Alternative Cropping Systems for Traditional Monoculture Wheat Acres in the Southern Plains for Two Farm Sizes

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Abstract

Alternative Production Systems for Traditional Monoculture Wheat Acres in the Southern Plains for Two Farm Sizes. JonAnn E. Decker, Francis M. Epplin, Deena L. Morley, and Thomas F. Peeper, Oklahoma State University

The economics of five alternative crop production systems for the Southern Plains winter wheat production region, for both conventional tillage and no-till, for two farm sizes, was determined. Yield data were obtained from a three-year experiment conducted on three farm fields in the region. Tillage costs differ across farm size.

Alternative Production Systems for Traditional Monoculture Wheat Acres in the Southern Plains for Two Farm Sizes

Continuous hard red winter wheat is the primary crop grown in the Southern Plains. Wheat is not typically rotated with other crops, but it can be grown for either grain-only, or forage-only, or for both fall-winter forage plus grain (dual-purpose). In the region, wheat can be planted as early as September 1 to maximize fall forage or as late as October 20 for grain production (Krenzer, 2000). Fall forage production is typically maximized when wheat is planted in early-September and production steadily declines as wheat is planted later in the season.

Grazing of fall winter wheat forage typically begins in late October. In a forage-only system, cattle may continue to graze until May of the following year. For a dual-purpose (forage plus grain) system cattle must be removed from the wheat prior to the development of first hollow stem which usually occurs in late February. After the livestock are removed, the crop is permitted to mature and produce grain that may be harvested in June. In a dual-purpose system where fall forage and grain are both considered important, growers traditionally plant wheat in mid-September (Krenzer, 2000). If the intended use of the wheat is for grain-only, the optimum planting date for maximizing grain yield is between late September and early October after which grain yields begin to decline (Heer and Krenzer, 1989; Krenzer, 2000; Lyon et al., 2007).

The USDA provides annual estimates of the wheat acres planted and harvested for grain. However, they do not differentiate among wheat uses. Hence, there are no routine data available from the USDA on the proportion of wheat acres used for each of the three purposes. Surveys conducted by True et al. (2001) and Hossain et al. (2004) found that between 9-20 percent of the wheat acres planted in Oklahoma were intended for forage-only; 49-66 percent were intended for dual-purpose; and 25-31 percent for grain-only.

The number of acres tilled with a moldboard plow has declined considerably; however, some form of conventional tillage continues to be used on the vast majority of acres in the region used to produce wheat. The reduction in tillage and corresponding increase in surface residue has been associated with an increase in weed problems. Perennial ryegrass, which was introduced to the region as a pasture grass, has invaded many wheat fields and is extremely difficult to control. The percentage in no-till has increased over the last twenty years to about ten percent, but even though no-till acres have increased considerably over the last few years, no-till production for continuous winter wheat lags behind the national average (CTIC, 2004).

Efforts to introduce no-till systems have been hampered by the inability of registered herbicides to provide effective and inexpensive weed control during the winter wheat growing season that extends from September through June, and by the inability to find an economically competitive crop that can be rotated with winter wheat. Prior to 1996, the search for alternatives to wheat, and crops to rotate with wheat, was hampered by federal policy that provided financial incentives for farmers in the region to produce wheat and build wheat base acres to the exclusion of other crops.

Heer and Krenzer (1989) reported that tillage method affected grain production only in years when precipitation was limited. In drier years, yields were higher with no-till. A ten-year study of continuous winter wheat trials was conducted to compare the economics of six tillage systems. The no-till system produced lower wheat grain yields than the conventional systems (Epplin et al., 1994). Conventional tillage systems produced greater net returns because of the greater yields and the high cost of (pre-generic) glyphosate used to control weeds during the fallow period between wheat harvest in June and wheat planting in September on the no-till plots. Other studies have shown that no-till did lower fuel and labor cost, but the cost of herbicide to control weeds was greater than the money saved on fuel and labor (Epplin et al., 1993; Williams et al., 1990).

A common practice for continuous winter wheat acres is to have a three month fallow period between crops of winter wheat with the intent to increase the amount of water stored in the soil for the next crop. Foxtail millet is a short season, summer annual grown primarily for forage that could be double cropped with wheat. From planting the foxtail millet to harvesting it for hay requires approximately 60 days, which fits the three month summer fallow period (Baker, 2003). Foxtail millet has a low water requirement and can produce 2,000 pounds per acre with 2.5 inches of water, which makes it capable of producing forage during hot, dry summers typical of the Southern Plains (Baker, 2003; Koch, 2002).

Herbicides may be used to control weeds during the summer fallow period between wheat crops (Wicks et al., 2003). Since its introduction in 1974, glyphosate has been the herbicide of choice for most no-till farmers because of its effective control of a broad spectrum of weed species. Generic glyphosate became available in 2000 after the original patent expired and the price declined substantially (Baylis, 2000; Franz et al., 1997; Mueller et al., 2005).

Some anticipated that the introduction of glyphosate-tolerant wheat would provide an additional means for controlling weeds, enable expansion of no-till acres, and enhance soil conservation efforts. However, in May of 2004, Monsanto announced that it was going to defer the introduction of glyphosate-tolerant wheat. Production systems for managing weed infestations on the traditional wheat acres can not rely on the in-season use of glyphosate.

Several factors have motivated additional investigation into the relative economics of the three wheat production systems and the economics of no-till relative to conventional tillage for continuous wheat production in the region. The increase in the price of Diesel fuel and the decrease in the price of glyphosate after patent expiration has changed the cost of weed control with herbicides relative to the cost of weed control with tillage during the three month summer fallow period. In addition, the increase in the price of feed grains has increased the relative value of wheat forage and has increased the opportunity cost of the summer fallow that could be used to produce a short-season double-cropped forage such as foxtail millet.

Objectives

The objective of this study is to determine the economics of five alternative cropping systems, for both conventional tillage and no-till, for two farm sizes; 640 acres and 2,560 acres. The five cropping systems include: (a) early September planted wheat for dual-purpose (fall forage for grazing plus wheat grain) (ESDP); early September planted wheat for forage-only (fall forage for grazing plus wheat hay harvested in the spring) (ESFO); early September planted forage-only double cropped with foxtail millet (fall forage for grazing plus wheat hay harvested in the spring plus millet hay harvested in the summer) (ESFM); late September planted wheat for dual-purpose (fall forage for grazing plus wheat grain) (LSDP); October planted wheat for grain-only (OG). The economics of each of the five cropping systems will be determined for both conventional tillage and no-till for both farm sizes.

This study has several unique aspects. First, the field experiments were conducted over three years on farm fields in three different counties. Second, in most previous research of dual-purpose wheat, the plots have been clipped to simulate grazing. It is not practical to graze small plots on most experiment station sites. In this study, wheat grain yields from both dual-purpose (ESDP and LSDP) production systems were taken from portions of the plots that were grazed during the fall and winter by steers and heifers owned by the farmers at a stocking density typical for the region. Third, the study includes a double cropping system designed to take advantage of the traditional summer fallow period.

Materials and Methods

Agronomic

Experiments were conducted on three farm fields located in north central Oklahoma to evaluate the effect of conventional tillage and no-till on different forage and grain production systems. Each of the five cropping systems (ESDP, ESFO, ESFM, LSDP, OG) was replicated four times on each of the three farms for each of the three growing seasons. The system used on each plot was maintained the same for the duration of the experiment. The individual plots for each system were 10 yards by 15 yards.

The field research was initiated in the summer of 2002 and completed with grain harvest in June and millet hay harvest in September of 2005. The fields were located in Alfalfa, Garfield, and Kingfisher counties in Oklahoma. Data from the 2003-04 crop year from the Alfalfa county site were deemed invalid and not used as a result of a stubble fire in August of 2003 that destroyed surface residue. Table 1 contains a listing of field operations for each of the five production systems for both tillage systems.

The field operations completed in the experiment are typical for north central Oklahoma wheat production. Field operations are similar across systems. However, wheat planting date differs. The average wheat planting date across the three locations and three years was September 6 for ESDP, ESFO, and ESFM, September 25 for LSDP, and October 17 for OG. The double cropped foxtail millet in the ESFM system was planted after wheat harvest in early June. For additional details regarding the field experiments see Morley (2006).

Economics

Enterprise budgets were prepared to conduct the economic analysis. A budget was constructed for each production system, for both tillage systems, and both farm sizes. The budgets were used to determine net returns to land, labor, management, risk, and overhead. Custom harvest of grain and hay is typical in the region as was assumed in the budgets. Custom application of fertilizer, herbicide, and insecticide was assumed for the small farm. However, the large farm was assumed to own spray and fertilizer application equipment.

Average grain, forage, and hay yields reported across the three locations over the three years for each system were used for the base budgets. Historical average (2003-2005) June and July wheat prices were used since farmers in the region sell most of their wheat in those two months (Oklahoma Agricultural Statistics Service).

Hay prices were based upon reports contained in the Oklahoma Annual Bulletin. The price for wheat hay was calculated by averaging prices from 2003-2005 for the month of May which was approximately $53 per ton. For the price of foxtail millet hay, the prices were averaged across 2003-2005 for the month of August instead of May. The average price for wheat hay in August was $49 per ton (Oklahoma Agricultural Statistics Service). No reported prices are available for foxtail millet hay. Based on differences in nutrient content, the price for foxtail millet hay was assumed to be 20 percent greater than the price of wheat hay (National Research Council, 1996).

The calculation of the forage for pasture price was arrived at by using the average value of a pound of gain for cattle grazing wheat pasture and dividing that value by the estimated quantity of wheat forage required to achieve a pound of gain. Prior research has found that one pound of gain for wheat pasture stockers requires approximately ten pounds of standing wheat forage (Kaitbie et al., 2002). A standard rental rate for wheat pasture forage is $0.33 per pound of gain (Doye and Sahs, 2005). Hence, the base price for fall-winter forage was set at $0.033 per pound of dry matter.

Prices for operating inputs including seed, herbicides, insecticides, and fertilizer were collected from Oklahoma State University base enterprise budgets that are updated annually to reflect prices specific to Oklahoma. Prices for items not included in the base budgets such as foxtail millet seed were collected from dealers and distributors.

Prices for custom applications and custom harvesting were based upon responses to surveys reported by Doye, Sahs, and Kletke (2006). The budgeted price for custom anhydrous ammonia application for conventional tillage plots was taken from the report. The budgeted custom rate for anhydrous ammonia application for no-till plots was increased by $1.00 per acre due to the higher cost of knifing fertilizer into fields that have not been tilled.

Fixed cost for machinery and equipment for each of the ten systems was calculated using MachSel software (Kletke, and Sestak, 1991). MachSel allows the user to select the number of times each machine is used and the month of use. MachSel produces an estimate of the total machinery fixed costs per acre, as well as the estimated costs for fuel, lubricants, and repairs. Machinery prices and parameter values were updated per conversations with dealers and information listed on manufacturer’s websites (Epplin et al., 2005). The software accounts for farm size, and equipment for each of the ten systems was selected to meet the needs of that system. Table 2 includes a list of machines selected, list price and machine width for each farm size for both tillage systems.

The net return for each system was calculated by subtracting cash costs and fixed costs from gross revenues. The net return for each system is stated in terms of return to land, labor, management, risk, and overhead.

Results

Agronomic

Figure 1 includes a chart of wheat grain yields for each of the three systems that included wheat grain harvest (ESDP, LSDP, OG) for both conventional tillage and no-till averaged across the three farms and three years. The yield reported in each bar is the average of 32 harvested plots (four replications at two locations for three years plus four replications at one location for two years). At each location the wheat grain yield from the conventional tillage plots was significantly greater ($P < 0.05$) than for the no-till plots. The overall average yield from the conventional tillage plots of 42.3 bushels per acre was more than 16% greater than the yield from the no-till plots of 36.3. Yields from the plots that were conventionally tilled were not significantly different across production system. Similarly yields from the no-till plots were not significantly different across production system.

The grain yield reductions associated with the no-till treatments are consistent with findings of other studies of continuous monoculture winter wheat conducted in the region. The reasons for the reduction in grain yields for no-till relative to conventional tillage are not clear. One hypothesis is that it is easier for wheat pathogens to move from the old crop to the new crop under a no-till system.

Figure 2 includes a chart of wheat fall forage yields for each of the four systems that included wheat fall forage harvest (ESDP, ESFO, ESFM, LSDP) for both conventional tillage and no-till averaged across the three farms and three years. At each location the wheat fall forage yield from the conventional tillage plots was significantly less ($P < 0.05$) than the yield obtained from the no-till plots. The overall average yield from the no-till plots of 1,469 pounds per acre was more than 17% greater than the 1,249 pounds per acre obtained from the conventional tillage plots. For the no-till plots, yields from the ESDP system were significantly ($P < 0.05$) greater than yields from ESFM and LSDP, and yields from ESFM were significantly greater than yields from LSDP. For the conventional tillage plots, yields from ESDP were significantly greater than yields from the other systems. And, no-till wheat fall forage yields for both ESFO and ESFM were greater than yields from LSDP.

The cause of the increase in fall forage yield for the no-till system relative to the conventional tillage system is not known. One hypothesis is that the no-till system retains more moisture during the summer fallow months that is then available for fall forage production (Heer and Krenzer, 1989). However, measurements of soil moisture were not taken in the current study. The increase in fall forage yield from the ESDP system relative to the ESFO system could be a result of differences in surface residue during the summer. For the ESDP system the wheat grain was harvested and the wheat straw was returned to the soil surface. However, for the ESFO system the wheat hay was baled and removed and little residue was left on the soil during the summer fallow period. It is likely that more moisture was retained with the ESDP system and that could explain the increase in fall forage yield for the ESDP system relative to the ESFO system.

Figure 3 includes a chart of wheat hay yields for both of the systems that included wheat hay harvest (ESFO, ESFM) for both conventional tillage and no-till averaged across the three farms and three years. Wheat hay yields were not significantly different across tillage system or production system. It is not clear as to why the no-till system would result in greater fall forage yield but not enhance the subsequent wheat hay yield.

Figure 4 includes a chart of foxtail millet hay yields obtained from the ESFM double-cropped foxtail millet system for both conventional tillage and no-till averaged across the three farms and three years. While the mean foxtail millet hay yields were greater for the no-till plots, the differences were not statistically significant.

Economics

Figure 5 includes a chart of the net returns to land, labor, management, risk, and overhead for each of five production systems for both tillage systems for the 640-acre farm. Net returns ranged from $50 per acre for the ESDP conventional tillage system to -$38 per acre for the OG no-till system. For each of the three systems that included harvest of wheat grain (ESDP, LSDP, OG), the returns are from $26 to $30 per acre greater for the conventional tillage systems. Net returns were also greater for the conventional tillage systems that produced only forage and hay (ESFO, ESFM). However, for the double-cropped ESFM system, the net returns were only $2 per acre greater for the conventional tillage system. For the small farm, the double-cropped ESFM system added $6 per acre to net returns above the ESFO system for conventional tillage and $15 per acre above the ESFO system for no-till.

Figure 6 includes a chart of the net returns to land, labor, management, risk, and overhead for each of five production systems for both tillage systems for the 2,560-acre farm. Net returns ranged from $58 per acre for the ESDP conventional tillage system to -$14 per acre for the OG no-till system. For each of the three systems that included harvest of wheat grain (ESDP, LSDP, OG), the returns are from $5 to $10 per acre greater for the conventional tillage systems. However, net returns for systems that produced only forage and hay (ESFO, ESFM) were $20 to $26 per acre greater for the no-till system than for the conventional tillage system.

For the systems that included grain harvest (ESDP, LSDP, OG), the economics of conventional tillage benefited from the 16% yield increase associated with conventional tillage. For both farm sizes, the conventional tillage ESDP production system generates the greatest net returns. This finding is consistent with survey results reported by True et al. (2001) and Hossain et al. (2004) that found that most of the acres planted to wheat in the state are intended for dual-purpose.

For large farms that intend to produce for forage-only, (ESFO), no-till generates the most net returns. However, adding a foxtail millet double crop to the system (going from ESFO to ESFM) added only $1 per acre net returns if under conventional tillage and $7 per acre if under no-till.

Discussion

For both farm sizes and both tillage systems, the ESDP production alternative generated the greatest net returns. This is not surprising since it is the most common cropping system in the region. For the small (640-acre) farm, conventional tillage generates greater net returns than no-till across all five production systems. For the large (2,560-acre) farm, conventional tillage generates greater net returns than no-till for each of the three systems that include wheat grain harvest (ESDP, LSDP, OG). However, for the large farm, no-till generates greater net returns for both total forage systems (ESFO, ESFM). For both farm sizes adding a foxtail millet double crop during the traditional wheat summer fallow time period generates small positive net returns.

The no-till system is relatively more economical for the large farm. Differences across farm size are largely the result of the relative difference in the cost of no-till seeders relative to the cost of conventional seeders. The list price of a small (i.e. 10-foot) no-till drill is almost three times that of a conventional drill whereas the list price of large (i.e. 40-foot) no-till air seeder is only 30 percent more than that of a conventional air seeder.

The reduction in the price of glyphosate after the patent expired and the increase in the price of Diesel fuel has clearly improved the relative economics of no-till. For large farms that intend to seed wheat for use as a forage-only crop, no-till is more economical. However, for farms that intend to harvest the wheat grain, since conventional tillage produces on the average 16 percent greater yield, no-till is not the most economical choice for continuous monoculture wheat in the region.

A major limitation of this study is that each of the five cropping systems included continuous wheat, and four included only wheat. Because of the climate and soils, cropping alternatives in the region are limited. However, additional research is warranted to identify alternative crops for the region that might fit in a rotation with winter wheat.

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Table 1. Field Operations for Alternative Wheat Production Systems

		Systems									
		Conventional Tillage					No-till				
Field Operations	Date	ESFO	ESFM	ESDP	LSDP	OG	ESFO	ESFM	ESDP	LSDP	OG
Chisel	May	✓	✓								
Disk	May	✓	✓								
Apply Fertilizer (82-0-0)	May		✓					✓			
Apply Herbicide (Glyphosate and AMS)	May						✓	✓			
Band Fertilizer (18-46-0)	May		✓					✓			
Plant German Foxtail Millet (Conventional-Till Drill)	May		✓								
Plant German Foxtail Millet (No-Till Drill)	May							✓			
Moldboard Plow (Used on 20% of Acres)	June	✓		✓	✓	✓					
Chisel (Used on 80% of Acres)	June	✓		✓	✓	✓					
Disk	June	✓									
Apply Herbicide (Glyphosate and AMS)	June						✓		✓	✓	✓
Harvest Millet Forage	August		✓					✓			
Apply Herbicide (Glyphosate, AMS, and 2,4-D)	August						✓		✓	✓	✓
Disk	August	✓	✓	✓	✓	✓					
Apply Fertilizer (82-0-0)	August	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Apply Herbicide (Glyphosate and AMS) & Pesticide (Chlorpyrifos)	August						✓	✓	✓		
Disk	Early Sept.	✓	✓	✓	✓	✓					
Band Fertilizer (18-46-0)	Early Sept.	✓	✓	✓			✓	✓	✓		
Plant Wheat (Conventional-Till Drill)	Early Sept.	✓	✓	✓							
Plant Wheat (No-Till Drill)	Early Sept.						✓	✓	✓		
Apply Herbicide (Glyphosate and AMS)	Late Sept.									✓	
Disk	Late Sept.				✓						
Band Fertilizer (18-46-0)	Late Sept.				✓					✓	
Plant Wheat (Conventional-Till Drill)	Late Sept.				✓						
Plant Wheat (No-Till Drill)	Late Sept.									✓	
Apply Herbicide (Glyphosate and AMS)	October										✓
Disk	October					✓					
Band Fertilizer (18-46-0)	October					✓					✓
Plant Wheat (Conventional-Till Drill)	October					✓					
Plant Wheat (No-Till Drill)	October										✓
Harvest Wheat Forage	February	✓	✓	✓	✓		✓	✓	✓	✓	
Apply Pesticide (Dimethoate)	April	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Harvest Wheat Hay	May	✓	✓				✓	✓			
Harvest Wheat Grain	June			✓	✓	✓			✓	✓	✓

ESFO = wheat seeded in early September for forage-only
ESFM = wheat seeded in early September for forage-only with foxtail millet seeded as a summer forage double crop
ESDP = wheat seeded in early September for dual-purpose (forage plus grain)
LSDP = wheat seeded in late September for dual-purpose (forage plus grain)
OG = wheat seeded in mid October for grain-only

Table 2. Machinery Complements for Conventional Tillage and No-till Wheat Production Systems for Two Farm Sizes

Machine	List Price ($)	Machine Width (Feet)	Conventional Tillage	No-till
640 Acre Farm				
155 hp Tractor	81707		✓	✓
Moldboard Plow	15812	7.75	✓	
Chisel	9673	18.6	✓	
Disk	20231	17.1	✓	
Conventional Till Drill	23957	20	✓	
No-Till Drill	51992	20		✓
2,560 Acre Farm				
95 hp Tractor	58167		✓	✓
Sprayer	5564	40	✓	✓
255 hp Tractor	156404		✓	✓
Disk	29022	28.13	✓	
Chisel	21982	30.6	✓	
Conventional Till Air Seeder	105000	36	✓	
No-Till Air Seeder	137500	36		✓
No-Till Anhydrous Applicator	24800	32		✓
255 hp Tractor	156404		✓	
Moldboard Plow	24516	12.75	✓	
Chisel	21982	30.6	✓	
Disk	29022	28.13	✓	
Cultivator w/ Anhydrous	19500	23	✓	

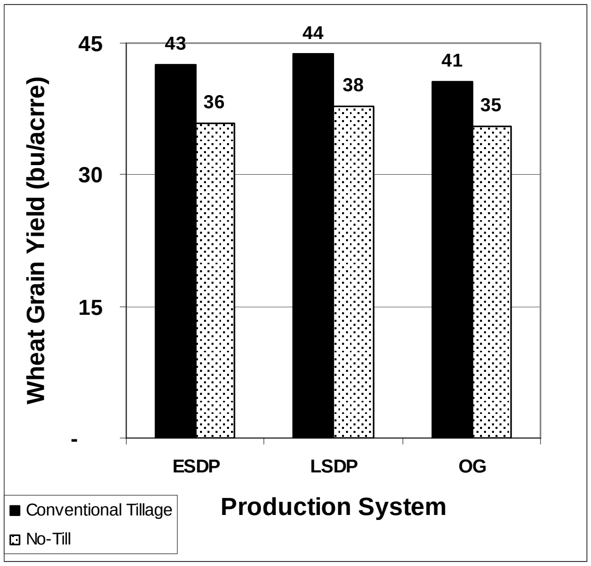

Figure 1. Wheat grain yields from conventional tillage and no-till for three production systems (ESDP = early September planted wheat for dual-purpose (fall forage for grazing plus wheat grain); LSDP = late September planted wheat for dual-purpose; OG = October planted wheat for grain-only) from three locations (2002-2005). Average planting dates were September 6 for ESDP, September 24 for LSDP, and October 17 for OG.

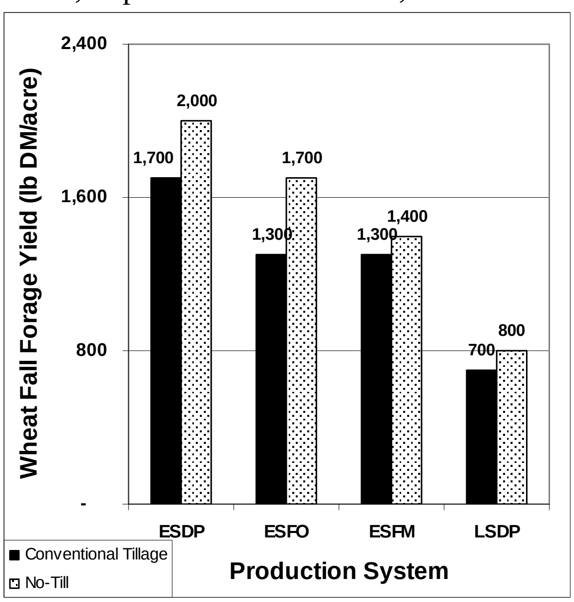

Figure 2. Wheat fall forage yields from conventional tillage and no-till for four production systems (ESDP = early September planted wheat for dual-purpose (fall forage for grazing plus wheat grain); ESFO = early September planted wheat for forage-only (fall forage for grazing plus wheat hay harvested in the spring); ESFM early September planted wheat for forage-only double cropped with foxtail millet (fall forage for grazing plus wheat hay harvested in the spring plus millet hay harvested in the summer); LSDP = late September planted wheat for dual-purpose) from three locations (2002-2005). Average planting dates were September 6 for ESDP, ESFO, and ESFM, and September 24 for LSDP.

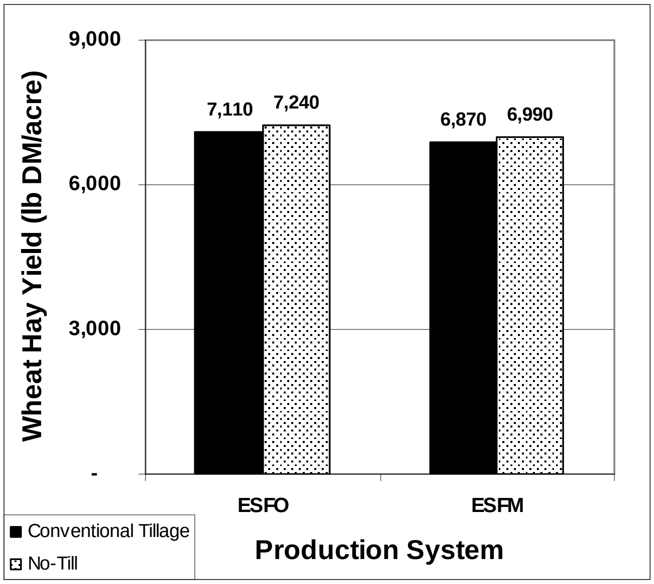

Figure 3. Wheat hay yields from conventional tillage and no-till for two production systems (ESFO = early September planted wheat for forage-only (fall forage for grazing plus wheat hay harvested in the spring); ESFM = early September planted wheat for forage-only double cropped with foxtail millet (fall forage for grazing plus wheat hay harvested in the spring plus millet hay harvested in the summer) from three locations (2002-2005). Average planting date was September 6 for both ESFO and ESFM.

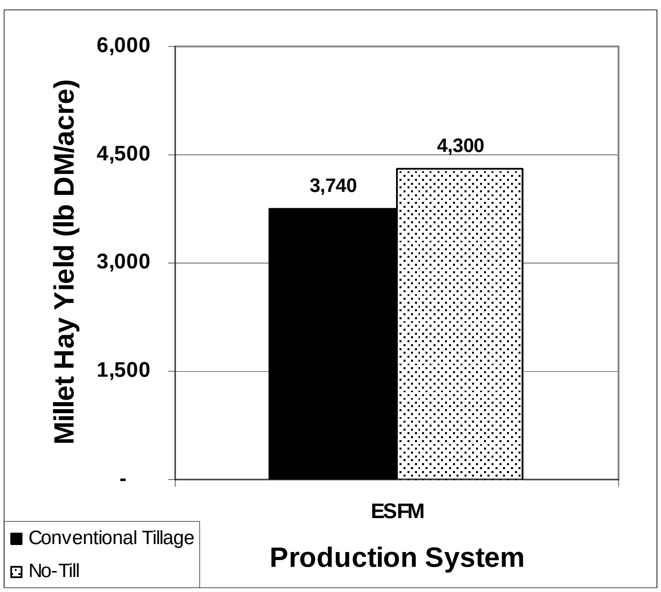

Figure 4. Foxtail millet hay yields from conventional tillage and no-till for one production system (ESFM = early September planted forage-only wheat double cropped with foxtail millet (fall forage for grazing plus wheat hay harvested in the spring plus millet hay harvested in the summer) from three locations (2002-2005). Average planting date was September 6.

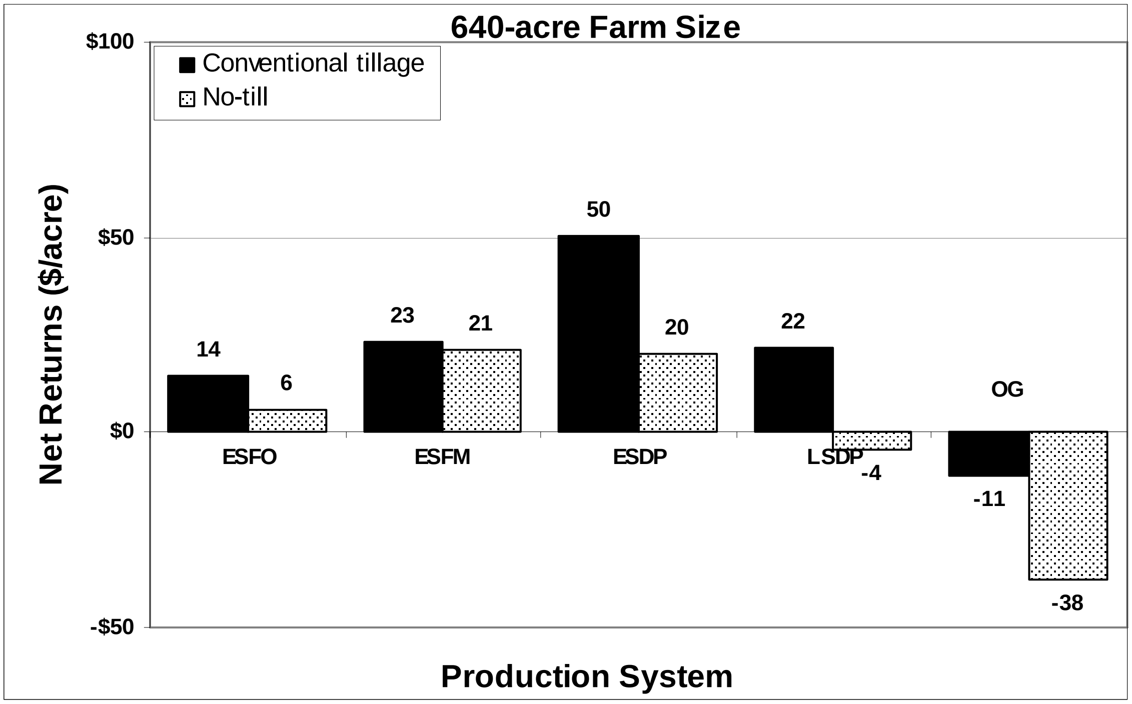

Figure 5. Net returns to land, labor, management, risk, and overhead for a 640-acre farm from conventional tillage and no-till from five wheat production systems. Where ESFO = early September planted wheat for forage-only (fall forage for grazing plus wheat hay harvested in the spring); ESFM = early September planted wheat for forage-only double cropped with foxtail millet (fall forage for grazing plus wheat hay harvested in the spring plus millet hay harvested in the summer); ESDP = early September planted wheat for dual-purpose (fall forage for grazing plus wheat grain); LSDP = late September planted wheat for dual-purpose; OG = October planted wheat for grain-only.

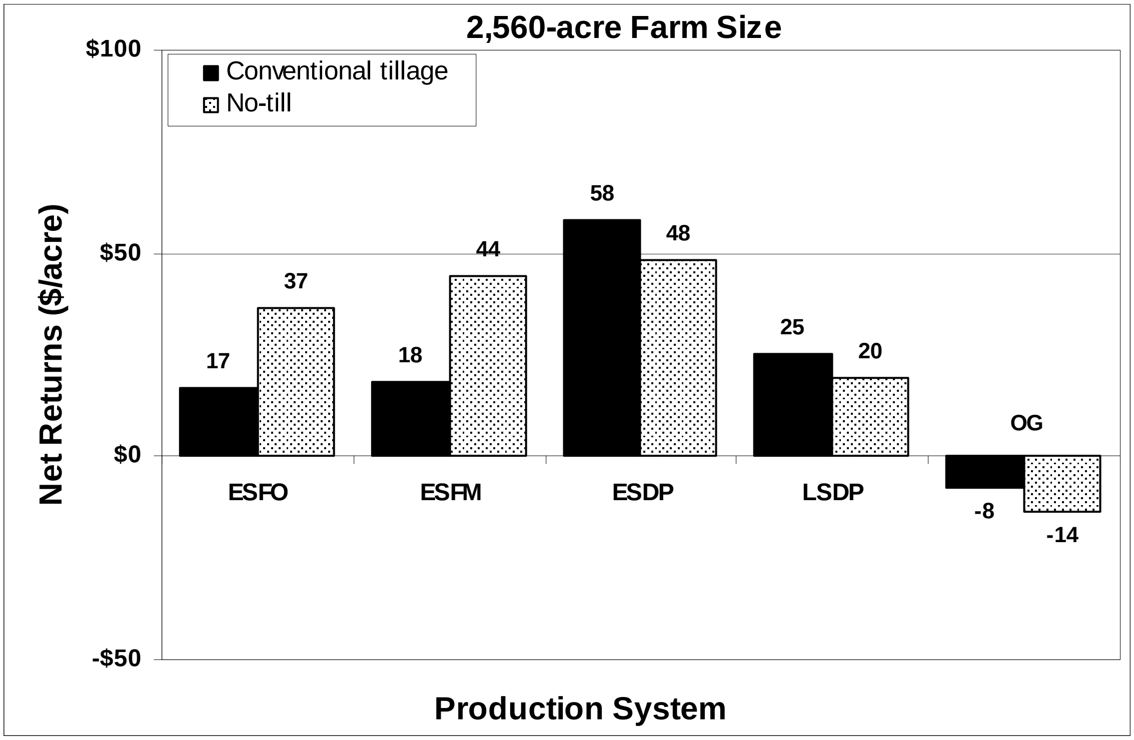

Figure 6. Net returns to land, labor, management, overhead, and risk for a 2,560-acre farm for conventional tillage and no-till for five wheat production systems. Where ESFO = early September planted wheat for forage-only (fall forage for grazing plus wheat hay harvested in the spring); ESFM = early September planted wheat for forage-only double cropped with foxtail millet (fall forage for grazing plus wheat hay harvested in the spring plus millet hay harvested in the summer); ESDP = early September planted wheat for dual-purpose (fall forage for grazing plus wheat grain); LSDP = late September planted wheat for dual-purpose; OG = October planted wheat for grain-only.