC is defined as the -U"(x) divided by U'(x), where U represents a von Neumann-Morgenstern utility function (Segarra, Keeling, and Abernathy, 1991; Giesler, Paxton, and Millhollan, 1993; Richardson, 2002). Hence, a positive ARAC implies a concave utility function resulting in a risk adverse decision maker. Conversely, a negative ARAC implies a convex utility function resulting in a risk loving decision maker. Furthermore, the specification of lower and upper bounds places constraints on the range of risk attitudes entering the STODOM analysis (Giesler, Paxton, and Millhollan, 1993). The advantages of STODOM is that it utilizes all simulated observations and provides an indication into the confidence a decision maker has regarding the ranking of the alternative cropping rotation strategies (Richardson, 2000). Furthermore, the results from STODOM should be preferred to the average results under the mean simulation models, which do not internalize any considerations for risk preferences.

Data. The data utilized in this study was collected from four irrigated cotton-grain sorghum producers in the SHP from 1996 to 2000. The data collection process involved working with grain sorghum producers to collect primary data including production, marketing, and financial information for the SPA analyses. Crop maps were also obtained from the producers to identify crop rotations within each farm. All observations included in this study were on a crop share basis.

Empirical Results

Regression Model

Several regression model specifications were estimated using ordinary least squares estimation procedures. Additionally, various statistical tests were used to select the optimal model. In all of the regression models estimated, there were a total of 78 farm level observations representing four producers within the SHP for the years 1998 to 2000 (two years were lost due to lags for CFS_1 and CFS_2) for irrigated operations.

The initial model framework specified cotton yields per acre as a function of: (1) a set of binary variables representing different producers, (2) a set of binary variables representing crop year, (3) an index specifying CFS_1, and (4) an index specifying CFS_2 in a rotation. The baseline for the initial model was the year 1998.

Initial estimates of the models, determined that there were no statistical differences in 1997 and 1999 compared to the baseline. There was also no statistical difference between three of the four producers. Statistical tests using various specifications of squared and inverse terms, determined that the relationship between cotton yields per acre and the indices was linear. Furthermore, slope shifters were included in the model to test if there was a statistical difference in the slope of the indices with respect to irrigated and dryland cotton. All slope shifters, however, were determined to be statistically insignificant at the ninety-five percent level of statistical certainty. Finally, after evaluating several regression model specifications and adjusting the models as dictated by statistical tests, the following model specification was selected:

$$YLD = ._0 + ._1*PROD_3 - ._2*DC + ._3*Y2000 + ._4*ICAFS_1 + ._5*ICASF_2 + \square , \quad (3)$$

where YLD, $PROD_3$, DC, Y2000, $ICAFS_1$, and $ICAFS_2$ represent cotton yield in pounds per acre, a binary variable for producer 3, a binary variable for dryland cotton, a binary variable for the year 2000, an index for CFS_1, and an index for CFS_2, respectively. The results for the above model are provided in Table 1.

The estimation results provided the following parameter estimates of 323.33, 636.05, -125.05, -77.27, 170.12, and 142.42 for the intercept, producer 3 binary variable, dryland cotton binary variable, year 2000 binary variable, CFS_1 index, and CFS_2 index, respectively. The $ICASF_1$ parameter estimate of 170.12 implies that cotton yields per acre increased by 170.12 pounds per acre on CFS_1 acres in a rotation. Likewise, the $ICASF_2$ parameter estimate of 142.42 implies that cotton yields per acre increased by 142.42 pounds per acre for CFS_2 acres in a rotation. The $ICAFS_1$ and $ICAFS_2$ parameter estimates were consistent with what was hypothesized with respect to expected sign and relative magnitude.

The regression results further indicated that all independent variables were statistically significant at the ninety-five percent level of statistical certainty according to t-tests and p-values. Additionally, the estimated model had an R-squared of 86.10, meaning that 86.10 percent of the variation in cotton yields per acre (dependent variable) was explained by the independent variables included in the model. The model also had a statistically significant f-statistic at the ninety-five percent level of statistical certainty. Furthermore, there was no evidence of multicollinearity as indicated by the variance inflation factors and condition index. Results from the durbin-watson test statistic and the white test also indicated no evidence of autocorrelation or heteroskedasticity in the model.

Simulation Models

Mean Simulation Models. Data from four irrigated producers in the SHP from 1998 to 2000 was utilized to design the mean simulation models to evaluate irrigated grain sorghum-cotton rotations for the following rotation strategies: (1) 1/3 grain sorghum - 2/3 cotton (Rotation A), (2) 1/4 grain sorghum - 3/4 cotton (Rotation B), (3) 1/5 grain sorghum - 4/5 cotton (Rotation C), (4)1/10 grain sorghum - 9/10 cotton (Rotation D), and (5) continuous cotton. Rotation D was included to account for producers who do not follow a rotation strategy, but occasionally plant grain sorghum behind failed cotton.

The data used in the mean simulation models for irrigated grain sorghum, CFS_1, CFS_2, and continuous cotton are provided in Table 2. The per acre yield, revenues, expenses, and net incomes remained constant for each component (sorghum, CFS_1, CFS_2, and continuous cotton) in all of the simulation models. However, the weight applied to each component in calculating the total rotation net income (TRNI) on a per acre basis varied according to the rotation strategy applied. For example, Rotation A implies that grain sorghum, CFS_1, and CFS_2 each account for one third of the total planted acres. Additionally, Rotation C implies that grain sorghum, CFS_1, and CFS_2 each accounts for 1/5 of the total planted acres with continuous cotton accounting for 2/5 of the total planted acres.

The mean simulation models assumed a crop share yield of 22 cwt per acre and a price of \$3.75 per cwt for grain sorghum. This resulted in primary product income of \$82.50 for grain sorghum observations included in the models. It was further assumed that government payments were \$35.21 per acre resulting in total revenue of \$117.71 per acre for irrigated grain sorghum. Total cash operating and overhead expenses were assumed to be \$150.76 and \$30.10 per acre, respectively. This resulted in a negative net income of \$-63.15 per acre for irrigated grain sorghum within the mean simulation models.

The mean simulation models assumed that all irrigated cotton received or incurred the same cotton lint price, government payments, cash operating expenses, and overhead expenses. Cotton lint prices of \$0.5689 per pound and government payments of \$55.60 per acre were assumed in the model. It was further assumed that cash operating and overhead expenses were \$204.64 and \$33.31 per acre, respectively, for all cotton observations. Cotton yields assumed for the cotton components of the mean simulation models were estimated using the results of the regression model previously discussed. The effects of the year 2000 and producer 3 were weighted back into the intercept to obtain an average irrigated cotton yield for continuous cotton across all producers and years.

These adjustments resulted in an estimated average total cotton yield of 402.36 lbs per acre for irrigated continuous cotton in the SHP. This total yield, however, was adjusted to a crop share yield given that the database used in this study was on a crop share basis. Making this adjustment resulted in a continuous cotton crop share yield of 302 lbs. per acre for irrigated production. Additionally, the regression model indicates that cotton yields per acre would increase by 170.12 and 142.42 lbs. per acre for CFS_1 and CFS_2, respectively. The total estimated yields for irrigated cotton following grain sorghum one and two years were 572.48 lbs. per acre (402.36+170.12) and 544.78 lbs. per acre (402.36+170.12) per acre, respectively. Adjusting these total yields by 75% resulted in crop share yields of 429 and 409 lbs. per acre for CFS_1 and CFS_2, respectively. Assuming crop share yields and a cotton lint price of \$0.5689 per lb., primary product income was simulated at \$244.26, \$232.44, and \$171.68 per acre for CFS_1, CFS_2, and continuous cotton, respectively. Furthermore, this resulted in mean simulated net incomes of \$61.91, \$50.09, and \$-10.67 per acre for CFS_1, CFS_2, and continuous cotton, respectively.

Considering the yields, revenues, expenses, and net incomes simulated for the irrigated grain sorghum and cotton components, models were developed to evaluate each of the rotation strategies. A summary of the mean simulation model results for each rotation strategy are provided in Table 3. The results indicated that the TRNI for all rotation strategies was higher when compared to continuous cotton. The results indicated that the highest TRNI was for Rotation A, with a rotation of 1/3 irrigated grain sorghum, CFS_1, and CFS_2. Rotation A resulted in weighted net incomes of $-21.05, $20.64, and $16.90 for grain sorghum, CFS_1, and CFS_2, respectively. Summing the weighted net incomes resulted in a TRNI for Rotation A of $16.29 per acre. The results further indicated TRNIs of $9.55, $5.50, and $-2.59 for Rotations B, C, and D, respectively. The mean simulation model indicated negative net returns of $-10.67 per acre for continuous cotton. Hence, all rotation strategies evaluated resulted in higher TRNIs to the producer when compared to continuous cotton.

Stochastic Simulation Models. The mean simulation models provide evidence that producers in the SHP should be willing to consider adopting a cotton-grain sorghum rotation. However, the mean simulation models did not consider risk preferences or take into account the variability associated with prices, yields, and production costs. Therefore, stochastic simulation models were developed to evaluate how the results might change when accounting for variability and considerations of different risk preferences. The stochastic simulation models also evaluated the following rotation strategies: (1) 1/3 grain sorghum - 2/3 cotton (Rotation A), (2) 1/4 grain sorghum - 3/4 cotton (Rotation B), (3) 1/5 grain sorghum - 4/5 cotton (Rotation C), (4)1/10 grain sorghum - 9/10 cotton (Rotation D), and (5) continuous cotton (Rotation E).

The data used in the stochastic simulation models for irrigated grain sorghum, CFS_1, CFS_2, and continuous cotton are provided in Table 4. The per acre yields, prices, variable expenses, and fixed expenses were assumed to be stochastic. The input data component of Table 4 provides the means, standard deviations, absolute minimums, and absolute maximums associated with the stochastic variables utilized in the simulation models. This input data was then utilized to generate the stochastic variables with the truncated normal function in Microsoft Excel. From this information, models were developed to simulate 500 TRNI observations for each rotation strategy, while accounting for the stochastic nature of yields, prices, and production costs.

Upon completion of the simulated observations, stochastic dominance (STODOM) analysis was used to evaluate each of the rotation strategies. STODOM was utilized to allow comparisons between various levels of risk aversion and risk neutrality. The STODOM analyses were conducted in SIMETAR for twenty alternative levels of risk aversion coefficients. STODOM analyses were conducted on various ARAC's ranging from -0.05 to 0.05 with the results presented in Table 5. Under an ARAC ranging from -0.05 to -0.045, the preferred crop rotation strategy was to plant continuous cotton followed by a descending ranking of crop Rotations D, A, B, and C. The STODOM analyses for ARAC's ranging -0.04 to -0.03 also indicated that the preferred crop rotation strategy was to plant continuous cotton. However, the ranking slightly changed compared to higher levels of risk loving preferences to a descending ranking following continuous cotton of Rotations A, D, B, and C. Under an ARAC of -0.025, the preferred crop rotation strategy was the 1/3 grain sorghum - 2/3 cotton rotation strategy followed by a descending ranking of Rotations E, D, B, and C. Furthermore, as the ARAC increased from -0.025 towards risk neutrality, the descending ranking of preferred crop rotations changed to a descending ranking of Rotations A, B, C, D, and E. This crop rotation ranking held for ARAC's ranging from -0.01 and 0.05.

Conclusions

Results of the regression model indicated that cotton yields would be expected to increase by 170 and 142 lbs per acre following grain sorghum one and two years, respectively, in a rotation. This increase in cotton yields appeared to have a significant impact on increased cotton profits when evaluated by the mean simulation models. Analysis of the mean rotation simulation results provided evidence for the profitability potential of utilizing grain sorghum in rotations with cotton. However, the STODOM results produced starkly different results depending on the assumption made with respect to risk preferences. For risk loving producers, STODOM analysis indicated different rankings of rotation strategies depending on their ARAC. However, as a producer approaches risk neutrality, the STODOM analysis indicated that producers would be more willing to adopt cotton-grain sorghum rotations, more specifically Rotation A. Furthermore, all rotation strategies were preferred to continuous cotton for all levels of risk aversion evaluated in this study. While the STODOM results produced more variability than one would desire, these should still be preferred to the mean results for decision making purposes. The advantage of the STODOM analysis is that this approach accounts for differences in risk preferences and variability in yields, prices, and production costs. Furthermore, given a producer's risk preferences, the STODOM analysis could help identify the optimal rotation strategy given their individual preferences towards risk.

There are two major limitations associated with this study. Crop rotation results were based on four irrigated producers in the SHP; actual results may vary from producer to producer depending on management strategies, weather conditions, and soil qualities. Second, the total enterprise costs and net income levels reported in this study do not include family living withdrawals. Producers should need to estimate their family living withdrawals and account for them appropriately.

References

Bagayoko, M., S.C. Mason, and R.J. Sabata. "Effects of Previous Cropping Systems on Soil Nitrogen and Grain Sorghum Yield." Agronomy Journal. Sept/Oct 1992. v. 84 (5) p. 862-868.

Keeling, J.W., C.G. Henniger, and M.W. Logan. "Cropping Systems Evaluation at the Texas Agriculture Experiment Station, Lubbock, Texas, 1990." Texas Agricultural Experiment Station: 1990 Annual Progress Report, Lubbock / Halfway. (1990a): 145-147.

Richardson, James. Simulation for Applied Risk Management: An Introduction to the Software Package Simetar. Department of Agricultural Economics. Texas A&M University. January 2002.

Segarra, E., J.W. Keeling, and J.R. Abernathy. "Tillage and Cropping System Effects on Cotton Yield and Profitability on the Texas Southern High Plains." Journal of Production Agriculture. Oct/Dec 1991. v. 4 (4) p. 566-571.

Texas Agricultural Statistics Service (TASS). Texas Agricultural Statistics. Austin, TX: Texas Department of Agriculture, various issues.

Texas Agricultural Extension Service (TAEX). "2000 Texas Crop and Livestock Budgets: Districts 1 and 2" (http://agecoext.tamu.edu/budgets/district/1&2/ 1999/list.htm), April 26, 2000.

Table 1. Regression Model Results.

Variable	Estimate	Standard Error	t-Value	p-value
Intercept	323.33	21.46	15.06	0.000
Producer 3 Binary Variable	636.05	47.45	13.4	0.000
Dry Cotton Binary Variable	-125.05	34.29	-3.65	0.000
2000 Binary Variable	-77.27	31.66	-2.44	0.017
$ICAFS_1$	170.12	49.12	3.46	0.001
$ICAFS_2$	142.42	69.81	2.04	0.045

Total Observations: 78
Degrees of Freedom: 72
R-Squared: 86.10%
F-Statistic: 89.446

Table 2. Simulation Model Data for Irrigated Crop Rotations on a Crop Share Basis.*

	Grain Sorghum	CFS_1	CFS_2	Continuous Cotton
	(cwt/acre)		(lbs/acre)	
Total Yield	33	572	545	402
Crop Share Yield	22	429	409	302
			($/acre)	
Primary Product	82.50	244.26	232.44	171.68
Government Payments	35.21	55.60	55.60	55.60
Total Revenue	117.71	299.86	288.04	227.28
Cash Operating Expenses	150.76	204.64	204.64	204.64
Overhead Expenses	30.10	33.31	33.31	33.31
Total Enterprise Cost**	180.86	237.95	237.95	237.95
Net Income	-63.15	61.91	50.09	-10.67

*Tenant crop share percentage is assumed 2/3 for irrigated grain sorghum and 3/4 for irrigated cotton
**Total enterprise cost does not include family living withdrawals

Table 3. Irrigated Grain Sorghum and Cotton Simulation Model Results on a Crop Share Basis. *

Rotation	Grain Sorghum	CFS_1	CFS_2	Continuous Cotton	TRNI**
			($/acre)		
1/3 Irrigated Grain Sorghum - 2/3 Irrigated Cotton	-21.05	20.64	16.90	0.00	16.49
1/4 Irrigated Grain Sorghum - 3/4 Irrigated Cotton	-15.79	15.48	12.52	-2.67	9.55
1/5 Irrigated Grain Sorghum - 4/5 Irrigated Cotton	-12.63	12.38	10.02	-4.27	5.50
1/10 Irrigated Grain Sorghum - 9/10 Irrigated Cotton	-6.32	6.19	5.01	-7.47	-2.59
Continuous Irrigated Cotton	0.00	0.00	0.00	-10.67	-10.67

*Tenant crop share percentage is assumed 2/3 for irrigated grain sorghum and 3/4 for irrigated cotton
**Net income is weighted per acre based on rotation

Table 4. Stochastic Simulation Model Input Data.

	Mean	Std. Dev	Min	Max
PDF for Pc	0.5689	0.328	0.39	0.706
PDF for Pgs	3.75	1.91	2.75	5.38
PDF for Ycc	302	141.94	234.06	871.97
PDF for Ycf1	429	201.63	332.4892	1238.659
PDF for Ycf2	409	192.23	316.9885	1180.913
PDF for Ygs	22	9.8	10.25	68.59
PDF for TVCc	204.64	95.81	136.56	408.14
PDF for TVCgs	150.76	62.472	77.45	328.54
PDF for TFCc	33.31	11.37	24.15	39.97
PDF for TFCgs	30.1	17.61	17.8	37.25

GPc 55.6
GPgs 35.21

Table 5. Stochastic Dominance Results.

	Risk Aversion Coefficient												
Ranking	0.05	0.045	0.04	0.03	0.025	0.02	0.01	0	0.01	0.02	0.03	0.04	0.05
1 (most pref.)	E	E	E	E	A	A	A	A	A	A	A	A	A
2	D	D	A	A	E	B	B	B	B	B	B	B	B
3	A	A	D	D	D	C	C	C	C	C	C	C	C
4	B	B	B	B	B	D	D	D	D	D	D	D	D
5 (least pref.)	C	C	C	C	C	E	E	E	E	E	E	E	E