Economics of Conservation Tillage Research in Texas

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Summary

Cost of production and profit implications from economic analyses of conservation tillage research differ by regions in Texas. In the semiarid regions, such as the High and Rolling Plains, conservation tillage practices usually reduce total costs of production but not necessarily variable or out-of-pocket costs. Returns to land, management, and risk are usually higher partially because of lower production costs but primarily because of higher value of sales associated with moisture conservation and increased crop yields. Cash flow difficulties may be encountered if increased sales income is insufficient to offset higher out-of-pocket expenses and added machinery investment or conversion costs.

One of the most promising conservation tillage systems for the Texas High Plains region is no-till sorghum following irrigated wheat. Maintaining high levels of wheat residue between crops with no-till practices reduces total production costs, provides for erosion control, and increases soil moisture storage for higher sorghum yields. No-till practices with supplemental irrigation in sorghum production increased returns to land, management, and risk $160 ha-' compared with conventional tillage. Under dryland conditions, returns were $98 ha-' higher with no-till. Substantial reductions in machinery depreciation costs by using no-till practices reduced total production costs $65 ha-' with irrigation but only $2 ha-' under dryland conditions. Relatively high no-till chemical costs compared with tillage costs under dryland conditions largely offset savings in no-till machinery depreciation costs.

Other research evaluating a dryland wheatlno-till sorghum/fallow rotation found that maintaining residues of dryland wheat, which are generally less than irrigated wheat, was profitable. Higher returns were largely due to increases in no-till sorghum yields and reductions in machinery depreciation costs.

New research is underway in the High Plains regarding cotton production following wheat as a grain crop and as a cover crop. Preliminary results indicate a high profit potential for no-till cotton planted in wheat stubble and irrigated cotton planted in a terminated wheat cover crop.

In the Rolling Plains, reduced-tillage cotton and sorghum in conjunction with furrow diking were the most profitable tillage systems analyzed. Lower machinery and labor costs decreased total production costs of reduced-tillage cotton by only $10 ha-' compared with conventional cotton. However, higher yields for reduced-tillage cotton resulted in $138 ha-' higher returns to land, management, and risk. Reduced-tillage sorghum returns were $76 ha-' higher than conventional tillage. Reduced-tillage wheat returns increased $37 ha' over conventional tillage.

Furrow diking in producing cotton and sorghum is a profitable conservation tillage practice in the Rolling Plains. The additional net returns above the additional costs of diking compared to check treatments averaged $57 ha-' in cotton production. The additional returns from diking sorghum averaged $69 ha1.

Economic analyses of conservation tillage research in the Blackland Prairie farming area showed that profitable no-tillage systems exist, but these systems are not yet as profitable as conventional tillage. Conservation tillage practices in this higher rainfall region do not increase crop yields and the value of sales as in the semiarid regions. Significantly higher herbicide costs of no-till exceed the savings in machinery and labor costs, reducing returns below conventional tillage.

This economic assessment revealed that additional conservation tillage research, including economic research, is needed in all regions of Texas. Further research is particularly needed in the higher rainfall areas of Texas to develop conservation tillage systems that are more profitable than conventional systems.

Current farm legislation emphasizes the need for more conservation tillage research. This legislation specifies that a conservation plan will be implemented by 1990 or producers will be denied government-related benefits. This has critical implications for producers in the higher rainfall areas where conservation tillage systems are less profitable than conventional systems.

Soil erosion in agriculture threatens crop and livestock productivity. Social concerns include potential damages from eroded sediment, shortened life of reservoirs, increased risk of flooding, increased costs of removing sediment from municipal water supplies, diminished recreational values, and damage to biological systems. These high socioeconomic costs could he minimized through additional research investments to develop profitable conservation tillage systems for agriculture. Society as well as producers would be mutual beneficiaries.

Introduction

Conservation tillage is one of many developments in agriculture receiving national, regional, and state attention as concerns heighten regarding soil erosion. Problems range from rill and sheet to wind erosion over the

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nation. Wind erosion is generally of more concern to Great Plains producers. In North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, more than 194 million hectares of range and cropland are experiencing wind erosion problems (USDA, 1981). Cropland acreage in the six plains states eroding at an 11 metric ton rate or more exceeds 15 million hectares or about 30 percent of the total cropland. Wind erosion losses in Texas average 33.6 metric tons per hectare, five times more than losses from water erosion.

In discussing environmental impacts of possible reductions in irrigated lands of the West, Stewart and Harman (1984) delineated major areas of highly erodible soil types overlying the Ogallala aquifer in the Great Plains. Conservation tillage was described as having potential to reduce widespread soil losses while conserving underground water supplies and naturally occurring rainfall. The United States Department of Agriculture has projected that more than 80 percent of the U.S. crop acreage will be farmed with some type of conservation tillage practice by 2000 (USDA, 1975).

Adoption rates of conservation tillage in the West are highest in the Northern Plains and lowest in the Southern Plains (Texas and Oklahoma) with the Mountain and Pacific regions intermediate (USDA, 1981). Rates of adoption are related to many factors. Harman and Wiese (1985) summarized several studies, concluding that producers generally accept minimum tillage practices if herbicides control weeds as effectively as conventional tillage practices and if economic advantages can be realized. Farmers adopted no-tillage practices because labor needs, fuel costs, and erosion were reduced. Producers with high education levels tended to adopt no-tillage practices sooner than others. Reasons for not adopting no-till practices were (1) the cost of planters and drills and (2) owned equipment was in good working order. Small farmers tended to be less interested and slow to adopt minimum tillage.

Phillips et al. (1980) summarized the major advantages and disadvantages of reducing tillage practices as follows:

Advantages:

1. Reduced wind and water erosion.
2. Reduced energy requirements.
3. Can be used on sloping land where conventional-tillage practices are not acceptable.
4. Timing of planting and harvesting operations can sometimes be improved.
5. Efficiency of water use can be increased.

Disadvantages:

1. Higher incidences of insects, diseases, and rodents require increased rates of pesticides.
2. Higher management ability is needed.
3. Low soil temperatures may delay planting.

Economic benefits and costs are often the deciding factors in converting successfully from conventional practices to new practices. Harman and Wiese (1985) listed several economic parameters important in estimating relative costs and profitability of alternative tillage systems, including:

1. Tractor fuel, oil, and lubrication costs.
2. Labor time and costs.
3. Herbicide and application costs.
4. Crop yields and related harvesting costs.
5. Interest charges on operating capital.
6. Tractor and equipment depreciation.

Other elements also may change as alternative tillage practices are adopted, such as land rental payments for share-rent situations and management time required per hectare. These two items are important factors to consider for farm operators who rent land on a crop-share basis or those who are planning to expand size of operation.

Effects of conservation tillage practices on variations in income are also important to producers and the rate of adoption. Variations in yields, costs, and benefits of conservation tillage need to be evaluated. Producers vary in their willingness to take risks, particularly in times of economic hardship. Financial commitments, the type of farm organization, and external economic forces can be important factors in forming attitudes toward risk and adopting new techniques of production.

Purpose and Objectives

The purpose of this discussion is to provide producers, scientists, extension professionals, policy makers, and administrators insights into the economic implications of conservation tillage research in Texas. Specific objectives are to:

1. Discuss the importance of economics in evaluating conservation tillage practices and indicate data needed for economic analyses.
2. Analyze economic benefits and costs of ongoing and new conservation tillage research results.
3. Discuss briefly the economic implications of conservation tillage research and additional research needs for Texas.

Importance of Economics in Evaluating Conservation Tillage Practices

Economic analyses of technological advances typically emphasize long-run benefits and costs. There are, however, several short-term impacts on the producer when comparing conservation tillage practices with conventional tillage practices. These include the immediate impacts on crop yields, sales income, variable operating costs, and the farm's cash flow. Longer-term impacts on machinery depreciation costs, yield and income trends, and pay-back on machinery investments must be considered.

Specific data needed for economic analyses of conservation tillage practices include:

1. Description of conventional and conservation tillage operations and dates performed.
2. Chemical application costs, dates applied, and whether custom-hired.
3. Labor time of tillage operations and chemical applications.

4. Comparative yields with indications of statistical significance.
5. Estimates of field operating efficiencies and horsepower requirements of conservation tillage equipment.
6. Investment costs of new equipment or conversion costs of owned equipment.

Such economic data are required to assess the impacts on variable (short-run) and fixed (long-run) costs of adopting alternative production practices or technologies. Once variable or out-of-pocket costs are determined, returns over variable costs (profits) can be estimated. Then, by adding certain fixed-cost items to variable costs such as machinery depreciation, land charges, farm overhead costs, or management fees, long-run profits can be estimated. Often, as in some of the following economic analyses, only those fixed-cost items that change are considered in a comparative analysis using partial budgeting methods. When evaluating conservation tillage practices, machinery depreciation may be the only fixed-cost item affected. Thus, long-run profits, sometimes called returns to land, management, and risk, may not include land charges, farm overhead expenses, or management fees if they are unaffected by the analysis.

Other data indicating long-term yield trends as well as changes in weed pressures, soil productivity, or soil characteristics that may require different levels of inputs in the future, enhance the value of economic analyses. Often, however, long-term research costs and interruptions in research programs prevent projects from being conducted for a sufficient length of time to ascertain long-term effects.

Other important economic impacts beyond the scope of this discussion include the aggregate impacts on crop prices and input costs. For example, increased crop output through increased yields from conservation tillage could increase supplies and, therefore, place downward pressure on crop prices. Similarly, increased use of chemicals and reduced fuel requirements might change the relative price relationship between these two inputs. These and other aggregate price impacts and relationships need to be analyzed to understand the full extent of the economic consequences of conservation tillage.

Economic Analyses of Conservation Tillage Practices

The following section discusses results of economic analyses for various conservation tillage practices in monocrop and crop rotation systems. The discussion emphasizes ongoing and new conservation tillage research by regions of the state for major crops such as sorghum, cotton, and wheat. Multicrop rotations are discussed following the major crops. To keep the presentation brief, a few detailed economic analyses of conservation tillage practices are included. Others are discussed briefly. Some ongoing research that is omitted from this discussion is discussed in the Texas Agricultural Experiment Station companion research monograph, Conservation Tillage in Texas.

Comparisons of conventional and conservation tillage practices used in the research as well as the research results are described briefly for each economic analysis. Some of the research programs are relatively new, being initiated as recently as 1985. Thus, the reader and potential user of these new initiatives should be aware of their very preliminary status at the present time.

Sorghum Conservation Tillage Systems

High Plains

Difficulties exist with volunteer seedling control in continuous no-till sorghum. Wiese et al. (1967) reported early germinating volunteer sorghum in dryland continuous sorghum reduced yields where no seedbed preparation was attempted. The most practical limited-tillage system at the time eliminated one preliminary plowing and one cultivation. Allen et al. (1975) reported no-till irrigated sorghum yields were slightly lower than yields with conventional tillage in the second year of continuous sorghum. Recent development of “safened” sorghum seed that can be used with selected herbicides could enhance the potential of continuous no-till sorghum.

A more promising conservation tillage system recently developed for Texas High Plains producers is no-till sorghum following irrigated wheat in a wheat/sorghum/fallow cropping sequence (Unger and Wiese, 1979; Wiese and Unger, 1983). Sorghum is planted by no-till methods in stubble of the previous wheat crop after an 11-month idle period. Maintaining stubble by chemical means during the 1975-1981 period at Bushland, Texas, resulted in an average 5.6 cm more soil water stored at sorghum planting time than by conventional disk tillage. This additional water storage is roughly equivalent to the gain from a preplant irrigation and resulted in an average 1.12 Mg ha^{-1} increase (51 percent) in dryland sorghum yields over the seven-year test period (Unger, 1987). When compared to sweep tillage, no-till sorghum yields were about 0.65 Mg ha^{-1} higher (30 percent) from an additional 3.8 cm soil water stored during the idle period.

Since no-till sorghum can be irrigated also by using preexisting furrows of the wheat crop, Musick et al. (1977) evaluated no-till irrigated yields with 15 cm and 30 cm applications of irrigation water. Researchers found that 15 cm water increased yields more than 1.01 Mg ha^{-1} with no-till practices compared with conventional disking. With the higher 30 cm application rate, no-till yields were increased nearly 0.50 Mg ha^{-1}. In another evaluation with graded furrows similar to typical irrigated farming conditions, no-till sorghum yields increased more than 1.23 Mg ha^{-1} with about 25 cm irrigation water when compared with disk tillage. The next season irrigation rates were reduced by one half, and no-till sorghum yields were more than 1.01 Mg ha^{-1} above conventional disking. Thus, weed-free wheat stubble maintained with chemicals increased sorghum yields over conventional tillage practices at Bushland. In addition, a preplant irrigation is not generally required to obtain satisfactory emergence of sorghum seedlings. This results in some additional water conservation.

An economic analysis of these no-till sorghum practices (including no-till corn) indicated the depletion rate of the Ogallala aquifer could be slowed while reducing on-farm energy requirements and increasing farm profits (Harman et al., 1985). Three pumping lift situations were evaluated for a 10-year period in the analysis. Present value of returns to land, management, and risk (discounted at 5 percent) were 50 percent higher using no-till practices compared with conventional practices in the average pumping lift situation of 108 meters. Under high lift conditions of 130 meters, returns were increased 67 percent with no-till and in the low lift situation of 85 meters, 45 percent. Water pumped over the 10-year period was reduced using no-till practices by 10 percent, 12 percent, and 13 percent for the low, average, and high pumping lift situations, respectively. On-farm energy use with no-till, including both irrigation and tractor fuel, dropped 15 percent for the low pumping lift, 16 percent for the average pumping lift, and 14 percent for the high lift situation. Energy and water use efficiencies (output per unit of energy or water) also increased dramatically. In the average pumping lift situation, energy use efficiency increased nearly 22 percent while irrigation water use efficiency increased 14 percent. Increases also were attained in the other pumping lift situations.

The following economic analyses of no-till irrigated and dryland sorghum systems update previous analyses in Harman et al., 1985, and Harman 1984 by using 1986 input costs, CCC loan rates, and ASCS deficiency payments. The analysis of irrigated no-till sorghum indicated that no-till variable costs were slightly less ($4 ha^{-1}) than conventional tillage variable costs (Table 1). Reduced tillage and irrigation requirements using the no-till system were offset by increased chemical costs. Total production costs (excluding land and management charges) were reduced by about $65 ha^{-1} with the no-till system, largely because of more than $46 ha^{-1} savings in machinery depreciation. Long-run profits (returns to land, management, and risk) were increased by $160 ha' with the no-till system. This includes added income of $95 ha' from the assumed higher sorghum yield of 0.84 Mg ha' using no-till practices.

Dryland conventionally tilled sorghum was compared with no-till dryland sorghum (Table 2). In this case, however, variable costs using no-till practices were $20 ha^{-1} higher than conventional tillage. Increased chemical costs of the no-till system exceeded savings in conventional tillage expenses. However, total costs of production using no-till practices were about the same as for conventional tillage because of a $23 ha-' reduction in machinery depreciation costs, a savings of about 50 percent with no-till. Returns to land, management, and risk with no-till dryland sorghum were $97 ha-' more than with conventional tillage practices.

Allen and Musick (1975) evaluated a "permanent" bed-furrow system of irrigated no-tillage sorghum following irrigated wheat from 1968 through 1973 at Bushland, Texas. Double-cropped sorghum yields were increased more than 0.66 Mg ha' average during the six years by no-till. This yield increase would allow an expenditure of $60 ha' for chemical control over tillage costs at the 1986 target price less harvesting and storage costs. Further, reduced irrigation costs and machinery ownership costs would allow even more for chemical control.

TABLE 1. ESTIMATED COSTS AND PROFITS FROM IRRIGATED SORGHUM WITH ALTERNATIVE TILLAGE PRACTICES IN AN IRRIGATED WHEAT/SORGHUM/FALLOW ROTATION, TEXAS HIGH PLAINS

Item	Conventional Tillage[1]	No-till[2]
Yield, Mg ha^{-1}	6.73	7.57
	---- $ ha^{-1} ----	
Income:[3]		
Grain	484.56	545.04
Deficiency payment	275.93	310.37
Total	760.49	855.41
Variable Costs:		
Seed	8.90	8.90
Insecticides	14.83	14.83
Fertilizer	38.55	46.26
Herbicides	12.95	61.23
Tractor, equip.	33.58	10.40
Irrigation	211.89	183.35
Labor	58.14	38.05
Interest	13.32	13.99
Harvest, haul	88.96	100.08
Subtotal	481.12	477.09
Returns Over Var. Costs:	279.37	378.32
Fixed Costs:		
Machinery depreciation	80.04	34.15
Irrigation facilities	112.53	97.38
Subtotal	192.57	131.53
Total Costs:	673.69	608.62
Returns to Land, Mgmt. & Risk:	86.80	246.79

[1]Operations included four diskings, sweeping, chiseling, bedding, rolling cultivate and rod weed beds, cultivation of crop and furrow opening for irrigation. Herbicides included 2.2 kg ha^{-1} propazine.

[2]Herbicides included 3.4 kg ha^{-1} atrazine + 9.84 kg ha^{-1} 2,4-D, two applications of Roundup of 0.26 kg ha^{-1} each and 2.2 kg ha^{-1} propazine, all applied by owned sprayer. A furrnw opening operation for irrigation is also included.

[3]Grain price is $0.072 kg^{-1} and deficiency payment $0.041 kg^{-1}.

A risk to this system in the northern Texas Panhandle is early frost and low yields, since no-till practices may delay maturity. New, shorter-season sorghum varieties, however, are being developed to aid in averting this risk. In addition, no-till can save several days of land preparation compared with conventional tillage, minimizing somewhat the hazard of crop injury.

Irrigated and dryland no-till sorghum planted in a terminated wheat cover crop was evaluated at Lubbock and Halfway in 1986 (Keeling, 1987). Although 1986

TABLE 2. ESTIMATED COSTS AND PROFITS FROM DRYLAND SORGHUM WITH ALTERNATIVE TILLAGE PRACTICES IN AN IRRIGATED WHEAT/SORGHUM/FALLOW ROTATION, TEXAS HIGH PLAINS

Item	Conventional Tillage[1]	No-till[2]
Yield, Mg ha^{-1}	**1.82**	**2.66**
	------------$ ha^{-1}	----------
Income:[3]		
Grain	**131.04**	**191.52**
Deficiency payment	**74.62**	**109.06**
Total	**205.66**	**300.58**
Variable Costs:		
Seed	**2.97**	**2.97**
Insecticides	**14.83**	**14.83**
Herbicides	**9.71**	**47.15**
Tractor, equip.	**22.24**	**8.03**
Labor	**20.14**	**10.48**
Interest	**3.06**	**5.34**
Harvest, haul	**29.80**	**34.45**
Subtotal	**102.75**	**123.25**
Returns Over Var. Costs:	**102.91**	**177.33**
Fixed Costs:		
Machinery depreciation	**47.64**	**24.96**
Total Costs:	**150.39**	**148.21**
Returns to Land, Mgmt. & Risk:	**55.27**	**152.37**

[1]Operations included two diskings and three sweepings. Herbicides included 1.7 kg ha^{-1} propazine applied with owned sprayer.

[2]Herbicides included 3.4 kg ha^{-1} atrazine + 0.84 kg ha^{-1} 2,4-D, 0.26 kg ha^{-1} Roundup and 1.75 kg ha^{-1} propazine, all applied with owned sprayer.

[3]Grain price is $0.072 kg^{-1} and deficiency payment $0.041 kg^{-1}

was a year of favorable rainfall in the southern High Plains, sorghum yields using no-till practices were significantly higher under both irrigated and dryland conditions. Irrigated yields with no-till sorghum following terminated wheat were 1.76 Mg ha' and 1.15 Mg ha-1 higher than conventional tillage at Lubbock and Halfway, respectively. Dryland no-till sorghum yields increased over conventional tillage 0.52 Mg ha1 at Lubbock and 2.09 Mg ha' at Halfway.

Using the experimental yields of 1986, irrigated returns to land, management, and risk based on custom tillage rates were more than $173 ha' higher than conventional tillage at Lubbock and $94 ha' higher at Halfway. Under dryland conditions, returns to land, management, and risk increased nearly $91 ha1 and $116 ha-' at Lubbock and Halfway, respectively, using no-till practices.

Rolling Plains

The soils of the Rolling Plains characteristically have poor structural stability, which often results in significant losses of water and soil to runoff following even moderate rainfall (Gerard, 1987). Water is the dominant factor influencing yields in this area (Clark, 1985). Since the conservation of water and soil in tillage systems occur simultaneously, it is not surprising that some of the most profitable new farming systems are conservation tillage systems. Tillage systems that reduce water runoff in the Rolling Plains generally have higher yields and tend to be more profitable compared to conventional systems that do not specifically conserve water. Research has been underway for a number of years (Gerard et al., 1983; Gerard and Bordovsky, 1984; Clark et al., 1985). Economic evaluations were initiated in 1985 (Clark, 1985; Martin, 1985).

At the Chillicothe-Vernon research station, C.J. Gerard (1987) analyzed the effects of subsoiling and diking on yields of sorghum from 1979 through 1985. Based on the results of this study, partial budgeting was used to estimate the additional costs and returns from different diking and subsoiling tillage practices by location on the land slope. The additional returns and production costs were based on average increases above a check treatment that received recommended crop production practices.

In Table 3, the additional costs of subsoiling sorghum exceeded the value of the additional returns on the upper and middle slope positions. Added returns exceeded the added tillage costs for all other treatments, making them more profitable than conventional practices. Diking only was the most profitable treatment on average for all slope positions, although diking with subsoiling was most profitable on the upper slope.

Other research at Chillicoth-Vernon included a continuous reduced-tillage sorghum production system using furrow diking and two less tillage operations than the conventional tillage system (Clark, 1985). The reduced-tillage system was clearly superior in terms of economic returns over the conventional system (Table 4). Based on 1985 experimental results, the returns were $76 ha-' above the conventional system. Although only two diking operations were planned in this research, an additional cultivation with diking was apparently needed to control weeds. However, the additional operation added only $9.24 ha-' to the total cost of production.

Cotton Conservation Tillage Systems

High Plains

A no-till dryland cotton system following irrigated barley was evaluated at Etter, Texas, from 1983 through 1986 (Harman and Wiese, 1987). The first and most important limitation of this no-till cotton system is absence of labeled herbicides that can be applied to small grain stubble to satisfactorily control weeds until cotton is planted the next spring. Producers using the experimental no-till weed control program in Table 5 are at risk since it is not now labeled for cotton. Barley stubble was maintained with no-till chemical weed control practices for 11 months before planting cotton.

No-till lint yields in 1983 were 0.017 Mg ha1 (9 percent) higher than conventionally tilled yields. In 1984,

TABLE 3. ESTIMATED ADDITIONAL RETURNS OVER ADDITIONAL COSTS OF DIFFERENT DIKING-SUBSOILING TREATMENTS AND LOCATION ON THE SLOPE FOR COTTON AND SORGHUM PRODUCTION IN THE ROLLING PLAINS[1]

Treatment and Position on Slope	Cotton[2]	Sorghum'
Upper Position	----------\$ ha^{-1}----------	
Subsoiled[3]	—	– 15.29
Half-diked*	**30.49**	**55.72**
Diked	**68.72**	**91.53**
Diked & subsoiled[5]	**42.57**	**100.32**
Middle Position		
Subsoiled	—	– 13.52
Half-diked	**16.46**	**13.47**
Diked	**72.10**	**70.05**
Diked & subsoiled	**63.38**	**62.96**
Lower Position		
Subsoiled	—	**32.42**
Half-diked	**14.85**	**11.91**
Diked	**26.93**	**44.82**
Diked & subsoiled	**39.19**	**17.94**
All positions		
Subsoiled	—	**1.16**
Half-diked	**19.99**	**27.03**
Diked	**56.63**	**68.84**
Diked and subsoiled	**47.91**	**60.42**

'All diking treatments include one preplant and one postplant operation.

[2]The analysis assumed 1986 input costs and crop prices received.

[3]Cotton did not receive a subsoil-only treatment.

[4]Half-diked treatment was diking every other row.

'Included diking & subsoiling as one preplant operation and diking only as a postplant operation.

1985, and 1986, no-till practices raised yields by 0.2 Mg ha^{-1} (76 percent), 0.022 Mg ha^{-1} (15 percent), and 0.219 Mg ha^{-1} (47 percent), respectively. Over the four years, average yields from no-till practices were 0.115 Mg ha^{-1} (44 percent) higher than with conventional tillage practices. The increase in the no-till yield was largely due to an average yearly increase of 4.5 cm available soil moisture stored during the 11-month idle period after barley harvest.

Thirteen cultural operations may be needed for conventional cotton production (Table 5). These 13 operations can be replaced by four, three of which are chemical applications. More chemical applications will be necessary if the unlabeled atrazine/Cotoran mix is substituted by repeated applications of contact herbicides to avoid risk of atrazine injury to the following cotton crop. Three additional Roundup applications of 0.43 kg ha^{-1} each would cost slightly less than the atrazine/Cotoran mix. Precautionary measures need to be taken to avoid possible drift injury to adjacent crops when applying contract herbicides by air.

TABLE 4. ESTIMATED COSTS AND RETURNS OF CONVENTIONAL VERSUS REDUCED TILLAGE SORGHUM IN THE ROLLING PLAINS OF TEXAS

Item	Continuous Conventional' (no diking)	Continuous Reduced' (3 dikings)
Yield, Mg ha^{-1}	**2.69**	**3.15**
	----------\$ ha^{-1}----------	
Income:		
Grain @ **\$0.097** kg^{-1}	**261.31**	**306.43**
Deficiency pmt. @ **\$0.018** kg^{-1}	**48.58**	**56.98**
Total	**308.59**	**363.41**
Expenses:		
Seed	**5.93**	**5.93**
Fertilizer	**47.47**	**47.47**
Herbicides	**10.08**	**8.40**
Custom Herb. applic.	**8.65**	—
Machinery	**21.52**	**19.97**
Machinery labor	**23.18**	**18.66**
Interest	**9.32**	**7.14**
Total Preharvest Costs:	**126.45**	**107.57**
Harvest, haul	**47.42**	**51.52**
Total Variable Costs:	**174.53**	**159.09**
Returns Over Variable Costs:	**134.36**	**204.32**
Fixed Costs:		
Machinery	**52.46**	**44.72**
Total Costs:	**226.32**	**203.81**
Returns to Land, Mgmt. & Risk:	**83.57**	**159.60**

'Operations included shredder, chisel, fertilize, tandem disk, sweep disk hedder, rolling cultivate, plant and rolling cultivate (eight operations plus one custom herh. application). Herbicide included 1.322 kg ha^{-1} of Milogard.

'Operations included sweep disk bedder, May diker/herb., rodweed/fert. June diker, plant and July diker (*six* operations). Herbicide included 1.10 kg ha^{-1} of Milogard.

A major limitation to the no-till system was that variable costs increased \$118 ha^{-1} over conventional tillage (Table 5). Producers having difficulty obtaining adequate operating capital may not be able to get financing for the high chemical costs. Total costs using no-till practices were \$45 ha^{-1} higher than conventional tillage. More than \$73 ha^{-1} (79 percent) in machinery depreciation costs were saved with the no-till system. Returns over variable costs were \$80 ha^{-1} higher for the no-till cotton system after including income from the additional yield of 0.115 Mg ha^{-1} lint. Returns to land, management, and risk were increased \$153 ha^{-1} with no-till practices.

No-till cotton planted in a wheat cover crop was evaluated at Lubbock and Halfway in 1986 (Keeling,

TABLE 5. ESTIMATED COSTS AND PROFITS OF CONVENTIONAL VERSUS NO-TILL DRYLAND COTTON FOLLOWING IRRIGATED SMALL GRAINS, TEXAS HIGH PLAINS*

Item	Conventional Tillage'	No-Ti11[2]
Lint Yield, Mg ha^{-1}	,265	,380
	-----------$ ha^{-1}	-----------
Income:[3]		
Lint	274.08	393.70
Seed	27.83	39.98
Deficiency payment	151.62	217.79
Total	453.53	651.47
Expenses:		
Seed	14.83	14.83
Fertilizer	12.36	12.36
Herbicides	14.83	147.86
Insecticides	19.77	19.77
Tractor, equipment	51.94	19.25
Tractor, labor	27.90	18.43
Hoe labor	25.95	25.95
Interest	13.74	26.69
Harvest, haul	37.07	37.07
Ginning bagging & ties	50.51	65.11
Total Variable Costs:	268.90	387.32
Returns Over Variable Costs:	184.63	264.15
Fixed Costs:		
Machinery depreciation	92.96	19.60
Total Costs:	361.86	406.92
Returns to Land, Mgmt. & Risk:	91.67	244.55

***Warning: the experimental no-till chemicals used include atrazine, which may cause crop injury. Producers are at risk using the atrazine/Cotoran mix since atrazine is not labeled preplant for cotton.**

'Operations included shredding, two diskings, chiseling, three sweepings, bedding, rolling cultivate beds, two sandfighter and two crop cultivations.

'Herbicides applied by owned sprayer included 1.7 kg ha^{-1} atrazine + 2.2 kg ha^{-1} Cotoran, 0.56 kg ha^{-1} Roundup + 0.56 kg ha^{-1} Banvel and in April, 2.2 kg ha^{-1} Caparol + 0.56 kg ha^{-1} 2,4-D. One seasonal cultivation is included. Note: Roundup can be used in lieu of the unlabeled atrazine/Cotoran mix to avoid possible crop injury.

[3]Lint price is $1.035 kg^{-1}, seed price is $.066 kg^{-1} and deficiency payment is $.573 kg^{-1}. Roundingofyields may prevent numbers from being accurate.

1987). Irrigated lint yields were not affected by no-till practices, but dryland yields trended lower although not statistically significant. The preliminary economic analysis was based on 1986 experimental lint yields and grades, and on custom rates for tillage operations. Under irrigated conditions, returns to land, management, and risk using no-till were increased over conventional tillage by $37 ha-' and $94 ha-' at Lubbock and Halfway, respectively. In contrast, under dryland conditions, returns to land, management, and risk were reduced by $47 ha-1 and $67 ha-1 at Lubbock and Halfway, respectively, using the lower experimental yields of no-till.

Significant reductions in tillage costs based on custom rates occurred in 1986 at Lubbock and Halfway using reduced-tillage methods in irrigated and dryland cotton following cotton and sorghum (Keeling, 1987). Compared with conventional tillage practices under irrigation at Halfway, reduced tillage preharvest costs were lowered by $54 ha^{-1} following cotton and $64 ha^{-1} following sorghum. At Lubbock, reduced tillage methods saved $35 ha^{-1} and $12 ha^{-1} prebarvest costs following cotton and sorghum, respectively.

In most cases cotton lint yields increased, with the exception being a 0.045 Mg ha^{-1} loss in yield at Halfway following sorghum. As a result of the yield increases, higher profits ranging from $104 ha^{-1} to $175 ha^{-1} were realized with reduced-tillage practices. At Halfway, where lint yields dropped, profits from reduced-tillage remained $40 ha^{-1} higher than with conventional tillage practices because of substantial reductions in tillage costs.

Under dryland conditions, production costs using reduced-tillage practices also were lower than conventional tillage. Preharvest costs of reduced-tillage cotton following cotton and sorghum at Lubbock were lowered by $27 ha-' and $15 ha-', respectively. At Halfway, cost reductions of $17 ha^{-1} and $52 ha-' were attained following cotton and sorghum, respectively. Impacts on lint yields at the two locations were mixed. At Lubbock, reduced-tillage yields were lower following cotton and maintained following sorghum. In contrast, an increase in lint yields occurred at Halfway following cotton and a reduction following sorghum. Returns to land, management, and risk using reduced tillage methods, as a result, were generally about the same or higher than conventional tillage with the exception being Lubbock, where lint yields were lower following cotton.

Rolling Plains

Furrow diking and subsoiling tillage practices in a continuous reduced-tillage cotton system were evaluated from 1980 through 1985 in the Rolling Plains (Gerard, 1987). In Table 3, results of the economic analysis indicate that the added costs and added returns from all diking or subsoiling practices were more profitable than conventional tillage at upper, middle, and lower positions on the land slope. Of the conservation tillage practices evaluated, diking only was more profitable than subsoiling, half-diked, and diking with subsoiling on the upper and middle positions of the slope. Diking with subsoiling was the highest profit practice on the lower slope position. On average, over all slope locations, diking only was the most profitable conservation tillage practice.

An economic analysis of two cotton production systems, conventional and reduced tillage with diking, were evaluated in 1985 at Chillicothe-Vernon (Table 6; Clark, 1985). With returns to land, management, and risk $138 ha-' above the conventional system, the continuous reduced-tillage cotton system appears very promising in terms of potential to increase returns. Key

TABLE 6. ESTIMATED COSTS AND RETURNS OF CONVENTIONAL VERSUS REDUCED TILLAGE COTTON IN THE ROLLING PLAINS OF TEXAS

Item	Continuous Conventional' (no diking)	Continuous Reduced' (2 dikings)
Lint Yield, Mg ha^{-1}	0.278	0.353
Lint price $ kg^{-1}	1.169	1.169
	--------------$ ha^{-1}---------- ---	
Income:		
Lint	324.79	412.14
Seed @ $0.076 kg^{-1}	33.01	42.28
Deficiency pmt. @ $0.419 kg^{-1}	116.43	147.89
Total	474.23	602.31
Expenses:		
Seed	13.64	13.64
Fertilizer	37.48	37.48
Herbicides	11.12	11.12
Machinery	26.12	21.40
Machinery labor	29.06	23.60
Interest	10.50	8.45
Total Preharvest Costs:	127.92	115.69
Harvest, haul	25.94	25.94
Ginning bagging & ties	57.03	72.45
Total Variable Costs:	210.89	214.08
Returns Over Variable Costs:	263.34	388.23
Fixed Costs:		
Machinery	102.79	89.72
Total Costs:	313.68	303.80
Returns to Land, Mgmt. & Risk:	160.55	298.51

'Operations included chisel, tandem disk/herb., sweep cult, sweep disk bedder, apply fertilizer, rolling cultivate, plant, rotary hoe, and two rolling cultivate (10 operations). Herbicide applied included 0.83 kg ha^{-1} of Treflan.

'Operations included sweep disk bedder/herb., May diker, rodweed/fert., plant, and June diker (five operations). Herbicide applied included 0.83 kg ha^{-1} of Treflan.

to the increased returns is the increased yield of 0.075 Mg ha-¹ of the reduced tillage system with two diking operations.

Wheat Conservation Tillage Systems

High Plains

The recent development of new herbicides, Glean and Ally, for continuous wheat production allows a reduction in tillage requirements. Some tillage will be needed, however, to control volunteer wheat and weedy grasses unless repeated applications of contact herbicides are applied. Before the development of the new herbicides, no-till continuous wheat production has met with only limited success, encountering difficulties in controlling weeds. Even now, uncontrolled volunteer wheat in the new crop may lead to an increased incidence of diseases. Wheat streak mosaic virus in the new crop is a common disease that occurs across the Great plains if volunteer wheat is not controlled (Porter, 1985).

Allen et al. (1976) reported yield increases in no-till irrigated wheat averaging 0.314 Mg ha' at Bushland, Texas. This irrigated system alternated between a year of no tillage followed by limited tillage the next year to rebuild irrigation beds-. Management of the limited-tillage second crop, however, was only partially successful because of excessive crop residues on the reformed beds. Recently improved no-till grain drills may alleviate some of these previous difficulties encountered in crop establishment.

Rolling Plains

A potential for soil erosion losses exists in dryland wheat/fallow production systems when land lies idle more than a year between crops. Producing continuous dryland wheat also poses problems, however. In addition to a higher risk of crop failure due to plant water stress, an increase in disease has been observed, particularly after several years of continuous wheat production. At Munday, on land having a long history of wheat production, reducing tillage in 1986 increased the estimated yield loss from diseases more than 10 percent compared with conventional tillage practices (Bordovsky and Worrall, 1987). This was not the case, however, at Chillicothe-Vernon on land that had one year of wheat production history. In this situation, diseases were nil under both conventional and reduced tillage (Worrall, 1987).

In other research at Chillicothe-Vernon using reduced tillage and no-till in 1985, yields of continuous reduced-tillage wheat were about the same as conventional tillage (Clark, 1985). Both of the reduced-tillage systems resulted in higher returns because of total production costs lower than the conventional tillage system (Table 7). In the two reduced tillage systems, substituting one Roundup application in the no-till system for the chisel/sweep tillage operation in the reduced-tillage system reduced machinery depreciation costs $9 ha-' but increased preharvest costs $19 ha^'. Thus, returns with no-till were $10 ha-' lower than the reduced-tillage system.

Multicrop Conservation Tillage Systems

Wheat/Sorghum/Fallow, High Plains

Jones (1987) reported an increase in no-till sorghum yields over conventional tillage yields of nearly 0.4 Mg ha-' following dryland wheat at Bushland, Texas, during 1982 through 1986. Another tillage system using no-till practices during the fallow period following sorghum and prior to wheat seeding also was evaluated. Wheat yields using no-till practices during fallow averaged nearly 0.1 Mg ha-' less than when using conventional sweep tillage.

An economic analysis in Table 8 compares the conventionally tilled wheat/no-till sorghum/fallow rotation

TABLE 7. ESTIMATED COSTS AND RETURNS OF CONVENTIONAL VERSUS NO-TILL AND REDUCED TILLAGE WHEAT IN THE ROLLING PLAINS OF TEXAS

Item	Continuous Conventional'	Continuous No-till[2] (Roundup)	Continuous Reduced[3] (sweeps)
Yield, Mg ha^{-1}	2.15	2.14	2.14
	----	--------$ ha^{-1} ----------	----------
Income:			
Grain @ $0.103 kg^{-1}	222.98	222.29	222.29
Deficiency pmt. @ $0.039 kg^{-1}	85.40	85.13	85.13
Total	308.38	307.42	307.42
Expenses:			
Seed	12.85	12.85	12.85
Fertilizer	44.18	44.18	44.18
Herbicides	—	35.21	15.44
Custom Herb. applic.	—	17.30	8.65
Machinery	35.85	6.62	13.54
Machinery labor	19.17	5.04	8.47
Interest	10.53	10.53	9.27
Total Preharvest Costs:	122.58	131.73	112.40
Harvest, haul	39.14	39.12	39.12
Total Variable Costs:	161.72	170.85	151.52
Returns Over Variable Costs:	146.66	136.57	155.90
Fixed Costs:			
Machinery	45.00	8.57	17.40
Total Costs:	206.72	179.42	168.92
Returns to Land, Mgmt. & Risk:	101.66	128.00	138.50

'Operations included deep chisel, three chiselisweep, drillifertiliae and fertilize (six operations).

'Operations included drill/fertilize and fertilize (two operations plus two custom applications of herb.). Herbicide included 0.017 kg ha^{-1} of Glean and 0.413 kg ha^{-1} of Roundup.

[3]Operations included chiselisweep, drill/fertilizer and fertilize (three operations plus one custom application of herb.). Herbicide included 0.017 kg ha^{-1} of Glean,

and the no-till wheatlno-till sorghumlfallow rotation with conventional tillage practices. Costs were summed for a complete cycle of the two-croplthree-year rotation based on **1** hectare each of wheat, sorghum, and fallow. Tillage and chemical expenses during fallow were included with the wheat expenses.

Reducing tillage practices and increasing chemical use raised variable costs over conventional tillage for the two-croplthree-year rotation by about $16 with the conventionally tilled wheatlno-till sorghumlfallow system and by $41 with the no-till wheat/no-till sorghum/fallow system. Reductions in depreciation costs were $22 and $30, respectively, which includes the yearly depreciation cost of a relatively expensive no-till grain drill for seeding no-till wheat in the latter rotation. Compared with conventional tillage of both crops, total costs were only slightly lower ($6) for the conventionally tilled wheat/no-till sorghumlfallow rotation but were $11 higher for the no-till wheat/no-till sorghum/fallow system. Returns to land, management, and risk were increased $48 and $21 for the respective systems, largely reflecting the additional income from the higher sorghum yield when using no-till practices.

Wheat/Sorghum with Limited Irrigation, High Plains

Declining water supplies, high irrigation costs, and operating capital limitations have forced producers in the Texas High Plains to consider reducing irrigation application rates. Residue levels from wheat stubble are, therefore, reduced compared with higher levels of irrigation. Unger (1978) indicates soil moisture storage increases significantly by maintaining residue levels on the soil surface during the 11-month idle period between wheat and sorghum. Musick et al. (1977) found no-till sorghum yields with low irrigation rates were higher than conventional-till yields, but this was following adequately irrigated wheat with high residue levels.

Harman and Regier (1987), using only one irrigation application on wheat and sorghum, compared yields, costs, and profitability of a conventionally tilled wheatlsorghum rotation with two skip-drilled wheat/no-till sorghum rotations in 1985 and 1986. Wheat was

TABLE 8. ESTIMATED COSTS AND PROFITS OF DRYLAND WHEAT/DRYLAND SORGHUM/FALLOW ROTATION WITH ALTERNATIVE TILLAGE PRACTICES, TEXAS HIGH PLAINS

Item	Conv. Wheat/ Conv. Sorghum[1]	Conv. Wheat/ No-till Sorghum[2]	No-till Wheat/ No-till Sorghum[3]
Wheat yield, Mg ha^{-1}	1.61	1.61	1.55
Sorghum yield, Mg ha^{-1}	1.82	2.19	2.19
Income:		--$ ha^{-1} --------------------	
Grain, wheat @ $0.088 kg^{-1}	141.68	141.68	136.40
Grain, sorg. @ $0.072 kg^{-1}	131.04	157.68	157.68
Grazing, wheat	22.24	22.24	22.24
Wheat deficiency pmt. @ $.073 kg^{-1}	117.53	117.53	113.15
Sorg. deficiency pmt. @ $.041 kg^{-1}	74.62	89.79	89.79
Total	487.11	528.92	519.26
Fallow and Wheat Expenses:			
Seed	7.41	7.41	7.41
Herbicides	11.12	11.12	53.57
Tractor, equip.	22.36	22.36	9.27
Labor	18.90	18.90	11.47
Interest	3.78	3.78	7.76
Harvest, haul	31.63	31.63	31.13
Subtotal, wheat	95.20	95.20	120.61
Sorghum Expenses:			
Seed	2.97	2.97	2.97
Insecticides	14.83	14.83	14.83
Herbicides	9.71	47.15	47.15
Tractor, equip.	23.47	8.03	8.03
Labor	20.83	10.48	10.48
Interest	3.19	5.34	5.34
Harvest, haul	29.80	31.83	31.83
Subtotal, sorghum	104.80	120.63	120.63
Total Variable Costs:	200.00	215.83	241.24
Returns Over Variable Costs:	287.11	313.09	278.02
Fixed Costs:			
Machinery depreciation, wheat	42.35	42.35	34.52
Machinery depreciation, sorghum	47.02	24.96	24.96
Subtotal	89.37	67.31	59.48
Total Costs:	289.37	283.14	300.72
Returns to Land, Mgmt. and Risk:	197.74	245.78	218.54

[1]Operations included five sweepings each for wheat and sorghum. Herbicide, included 0.56 kg ha^{-1} 2.4-D on wheat and 1.7 kg ha^{-1} propazine on sorghum.

[2]Operations included five sweepings for wheat. Herbicides included 0.56 kg ha^{-1} 2,4-D on wheat and 3.4 kg ha^{-1} atrazine + 0.84 kg ha^{-1} 2,4-D, 0.26 kg ha^{-1} Roundup and 1.7 kg ha^{-1} propazine for sorghum.

[3]Herbicides for wheat included 0.035 kg ha^{-1} kg ha^{-1} Glean and three applications of Roundup of 0.19 kg ha^{-1} each. No-till sorghum herbicides are in [2].

planted each year following sorghum harvest, and sorghum was planted into standing wheat stubble in the two no-till treatments. Wheat stubble from two alternative drilling patterns of 4 in/1 out and 3 in/2 out (20-cm row spacing) at reduced seeding rates per unit land area was maintained by no-till methods from wheat harvest to sorghum planting. Wheat yields in 1985 and 1986 and sorghum yields in 1986 were not significantly different between treatments. Thus, it was possible to reduce wheat seeding rates using alternative drilling patterns without affecting yields of either wheat or sorghum. Soil moisture stored between crops was about the same between the alternative systems.

A preliminary economic analysis indicated variable costs were nearly equivalent with the three tillage/drilling pattern systems. However, machinery and irrigation equipment depreciation costs were reduced a total of $82 for a complete cycle of the two-cropltwo-year rotation (based on 1 hectare of each crop) by the skip-drilled/no-till alternatives compared with conventional tillage. Thus, returns to land, management, and risk of the two skip-drilled wheat/no-till sorghum systems were about $82 higher than conventional tillage practices.

Wheat/Sorghum or Cotton/Fallow, Rolling Plains

An assessment of reduced-tillage practices during the fallow period following cotton or sorghum and preceding wheat seeding was conducted at Chillicothe-Vernon (Worrall, 1987). Impacts on wheat yields in 1986 were mixed using different crop rotations and reduced tillage methods during fallow compared with conventional tillage practices. Following cotton and a fallow period, wheat yields increased 0.54 Mg ha-' or 42 percent with reduced tillage practices, but following sorghum and fallow, reduced tillage yields dropped 0.30 Mg haL or 17 percent. Wheat diseases posed no particular problems for either rotation using reduced tillage during the fallow period.

Sorghum/CottonlWheat Rotation, Blackland Prairie

An important difference between the Blackland Prairie, a high rainfall region, and the semiarid regions of the High and Rolling Plains is that moisture conservation in the Blackland Prairie does not typically increase crop yields. As long as the yield levels of no-till crops are only maintained relative to conventional tillage, higher economic benefits to crops in no-till systems must be totally derived from reducing input use or by substituting inputs with lower total production costs.

Morrison, Gerik, and Chichester developed an experimental system for long-term conservation crop production on high-clay soils at the Blackland Research Center, Temple, Texas. This no-till system uses wide beds, controlled traffic, and crop residue management. Soil is protected from erosion using this system, and experimental results indicate crop yields are maintained. The system incorporates management practices and production procedures common to most continuous no-till systems in North America, in unique combination with other technologies that required machine adaptation for no-till practices in high-clay soils. The technologies used were reported in Morrison et al., 1985.

Three years of results (1982-1984) from this experimental system were used in the economic analysis of no-till compared with aconventional tillage system. The analysis was based on 1986 input costs and crop prices. The crop systems analyzed included sorghum, cotton, and wheat in rotation. Experimental results indicate little difference in yield levels between notill and conventional tillage with similar fertilization and adequate insect control programs. The average no-till yields from the 1982-1984 experiments were assumed for both no-till and conventional crops.

Labor and machinery costs of producing no-till cotton were more than 40 percent lower than conventional tillage (Table 9). Chemical weed control substitutes for labor and machinery, but in the case of no-till cotton, the significant increase in herbicides used and their costs more than offset the savings in labor and machinery costs. Preharvest costs were $150 ha-' lower for conventional tillage compared with no-till. It should be noted, however, that the no-till system was profitable under 1986 cost-price assumptions.

If herbicide costs decline and if an improved no-till system increased the yield relative to the conventional system, no-till could be competitive in terms of net economic returns. Under the assumed cost-price conditions, a 10 percent increase in the no-till yield would make no-till more profitable than conventional tillage.

Net returns from both sorghum systems in the rotation were lower than cotton, but the same general production cost relationships existed for each crop (Table 9). Labor and machinery costs were lower for no-till sorghum, but the sharply higher use and cost of herbicides increased total costs of the no-till system compared with conventional tillage. However, both sorghum systems were profitable, and a 7 percent increase in the no-till sorghum yield relative to conventional sorghum would make no-till more profitable than the conventional system.

Labor and machinery costs were lower for no-till wheat compared to conventional wheat (Table 9). However, higher herbicide costs for no-till wheat offset the savings in labor and machinery costs. Thus, total production costs were slightly higher, $9 ha', for the no-till wheat system, the difference being less than the value of one bushel of wheat. Returns were low for both wheat production systems. A normal return to land would leave low residual returns for management and risk.

Economic Implications

General implications from these economic analyses of conservation tillage research in Texas are (1) conservation tillage practices usually reduce total costs of production where substantial savings in machinery depreciation costs occur, but (2) variable costs or "out-of-pocket expenses" are not always reduced by adopting conservation tillage practices. As a result, cash flow difficulties may be encountered by adopting conservation tillage unless sufficient sales income is realized from increased yields to offset higher out-of-pocket expenses and machinery investment or conversion costs.

Crop yields may be higher with conservation tillage if significant soil moisture savings are realized. Thus, long-term prospects for raising farm profit levels are encouraging in semiarid regions of Texas where water availability limits crop yield potential. In these regions, economic analyses indicated returns to land, management, and risk were usually higher with conservation tillage, particularly where moisture conservation increased yields and the value of sales. This was especially evident in situations where residue was produced by a cover crop or was maintained between crops, and when furrow diking was used to prevent runoff losses.

In higher rainfall regions, such as the Blackland Prairie where rainfall is higher and water erosion is a problem, limited yield benefits from soil moisture conservation, increased grassy weed pressures, and other

TABLE 9. ESTIMATED COSTS AND RETURNS OF CONVENTIONAL TILLAGE VERSUS NO-TILL FOR A SORGHUM/COTTON/WHEAT ROTATION IN THE BLACKLAND PRAIRIE OF TEXAS

	Cotton		Sorghum		Wheat	
Item	Conven-tional[1]	No-till[2]	Conven-tional[3]	No-till[4]	Conven-tional[5]	No-till[6]
Grain yield, Mg ha^{-1}	—	—	5.49	5.49	2.42	2.42
Lint yield, Mg ha^{-1}	0.532	0.532	—	—	—	—
		----- $ ha^{-1} -----				
Income:						
Grain	—	—	622.35	622.35	355.82	355.82
Lint	880.29	880.29	—	—	—	—
Cottonseed	64.79	64.79	—	—	—	—
Expenses:						
Herbicide	22.76	168.18	17.00	117.62	16.26	37.90
Mach. & labor	39.39	17.64	40.60	15.22	16.78	9.79
Other costs	117.89	121.15	140.94	140.94	120.91	114.12
Interest	16.11	19.03	13.99	19.00	12.75	13.86
Total preharvest costs:	196.15	346.00	212.53	292.78	166.70	175.67
Harvest, haul, ginning	197.25	197.25	78.70	78.70	40.33	40.33
Total variable costs:	393.40	543.25	291.23	371.48	207.03	216.00
Ret. over variable costs:	551.68	401.83	331.12	250.87	148.79	139.82
Fixed costs:						
Machinery	89.65	58.98	89.08	56.09	40.05	39.61
Total costs:	483.05	602.23	380.31	427.57	247.08	255.61
Ret. to Land, Mgmt., **Risk:**	462.03	342.85	242.04	194.78	108.74	100.21

[1]Operations included shredder, disk, chisel, disk, chisel, fertilize, cultivate, plant/fert./insect./herb., and two cultivations (10 operations + 2 custom insect. applications). Herbicides applied included 0.827 kg ha^{-1} Caparol and 0.827 kg ha^{-1} of Dual.

[2]Operations included **3** herb. applications, plant/fert./herb./insec., shredder, apply herb. (6 operations + 2 custom insect. appl.). Herbicides applied include **0.827** kg ha^{-1} Roundup (2 appl.), **3.86** kg ha^{-1} Caparol (2 appl.), **1.65** kg ha^{-1} Dual, and **0.42** kg ha^{-1} Fusilade.

[3]Operations included disk, chisel, two disks, chisel, fertilize, cultivate, plant/fert./insect./herb., and two cultivations (10 operations + 1 custom insect. application). Herbicides applied included 0.824 kg ha^{-1} Milogard and 0,827 kg ha^{-1} Dual.

[4]Operations included **3** herb. applications, fertilize, plant/fert./herb./insec., and apply herb. (6 operations + 1 custom insect. appl.). Herbicides applied include 1.24 kg ha^{-1} Roundup (**3** appl.), **1.653** kg ha^{-1} atrazine, 1.65 kg ha^{-1} Milogard, 0.206 kg ha^{-1} Dual, and 0.207 kg ha^{-1} of paraquat.

[5]Operations included shredder, chisel, fertilize, cultivate, drill/fert./ (5 operations + 1 custom herb. appl. and 2 custom insect. appl.). Herbicides applied included **0.138** kg ha^{-1} Banvel and 1.455 kg ha^{-1} of MPCA.

[6]Operations included apply herb., apply fert., drill/fert., and apply herb. (**4** operations + 1 custom insect. appl.). Herbicides applied included **0.413** kg ha^{-1} Roundup, 0.138 kg ha^{-1} Banvel, and 1.1 kg ha^{-1} **MCPA.**

problems such as soil compaction may inhibit higher yields and increased profit potentials. Conservation tillage systems being evaluated in these areas are apparently not as profitable as conventional systems. This has critical implications in the event producers are forced to comply with conservation practices.

Adoption rates of conservation tillage will likely accelerate in areas where there is a higher profit potential compared with conventional practices. In other areas, conservation practices may have to be adopted because of recent legislation. The Food Security Act of 1985 (farm legislation) contains conservation regulations that have the potential of significantly affecting producers, processors, agribusiness, and rural communities. One provision of the regulation denies all government benefits to producers who continue to crop highly erodible cropland or converted wetland after December 23, 1985. Land is exempt until January 1990 if it had a cropping history in any of the 1981 through 1985 crop years. Although not analyzed herein, denial of government benefits such as deficiency payments if out of "conservation compliance" could substantially enhance the relative profitability of conservation practices, considering the alternative.

Research Needs

The above-described conservation tillage research programs were designed for the future needs of producers in Texas. Problems that may continue to be challenges to scientists in terms of developing profitable conservation tillage practices include possible increased disease in continuous wheat production and volunteer seedling control in continuous wheat, corn, and sorghum production. These problems may necessitate some mechanical tillage in specific production systems. Continued advances in developing selective herbicides will likely broaden the need for further research and economic evaluations of alternatives in conservation tillage.

Recent comprehensive changes in public policy concerning soil conservation emphasize the need to expand research efforts. A recent analysis of the conservation requirements of the current farm bill by the Texas Agricultural and Food Policy Center at Texas A&M University (Lippke et al, 1986) indicated substantial economic losses could occur in the southern Texas High Plains where cotton is the primary crop. Based on current cultural practices, the impacts of adopting two types of conservation measures, windstrips and crop rotations, were evaluated for an eight-county area south and west of Lubbock, Texas. Depending on the conservation measure, farm receipts were estimated to drop by $21 million to $244 million. Jobs lost ranged from 1,000 to 12,450. Farm survival possibilities were nil using crop rotations on light soils. Windstrips were a better alternative, but even then, the financial position of farms was negatively affected.

While the above analysis highlights the critical need for increasing resources devoted to conservation tillage research in the near future, it was based on current tillage practices combined with windstripping or crop rotations. A similar but expanded study is needed to analyze the impacts of emerging conservation tillage methods such as those in this report. It should consider erosion control through maintaining residue levels with conservation tillage practices, which is an effective method of reducing wind and water erosion (Stewart and Harman, 1984). It should also examine the impact of planting cover crops, which is an alternative in areas where soil moisture for the succeeding cash crop can be replenished by timely rainfall or supplemental irrigation.

Farm program legislation changes from time to time, and concern about "conservation compliance" in connection with the 1985 farm legislation may come and go. However, the potential cost of soil erosion to agriculture and society through decreased crop and livestock productivity will remain. Pierre Crosson (1986) also discusses the cost of erosion in terms of damages from eroded sediment, shortened life of reservoirs, increased risk of flooding, increased costs of removing sediment from municipal water supplies, diminished recreational values, and damage to biological systems. These high socioeconomic costs may require more from society in public funds than it is willing to pay. We believe that additional public and private funding of research to make conservation tillage more profitable on highly erosive soils may not only be the lower cost alternative but also the most cost-effective method of reducing these socioeconomic costs. Producers will benefit from incurring conservation tillage costs in the long run if adequate rewards, specifically higher profits, can be realized through improved conservation tillage systems and if these profits exceed those of conventional farming methods.

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