CONSERVATION TILLAGE vs CONVENTIONAL TILLAGE SYSTEMS FOR COTTON: AN ECONOMIC COMPARISON

Kenneth W. Paxton, David R. Lavergne, and Robert L. Hutchinson[1]

INTRODUCTION

Increasing concern about soil erosion, water quality, and diminishing soil productivity has stimulated interest in alternative cotton production systems designed to minimize these problems. These concerns about soil and water resources have been reflected in recent legislation, including the 1990 farm bill. Current regulations apply primarily to producers on highly erodible land. Producers on soils defined as highly erodible must implement practices that reduce soil erosion rates to acceptable levels if they wish to remain eligible for certain commodity program benefits.

Approximately 40% of the cotton production in Louisiana is located in the Macon Ridge area of the state. The loess soils of this area are silt loam and are classified as highly erodible. Many of these soils have K values of 0.41 or greater. Slopes of these soils typically range from 3 to 5%, but may be 8% or higher (Martin et al., 1981). The USDA-SCS has estimated that sheet and rill erosion rates exceed the 3 tons/A tolerance (T) level on 80% of the cotton acreage in the Macon Ridge area (Hutchinson et al., 1991). Conservation of the topsoil in this area is particularly important because the layer of topsoil is very thin (approximately 4 to 6 inches). There are also naturally occurring dense subsoil layers called fragipans that inhibit root penetration (Hutchinson ef al., 1991).

Given the importance of cotton production to this area of Louisiana and the amount of cotton produced on these types of soils, it is important for producers **to** be aware of possible advantages associated with alternative tillage systems. This economical study examines alternative tillage systems for cotton in this area and evaluates them within a whole-farm context. Results of this study should be helpful to farmers faced with the decision to modify production practices.

[1] Department of Agricultural Economics and Agribusiness and Northeast Research Station, Louisiana Agricultural Experiment Station, LSU Agricultural Center, Baton Rouge and Winnsboro, Louisiana.

MATERIALS AND METHODS

Data for this analysis were obtained from research on tillage systems conducted at the Macon Ridge Branch of the Northeast Research Station for the period 1987-92. This research was conducted on a Gigger silt loam soil with a slope of about 2%. Three tillage methods (conventional tillage, ridge-till, and no-till) were studied in conjunction with four cover crops (crimson clover, hairy vetch, winter wheat, and native winter vegetation). The study was set up as a factorial arrangement of tillage systems and winter cover crops in a randomized complete block design with four replications. Each plot was maintained in the same location each year to evaluate the long-term effect of a particular tillage system. For a detailed description of the experimental design and results, see the annual reports from the Northeast Research Station (Hutchinson, 1986-92).

Additional data on erosion potential for selected tillage systems were obtained from the field demonstration/research project (Hutchinson et al. 1991). This project also evaluated the three tillage systems noted above, but with a limited number of cover crop treatments, resulting in a total of six combinations of tillage systems and cover crops. These systems were identical to systems contained in the larger on-station research above.

The agronomic data obtained from the experimental plots were combined with economic data to estimate enterprise budgets for each of the tillage systems. For purposes of this study, each combination of tillage system and cover crop was defined as a separate tillage system. The study was conducted in two phases, with the first phase involving an economic analysis to determine the preferred system from among the 12 alternatives. Individual replications were used as a unit of observation for this analysis, and a total of 24 observations for each system were obtained. The second phase of the analysis incorporated estimates of soil erosion developed for selected tillage systems. These estimates were used to evaluate the impact on profitability of the tillage system's ability to control erosion. Enterprise budgets were used to calculate returns above variable costs (gross margins) for each of the systems. These gross margins were then used to estimate returns above variable costs for each system within a whole-farm context. For this analysis, a farm was assumed to be677 acres of cotton, based on results of a recent survey of cotton farms in the area. Whole-farm returns are used because it is theoretically correct and farmers generally adopt such a system for the entire farm rather than a portion of the operation.

Stochastic dominance techniques were then used to evaluate the distributions of gross margins on a whole-farm basis. This technique allowed for the inclusion of more information in the analysis. Traditionally, mean values have been used to evaluate alternative production systems or other farm management decisions. While mean values serve as a good first approximation, analytical techniques that consider additional dimensions provide better answers and are preferred. One essential difference is that stochastic dominance techniques consider not only the mean values, but also the variability in the returns.

RESULTS AND DISCUSSION

No Soil Loss Restriction

The first phase of the analysis evaluated the 12 tillage systems without considering soil erosion associated with each system. A summary of yields and associated data from each of the 12 tillage systems (Table 1) indicated the highest average yields were obtained from the no-till system with a wheat cover crop (NT-W). This system also had less variability (as measured by the standard deviation) in yields than any of the other treatments. The wheat cover crop produced the highest yield for all tillage systems, except the conventional tillage system where there was less than a 1-lb difference between the wheat plot and the hairy vetch plot.

While yield is an important factor in evaluating the performance of a tillage system, it is more important to examine costs and returns. Table 1 also shows the per acre costs for each of the systems. These costs represent typical operations and input levels for each system and not average costs for each system. The conventional tillage system with no cover produces the lowest cost/A. The highest cost/A was for the no-till system and wheat cover crop. This system had only slightly higher costs than the no-till system with a hairy vetch cover crop. Most of the variability in costs among systems is due to differences in herbicide costs. While not shown here, there is approximately $25/A difference between the high and low herbicide costs among tillage systems. Differences in insecticide costs among systems also reflect the need to treat for cutworms on the ridge-till and no-till plots. In addition, part of the difference in costs among systems is due to differences in fuel costs. These differences reflect the varying amount of tillage and/or trips over the field required by each tillage system.

By combining the cost information with the yield information presented in Table 1, it is possible to calculate gross margins. For purposes of this analysis, constant input costs and output prices were assumed. While this assumption is somewhat restrictive, it places the focus on the performance of the tillage system and not on changes in input and/or output price changes. The conventional tillage system with a wheat cover crop yielded the highest gross margin (Table 2). Note that this system also had the highest minimum net return. This is important for producers who cannot afford a system that may produce negative returns. The standard deviation gives an indication of the Variability in net returns among the tillage systems. Note that the system with the highest net returns also has one of the lowest standard deviations. This means that this system produced a high income with low variability from one year to the next.

The distributions of gross margins were evaluated utilizing a software package developed by Cochran and Raskin (Cochran and Raskin, 1988). This program produces efficient sets for quasi first- and second-degree stochastic dominance. Results of this analysis are also presented in Table 2. As shown here, several tillage systems are in the quasi first-degree stochastic dominant set. Only those tillage systems with very low gross margins are eliminated from the efficient set. For the quasi second-degree stochastic dominant efficient set, only the conventional tillage system with a wheat cover crop is selected. This tillage system is preferred to the other systems in the test. Note that this system did not have the highest average yield nor the lowest cost on a per acre basis. However, the whole farm returns (Table 2) indicate that this system had the highest return and relatively low Variability in returns as measured hy the standard deviation.

Table 1. **Average yield and standard deviation** for **selected cotton tillage systems, Northeast Research Station, Macon Ridge Branch,** Louisiana, **1987-1992.**

Tillage Systems[1]	Average Yield	Standard Deviation	Variable Costs	Soil Erosion[2]
	(lb/A)	(lb/A)	($/A)	(t/A)
CT-NC	717.04	185.21	345.45	16.17
CT-CC	708.46	163.92	351.10	N/A
CT-HV	738.25	207.59	362.06	13.88
CT-W	737.42	152.97	35959	N/A
RT-NC	61933	185.97	35835	11.91
RT-CC	591.42	154.53	361.49	N/A
RT-HV	700.71	190.57	380.96	N/A
RT-W	73758	204.25	382.87	N/A
NT-NC	674.25	190.66	366.41	6.04
NT-CC	660.67	205.97	371.14	N/A
NT-HV	737.58	229.23	387.15	3.27
NT-W	753.96	171.15	389.11	2.12

[1] **CT = Conventional Tillage, RT = Ridge-Till, NT = No-Till, NC = No Cover, CC = Crimson Clover Cover, HV = Hairy Vetch Cover, W = wheat Cover.**

[2] **Estimated 3-year average for the period 1988-90. For details on estimating procedure, see Hutchinson *el al.*, 1991.**

Table 2. **Quasi first- and second-degree stochastic dominance** rankings **of cotton tillage systems, Northeast Research Station, Macon Ridge Branch, Louisiana, 1987-1992.**

Tillage Systems[1]	First-Degree Dominant	Second-Degree Dominant	Average Returns	Standard Deviation
			($/farm)	($/farm)
CT-NC	•		166,242.90	89,937.65
CT-CC	•		157,750.10	79,264.38
CT-HV	■		166,34030	99,666.86
CT-W	•	•	167,969.60	73,609.28
RT-NC			103,092.60	90,20020
RT-CC			85,870.35	74,930.14
RT-HV	•		132,949.40	92,150.73
RT-W	•		152,078.40	98,77530
NT-NC			128,561.10	91,723.10
NT-CC			117,961.80	99,489.94
NT-HV	■		150,133.10	10,504.50
NT-W	•		157,863.90	83,009.95

[1] **CT = Conventional Tillage, RT = Ridge-Till, NT = No-TI, NC = No Cover, CC = Crimson Clover Cover, HV = Hairy Vetch Cover, W=wheat Cover.**

Limits on Soil Loss

The second phase of this analysis incorporated restrictions on the amount of soil loss permitted to maintain eligibility for government program participation. The analysis was restricted to six tillage systems and cover crop combinations because estimates for soil losses were available only for those six systems. These data on erosion were used in conjunction with the test plot data to estimate the possible impact of non-compliance on profitability.

It was assumed, for purposes of this analysis, that producers would maintain eligibility for program benefits if erosion could be held to less than 7 t/A/year. Program benefits, as defined here, were restricted to eligibility for deficiency payments. Producers not eligible for this payment would be limited to receiving only the market price for cotton lint. Three of the treatments met the erosion criteria assumed for this analysis (Table 1) (Hutchinson et al. 1991). All of the treatments meeting this standard were no-till treatments.

Results of the stochastic dominance analysis comparing the six tillage systems are shown in Table 3. As shown here, three of the systems were in the first-degree efficient set. This included one system (CT-HV-NG) deemed not eligible for program benefits. Inclusion of this system was somewhat surprising because the average returns were lower and the standard deviation was higher than the conventional tillage system without a cover crop. The primary reason the conventional tillage system was not in the first-degree efficient set was that it had negative returns for some observations. In addition, the stochastic dominance technique used here also considered higher moments of the distribution, such as skewness and kurtosis. Under the rationale of the analytical procedure used here, a low positive return is preferred to a negative return.

Only the no-till system with a wheat cover crop was included in the second-degree eflicient set. This system yielded the highest average net return with a relatively low standard deviation. The average net return for this system was approximately $157,864 compared with $103,173 for the CT-HV-NG system in the first-degree eflicient set. This implies that non-compliance with the assumed level of erosion tolerance cost the producer $54,691 on the average for the whole farm (or approximately $82/A). However, some years the cost would be lower and some years it would be higher.

Table 3. Quasi first- and second-degree stochastic dominance ranking of selected cotton tillage systems, with soil loss constraints, Northeast Research Station, Macon Ridge Branch, Louisiana, 1987-1992.

Tillage Systems[1]	First-Degree	Second-Degree	Average Returns ($/farm)	Standard Deviation ($/farm)	Minimum Return ($/farm)
CT-NC-NG			**105,115.60**	**73,616.69**	**-9830.58**
CT-HV-NG	*		**103,173.30**	**81,543.29**	**-49504.90**
RT-NC-NG			**50,310.94**	**73,963.00**	**-64789.80**
NT-NC-WG			**128,561.10**	**91,723.10**	**2773.87**
NT-HV-WG	*		**150,133.10**	**110,504.50**	**-51055.90**
NT-W-WG	*	*	**157,863.90**	**83,009.95**	**45525.53**

[1] CT = Conventional Tillage, RT = Ridge-Till, NT = No-Till, NC = No Cover, HV = Hairy Vetch Cover, W = Wheat Cover, NG = No Government Payments, WG = With Government Payments.

SUMMARY AND IMPLICATIONS

Twelve tillage systems were evaluated within a whole-farm context utilizing stochastic dominance techniques. The systems included a wide range of tillage operations ranging from no-till to conventional tillage. Each tillage system was evaluated with alternative cover crops, including native winter vegetation. From an agronomic point of view, it is interesting to note that some of the reduced-tillage plots had yields equal to or greater than the conventional tillage plots. Similarly, gross margins on some of the no-till plots were about the same as those on the conventional plots. One important difference was that the no-till plots yielded larger negative returns than conventional tillage plots. This difference in negative gross margins was largely responsible for the no-till systems not being included in the second-degree efficient set.

The conventional tillage plot with a wheat cover crop was the dominant tillage system if limits on soil erosion were not considered. This system produced higher gross margins and lower variability of gross margins than other tillage systems. Costs/A were higher for this system, but the higher returns from increased yields were great enough to offset the higher costs.

Many of the systems did not meet restrictions imposed on the allowable amount of soil erosion. Under these limits, the no-till system with a wheat cover crop was the preferred system. This system produced the highest net returns while keeping soil erosion within the assumed limits.

LIMITATIONS

The results obtained here are applicable to the soil and environmental resources identified above. Since the soils on which the experiments were conducted do not require subsoiling, results obtained here may not be applicable to cotton production on soils requiring deep tillage. Data for this analysis were collected over a 6-year period of time. While this is a substantial time period for most agronomic work, it is not a long time period for observing changes in weather patterns. Results of this analysis might be altered if examined over a longer time period; however, data for longer time periods were not available. While this analysis attempted to incorporate the potential benefits of the soil-conserving abilities of the systems, more work is needed in this area. The soil erosion measures used here were based on estimates of erosion rather than actual measurements. Furthermore, these estimates were not available for all 12 systems. While this analysis incorporated costs to the producer of non-compliance with assumed soil loss tolerances, no attempt was made to estimate costs on a broader scale.

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