FARM LEVEL PROFITABILITY AND RESOURCE REQUIREMENTS OF COTTON FARMING SYSTEMS

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Abstract

An evaluation of the profitability of promising irrigated and dryland cotton farming systems developed at AG-CARES is conducted in this study. An optimization model for a representative farm in Dawson County, Texas was developed. Optimal decision rules of cotton farming systems use are found under alternative irrigation water availability scenarios over a twenty-year planning horizon. It was found, that optimal solutions do not include conventional cotton production practices currently used in the area. Also, it was found that producers could increase present value of net returns by adopting cotton farming systems being developed at AG-CARES.

Introduction

Water availability is a major concern for agricultural producers in the southern United States. Producers compete for water resources with municipalities, industry, and recreational activities. Producers are further affected by increasing production costs and environmental concerns over point and non-point source pollution from agricultural activities. In order to optimize cotton production objectives, cotton production systems which utilize all production inputs, including water, more efficiently, while reducing potential environmental impacts, need to be developed and implemented.

The most important crop produced on the Texas High Plains, in terms of both acreage and crop value, is cotton. Cotton acreage planted each year ranges from 2.6 to 3.3 million acres within the 25-county region that make up the Texas High Plains. Approximately 50 percent of this acreage is irrigated. Most irrigation water is obtained from the Ogallala aquifer. Agricultural producers obtain higher returns from cotton production when compared to other crops which could be produced in this region. Also, producers in the region tend to follow conventional tillage cotton production practices and a cotton monoculture production system has evolved. This cotton production monoculture system typically involves 12 to 15 mechanical operations per field in a typical growing season. When an excessive amount of practices are used, soil becomes vulnerable to water and wind erosion. Long-term cotton farming systems, such as minimum-tillage and conservation tillage have been evaluated for use on the Texas High Plains. These studies were conducted on soil types ranging from clay loam to fine sandy loam and have shown that increases in both cotton yields and profitability are possible (Keeling, et al., 1989, and Segarra et al., 1991).

A large proportion of soil on the Texas High Plains is sandy. Most producers attempt to maximize yields by following heavy fertilization and irrigation strategies. However, these practices can lead to nitrate leaching problems. In order to offset the effects sequential high frequency fertilization through the growing season in amounts equal to projected plant uptake can be accomplished by the use of Low Energy Precision Application (LEPA) irrigation (Onken, et al., 1979). Pest management can also be improved by the use of LEPA irrigation. Biorational insecticides (i.e., soaps and oils) applied through LEPA can improve in-canopy coverage with low water volumes. While improving insecticide usage, this type of application also addresses environmental concerns with respect to the indiscriminate use of some pesticides (Lyle, et al., 1989). These type of integrated production practices will not be accepted and widely used unless their economic performance is deemed as profitable or more profitable than current conventional cotton production practices. For this reason, in the fall of 1989, the Lamesa Cotton Growers Association, the Texas Agricultural Extension Service, and the Texas Agricultural Experiment Station signed a cooperative agreement to create the Agricultural Complex for Advanced Research and Extension Systems (AG-CARES). The AG-CARES facility is located in Lamesa, Texas and began operations in the fall of 1990.

The AG-CARES facility was developed in order to pull together available resources to evaluate the profitability and economic viability of alternative cotton production systems at a farm scale level. Since 1990 many production technologies and alternative cotton farming systems have been studied and evaluated. Previous studies have focused on the profitability of the most economically promising irrigated and dryland farming systems developed at AG-CARES (Segarra et al., 1995). The objective of this study is twofold: (1) to identify optimal decision rules of cropland and irrigation water use of alternative cotton farming systems being developed at AG-CARES; and (2) to find out if these cotton farming systems would be more profitable than conventional cotton production practices used in the area.

Materials and Methods

Using data from the Agricultural and Food Policy Center (AFPC) at Texas A&M University, a representative farm with 1,360 acres of cropland was developed for Dawson County, Texas. Given that most cropland in this county is

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:259-262 (1997)
National Cotton Council, Memphis TN

used for cotton production, the whole farm linear programming optimization model included twenty-five cotton production activities. Eighteen of these production activities assumed irrigated conditions and seven assumed dryland conditions.

The irrigated cotton production activities in the linear programming model included: (1) three conventional-cotton activities under sprinkler irrigation at three different evapo-transpiration (ET) levels which were defined as: CTSL at 0.50 ET, CTSM at 0.75 ET, and CTSH at 1.00 ET; (2) three conventional-cotton activities under LEPA irrigation at three different ET levels which were defined as: CTLL at 0.50 ET, CTLM at 0.75 ET, and CTLH at 1.00 ET; (3) three cotton-sorghum rotation activities under LEPA irrigation at three different ET levels which were defined as: CSL at 0.50 ET, CSM at 0.75 ET, and CSH at 1.00 ET; (4) three cotton-wheat rotation activities under LEPA irrigation at three different ET levels which were defined as: CWL at 0.50 ET, CWM at 0.75 ET, and CWH at 1.00 ET; (5) three minimum-tillage cotton activities under LEPA irrigation at three different ET levels which were defined as: MINL at 0.50 ET, MINM at 0.75 ET, and MINH at 1.00 ET; and (6) three cotton-terminated-wheat activities under LEPA irrigation at three different ET levels which were defined as: TRWL at 0.50 ET, TRWM at 0.75 ET, and TRWH at 1.00 ET.

The dryland cotton production activities in the linear programming model included: (1) conventional-cotton-solid (CTDS); (2) minimum-tillage -cotton-solid (MINDS); (3) minimum-tillage-cotton-two-by-one (MINDK); (4) cotton-terminated-wheat-solid (TRWD); (5) cotton-sorghum-solid rotation (CSD); (6) cotton-wheat-solid rotation (CWD); and (7) cotton-fallow- wheat-solid rotation (CFWD). In Table 1, the average cotton lint yields across all production activities in the model are presented.

The objective function of the model was that of maximizing the present value of net revenues to land, management and unpaid labor, and risk over a twenty year planning horizon. The cost of production and cotton prices used in the programming model were obtained from the 1993, 1994, and 1995 AG-CARES reports. It is important to point out, that the cotton prices used, reflected the cotton lint quality differentials associated with each of the production systems. Table 2, depicts the three-year average net returns per acre for each of the production activities included in the optimization model. Also, a water availability constraint at twenty-one different levels was included in the model. The number of water availability levels were determined as follows. First, the optimization model was run with a very high level irrigation water available to find out the upper bound level of water that would be required for the irrigation water availability constraint not to be binding. The results for this run showed that the upper bound optimal amount of water was 326,400 acre-inches over the assumed twenty-year planning horizon. Then, the model was ran 20 times, each additional run was conducted assuming a 5 percent decrease in irrigation water availability. It is important to point out that this model was ran assuming implementation of the 1996 Farm Bill, or Federal Agriculture Improvement and Reform (FAIR) Act of 1996 (ie. base acreage requirements for cotton, as well as for other crops were removed).

Results

As mentioned previously, there were twenty-one different water availability constraints considered. Because of space limitations, the explicit results of the optimal decision rules of cropland use for only five of scenarios considered are presented here. In particular, Table 3 depicts the results of the linear programming model for zero acre-inches of water availability. This table shows that, if there is no water available, it would be optimal to plant all 1360 acres to minimum-tillage-cotton-solid (MINDS) each year. The present value of net revenues under this irrigation water availability scenario is $1,138,776.

Tables 4 to 7, depict the explicit cropland optimal decision rules under alternative irrigation water availability scenarios. For example, Table 4 shows that the optimal decision rule to follow when water availability is 114,240 acre-inches would be: to plant all 1360 acres to cotton-terminated-wheat (TRWM) with LEPA irrigation at the 0.75 ET level from year 0 to 8. In year nine 453.33 acres should be planted to TRWM and 906.67 acres should be planted to MINDS. Then, for the remainder of the twenty year period, from year 10 to 19, all 1360 acres should be planted to MINDS. Similar interpretations could be made of the explicit solutions depicted in Tables 5 to 7.

It is important to point out, however, that the presence of the cotton-terminated-wheat farming system (at the medium or high level of ET), when irrigation water is available, and the minimum-tillage-cotton-solid farming system, when irrigation water is constrained, prevailed throughout all irrigation water availability scenarios analyzed. Overall, an evaluation of all the optimal solutions found reveals that as irrigation water availability is reduced, the optimal strategy would be to use those farming systems with high water use levels in the early years. Then, as the planning horizon progresses, the optimal solution becomes one which uses farming systems with lower water requirements until the point at which dryland cotton is fully brought into the optimal solution.

Figure 1, depicts the impacts of irrigation water availability on the present value of net returns. This figure reveals that the differential between having and not having irrigation water is quite significant, ie. a 71 percent reduction of the present value of net revenues can be expected between a no binding constraint on irrigation water and dryland farming.

Conclusions

Few conclusions can be drawn from the findings in this study. First, significant cropland use shifts would be expected to occur as a result of irrigation water availability. Second, irrigation water availability has a significant impact on the expected level of net returns. Finally, it is important to point out that regardless of the level of irrigation water availability, the optimal solutions from all scenarios analyzed do not include the conventional cotton production practices which most producers in the area use at this time. That is, producers in the area could increase the present value of net returns to land, management and unpaid labor, and risk by adopting the cotton farming systems being developed at the AG-CARES facility in Dawson County, Texas.

Acknowledgments

The authors thank Phillip Johnson, Sukant Misra, and Blake Bennett for their assistance. Texas Tech University, College of Agricultural Sciences and Natural Resources Publication T-1-445.

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Table 1. Average cotton lint yields (lbs/acre) by farming system and irrigation quantity at AG-CARES, Lamesa, Texas, (1993-1995).

		Irrigation Treatment		
		(L)	(M)	(H)
Farming System	Dryland	0.5ET (6")	0.75ET (9")	1.00ET (12")
CTDS	279	-	-	-
CTS	-	488	692	953
CTL	-	631	992	951
CSD	255	-	-	-
CS	-	871	1026	1230
CWD	553	-	-	-
CFWD	490	-	-	-
CW	-	882	1087	1300
MINDS	371	-	-	-
MINDK	295	-	-	-
MIN	-	761	941	978
TRWD	274	-	-	-
TRW	-	753	1082	1151

Table 2. Average net returns ($/acre) by farming system and irrigation quantity at AG-CARES, Lamesa, Texas, (1993-1995).

		Irrigation Treatment		
		(L)	(M)	(H)
Farming System	Dryland	0.5ET (6")	0.75ET (9")	1.00ET (12")
CTDS	279	-	-	-
CTS	-	258	366	505
CTL	-	336	529	507
CSD	109	-	-	-
CS	-	315	355	408
CWD	152	-	-	-
CFWD	105	-	-	-
CW	-	882	1087	1300
MINDS	195	-	-	-
MINDK	155	-	-	-
MIN	-	761	941	978
TRWD	146	-	-	-
TRW	-	401	575	612

Table 3. Optimal Farm Plan - 0 Acre Inches Water Availability.

	Activity Acreage			Total
Year	TRWH	TRWM	MINDS	Acreage
0	-	-	1360	1360
.	-	-	.	.
.	-	-	.	.
19	-	-	1360	1360

Table 4. Optimal Farm Plan - 114,240 Acre Inches Available.

	Activity Acreage			Total
Year	TRWH	TRWM	MINDS	Acreage
0	-	1360	-	1360
.	-	.	-	.
.	-	.	-	.
8	-	1360	-	.
9	-	453.33	906.67	.
10	-	-	1360	.
.	-	-	.	.
.	-	-	.	.
19	-	-	1360	1360

Table 5. Optimal Farm Plan - 244,800 Acre Inches Available.

	Activity Acreage			Total
Year	TRWH	TRWM	MINDS	Acreage
0	-	1360	-	1360
.	-	.	-	.
.	-	.	-	.
19	-	1360	-	1360

Table 6. Optimal Farm Plan - 293,760 Acre Inches Available.

	Activity Acreage			Total
Year	TRWH	TRWM	MINDS	Acreage
0	1360	-	-	1360
.	.	-	-	.
.	.	-	-	.
11	1360	-	-	.
12	-	1360	-	.
.	-	.	-	.
.	-	.	-	.
19	-	1360.	-	1360

Table 7. Optimal Farm Plan - 326,400 Acre Inches Available.

	Activity Acreage			Total
Year	TRWH	TRWM	MINDS	Acreage
0	1360	-	-	1360
.	.	-	-	.
.	.	-	-	.
19	1360	-	-	1360

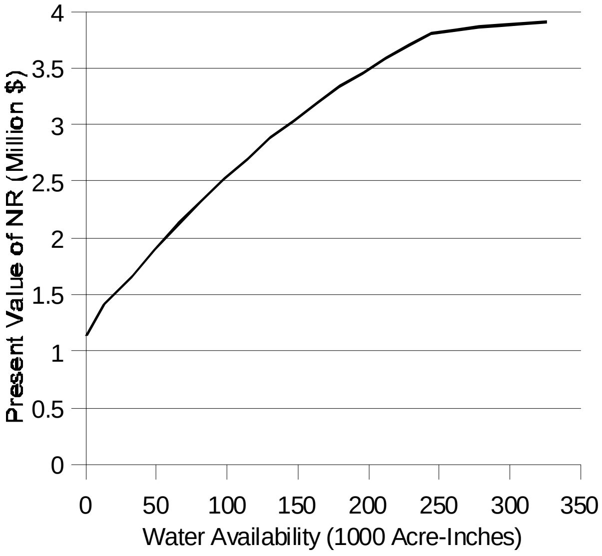

Figure 1 Present of Net Revenues of Water Availibility Levels.