Cost of Conventional Tillage and No-till Continuous Wheat Production for Four Farm Sizes

By Francis M. Epplin, Curtis J. Stock, Darrel D. Kletke, and Thomas F. Peeper

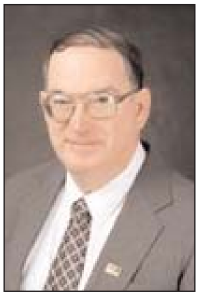
Abstract

The objective of this study was to determine production costs for both conventional tillage and no-till for continuous monoculture wheat production in the southern Great Plains. The reduction in the price of glyphosate after the original patent expired has improved the relative economics of no-till for continuous winter wheat. However, if differences in the opportunity cost of labor are ignored, for some farm sizes, total operating plus machinery fixed costs are greater for the no-till system.

Introduction

Cropping alternatives in the Northwestern Oklahoma plains are limited as a result of climate and soil type. Continuous monoculture hard red winter wheat is the predominate crop. In 1975, more than 96 percent of the cropland in Garfield County, Oklahoma was seeded to winter wheat. By 1995, the proportion seeded to wheat, excluding land in the Conservation Reserve Program, had increased to more than 99 percent (Oklahoma Agricultural Statistics Service).



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Less than three percent of the wheat farms in the Prairie Gateway use no-till (direct seeding) to produce wheat (Ali). This includes wheat produced in rotations as well as wheat in monoculture. Previous studies have identified several impediments to the adoption of no-till for continuous monoculture winter wheat production. The lack of an inexpensive and effective herbicide program necessary to control weeds throughout the summer from harvest in June until planting in October has been an impediment. A no-till budget prepared in 1994 included 4.5 pints per acre of glyphosate (four pounds of emulsifiable concentrate per gallon) at $6 per pint ($48 per gallon) for a per acre cost of $27 per acre (Epplin, Al-Sakkaf, and Peeper). In the Prairie Gateway, two thirds of the farms that produce wheat, most with conventional tillage, use no herbicide (Ali). The 1994 study found that the reduction in tillage costs when switching from conventional tillage to no-till was insufficient to offset the expected increase in herbicide costs.

A second impediment was that some of the first generation no-till grain drills did not always result in successful stands of wheat. Wheat yields obtained from no-till systems were often lower than yields obtained from conventional till systems (Bauer and Black; Epplin, Al-Sakkaf, and Peeper; Heer and Krenzer; Williams et al.). In some cases, the marginally effective no-till drills may have been partly responsible for the lower yields.

During the last decade, two changes have occurred that provide justification for reevaluating the economics of no-till monoculture wheat production for the region. First is the development of more effective no-till grain drills and air seeders. Second is the reduction in the price of glyphosate. Generic glyphosate became available in 2000 after the original patent expired. The price of glyphosate (four pounds of emulsifiable concentrate per gallon) has declined from a U.S. average of $45.50 per gallon in 1999 (USDA, 2003) to $20 per gallon in 2004. The result of this change is that the cost of herbicide to control summer weeds from harvest in June until planting in October for continuous monoculture no-till winter wheat production is less than half of what it was in 1990.

The general objectives of this study are to determine the production costs for both conventional tillage and no-till (direct seeded with a no-till drill or air seeder) continuous monoculture wheat production in Oklahoma for farms of different size. More specifically, the objectives are to determine the costs of conventional tillage and no-till management farm practices for each of four farm sizes (320, 640, 1,280, and 2,560-acres) from monoculture wheat used to produce grain.

Methods

The number and type of field operations (tillage, seeding, herbicide application, insecticide application, fertilizer application, and harvest) for both conventional tillage and no-till production systems are listed in Table 1. For the conventional tillage system it was assumed that the field would be tilled after harvest in June with either a moldboard plow (20%) or chisel (80%). It was assumed that 20 percent of the farm would be plowed each year so that each field is plowed with a moldboard once in five years. A disk operation is budgeted for August followed by urea (46-0-0) application and disk operation in September. A final tillage operation is conducted in October prior to seeding with a conventional drill or conventional air seeder. For the no-till system, glyphosate applications are budgeted for June, August, and prior to planting in October. A no-till drill or no-till air seeder is used to plant the wheat in October. An April insecticide application is budgeted for both systems. Table 2 includes a list of the operating input prices and application rates for both systems. Applications of fertilizer, seed, and insecticide are assumed to be the same for both systems.

Machinery Selection

Available tractors and machines were determined from personal interviews and discussions with dealers and confirmed by information posted on manufacturers' Web sites. These discussions resulted in three important assumptions. First, it was assumed that all wheat produced would be custom harvested and hauled, typical for the area. The machinery complements do not include combines and trucks. Second, it was assumed that herbicide, fertilizer, and insecticide would be custom-applied on the two small farms but farmer-applied on the two large farms. The machinery complements for the 1,280 and 2,560-acre farms include fertilizer applicators and sprayers. Third, it was assumed that air seeders rather than grain drills would be budgeted for the 2,560-acre farm.

The list prices for drills and air seeders as reported in Table 3 show that the relative cost difference between conventional and no-till seeding equipment depends upon machine size. A 10-foot no-till drill costs almost three times as much as a 10-foot conventional drill; a 20-foot no-till drill costs more than twice as much as a 20-foot conventional drill. However, a 36-foot no-till air seeder costs only 30 percent more than a 36-foot conventional air seeder.

MACHSEL is a machinery complement selection software program developed by Kletke and Sestak. It enables a user to assemble a set of tractors and machines that can perform the budgeted field operations in the expected time available. For this study, fieldwork day probability distributions based upon historical weather of central Oklahoma and clay loam soils were used (Kletke and Sestak). The 85 percent probability level was used meaning that machines were sized to accomplish the work in the appropriate time period in 17 of 20 years. Candidate machines were selected based on farm size, estimated fieldwork days, machines available, and required field operations.

Table 3 includes a list of the selected machines for each farm size for both production systems. Parameters, including field efficiency, draft, speed, repair factors, and depreciation costs, were based upon Agricultural Machinery Management Data Standards estimates as published by the American Society of Agricultural Engineers (ASAE). Diesel fuel price was budgeted at $1.00 per gallon, interest rate at $0.09 per dollar per year borrowed, and insurance at 0.006 of average value. A tax rate of 0.01 of purchase price was assumed.

The machinery complement for the 320-acre conventional tillage farm includes a 95 horsepower tractor matched with a plow, chisel, disk, and conventional drill. The 320-acre no-till farm includes a 95 horsepower tractor and a 10-foot no-till drill. For the 640-acre conventional tillage farm a 155 horsepower tractor is matched with a plow, chisel, disk, and conventional drill. The no-till farm includes only a 155 horsepower tractor and a 20-foot no-till drill.

The machinery complement for the 1,280-acre conventional tillage farm includes two tractors (155 and 170 horsepower), sprayer, fertilizer spreader, plow, chisel, disk, and conventional drill. The 1,280-acre no-till farm machinery complement includes two tractors (95 and 155 horsepower), sprayer, fertilizer spreader, and no-till drill. The complement assembled for the 2,560-acre conventional tillage farm includes three tractors (95 and two 255 horsepower), sprayer, fertilizer spreader, plow, two chisels, two disks, and a conventional air seeder. The 2,560-acre no-till farm complement includes two tractors (95 and 255 horsepower), sprayer, fertilizer spreader, and a no-till air seeder.

Results

Table 4 includes estimates of production costs for both systems across the four farm sizes. Figure 1 includes a chart of the average machinery investment per acre. The difference in average machinery investment between the conventional tillage and no-till machinery complements ranges from $22 per acre for the 640-acre farm to $56 per acre for the 2,560-acre farm. The machinery cost estimates depend upon the type and set of machines selected to include in the complement for a particular farm size. For example, economies of size in average machinery investment are more evident across the range of farm sizes for the no-till system. The list price for the 36-foot no-till air seeder budgeted only for the 2,560-acre farm is 2.6 times as much as the 20-foot no-till drill budgeted for the 1,280-acre farm. However, the list price for the 36-foot conventional till air seeder budgeted only for the 2,560-acre conventional tillage farm is more than four times as much as the list price for the 20-foot conventional till drill selected for the 1,280-acre conventional tillage farm. This difference explains much of the relative difference in size economies across the two production systems when the farm size increases from 1,280 to 2,560 acres.

Machinery fixed costs (depreciation, insurance, interest on average investment, and taxes) for both systems across the four farm sizes are included in Table 4 and graphed in Figure 2. The estimates are very similar across farm size. They range from $25 to $35 per acre for the conventional tillage farms and from $16 to $28 per acre for the no-till farms. For the four farms the estimated difference in machinery fixed costs between conventional tillage and no-till range from $6 to $12 per acre. The chart in Figure 2 illustrates the potential economies of size in machinery fixed costs per acre especially for the no-till production systems. Machinery fixed costs per acre is greater for the 2,560-acre conventional tillage farm than for the 1,280-acre conventional tillage farm primarily because an air seeder rather than conventional drill was budgeted for the larger farm.

As shown in Table 4, wheat seed ($10.50 per acre), fertilizer ($22.55 per acre), insecticide ($3.00 per acre), and custom harvest and hauling ($20.80 per acre) costs are assumed to be the same for both systems across all farm sizes. The budgeted cost of the herbicide program for the no-till system is $11.25 per acre. No herbicide is budgeted for the conventional tillage system.

Figure 3 includes a chart of total operating costs ($/acre) for both production systems across the four farm sizes. Operating costs for the no-till system are $5 to $6 per acre more than for the conventional tillage system for the two large farms. For these farms, no-till requires $11.25 per acre more for herbicide and saves $6 to $7 per acre in machinery fuel, lube, and repairs. For the two small farms, no-till requires $11.25 per acre more herbicide and $11 per acre more custom application, but saves about $7 per acre in fuel, lube, and repairs. Estimated operating costs for the two small farms are approximately $16 per acre greater for the no-till system.

Figure 4 includes a chart of total operating plus machinery fixed costs for both production systems across the four farm sizes. The estimated total operating and machinery costs are $10 per acre greater for the 320 and 640-acre no-till farms than for the corresponding conventional tillage farms. However, estimated costs are $3 per acre greater for the conventional tillage 1,280 and 2,560-acre farms. These estimates do not include differences in the opportunity cost of labor across farm sizes and production systems.

Figure 5 includes a chart of the cost difference between conventional tillage and no-till for selected items for the four farm sizes. The chart depicts the estimated cost changes in herbicide, fuel, lube, and repairs, and custom application (for the two smaller farms) between conventional tillage and no-till for the four farm sizes. The chart shows that no-till requires more herbicide, custom application, and total operating costs. Conventional tillage requires more fuel, lube, and repairs, and more machinery fixed costs. The final sets of bars in Figure 5 depict the net result. For the two small farms, estimated total operating plus machinery fixed costs are slightly greater for the no-till system. However, for both the 1,280 and 2,560-acre farms estimated costs are less for the no-till system.

Summary and Conclusions

Less than three percent of the wheat farms in the Prairie Gateway use no-till to produce wheat. This suggests that no-till has not been more economical than conventional tillage for continuous monoculture wheat in the region. Earlier studies have found that the reduction in tillage costs when switching from conventional tillage to no-till was insufficient to offset the increase in herbicide costs. Several changes provided justification for reevaluating the cost of no-till relative to conventional tillage for wheat production in the region. The most important change has been the more than 55 percent reduction in the price of glyphosate that has occurred since generic glyphosate became available.

The objectives of this study were to determine the costs of conventional tillage and no-till for continuous monoculture wheat production for each of four farm sizes (320, 640, 1,280, and 2,560-acres). Estimated costs depend upon the assumptions made regarding machine selection and custom applications.

Estimated operating costs for the two small farms were approximately $16 per acre greater for the no-till system. The two small no-till farms require $11.25 per acre more herbicide and $11 per acre more custom application, but save about $7 per acre in fuel, lube, and repairs and $6 to $7 per acre in machinery fixed costs. The estimated total operating and machinery fixed costs are $10 per acre greater for the 320 and 640-acre no-till farms than for the corresponding conventional tillage farms.

For the two large farms, estimated operating costs for the no-till system are $5 to $6 per acre more than for the conventional tillage system. For these farms no-till requires $11.25 per acre more for herbicide and saves $6 to $7 per acre in machinery fuel, lube, and repairs, and $7 to $12 per acre in machinery fixed costs. Estimated total operating plus machinery fixed costs are $3 per acre greater for the conventional tillage 1,280-acre and 2,560-acre farms.

The reduction in the price of glyphosate has clearly improved the relative economics of no-till. However, if differences in the opportunity cost of labor are ignored for both small farms, total operating plus machinery fixed costs are greater for the no-till system. For these farm sizes if yields are equivalent conventional tillage is more economical. However, for the two large farm sizes, if yields are equivalent, no-till is more economical. Given the small difference in costs rapid adoption of no-till would not be expected. However, the findings suggest that adoption on large farms is likely to precede adoption on small farms.

A major limitation of this study is that yield differences, and thus, revenue have not been considered. Research is warranted to determine relative yield differences between no-till and conventional tillage given the availability of effective no-till drills and less expensive glyphosate.

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Table 1. Field Operations for Conventional Tillage and No-till Wheat Production Systems

Field Operations	Month	Conventional	No-till
Moldboard Plow (Used on 20% of Acres)	June	✰	
Chisel (Used on 80% of Acres)	June	✰	
Apply Herbicide (Glyphosate)	June		✰
Apply Herbicide (Glyphosate)	August		✰
Disk	August	✰	
Broadcast Fertilizer (46-0-0)	August	✰	✰
Disk	September	✰	
Apply Herbicide (Glyphosate)	October		✰
Disk	October	✰	
Band Fertilizer (18-46-0)	October	✰	✰
Plant Wheat (Conventional-Till Drill)	October	✰	
Plant Wheat (No-Till Drill)	October		✰
Apply Insecticide (Dimethoate)	April	✰	✰
Harvest Wheat Grain	June	✰	✰

Table 2. Operating Inputs for Conventional Tillage and No-till Wheat Production Systems

Operating Inputs	Date	Unit	Price ($)	Conventional	No-till
Glyphosate	June	Pt.	2.5		1.5
Custom Application[a]		Acre	3.66		1
Glyphosate	August	Pt.	2.5		2
Custom Application		Acre	3.66		1
Urea (46-0-0)	August	Lbs.	0.09	196	196
Custom Application		Acre	2.6	1	1
Glyphosate	October	Pt.	2.5		1
Custom Application		Acre	3.66		1
Diammonium Phosphate (18-46-0)	October	Lbs.	0.11	50	50
Wheat Seed	October	Bu.	7	1.5	1.5
Dimethoate	April	Pt.	4	0.75	0.75
Custom Application		Acre	3.04	1	1

[a] *Custom application of herbicide, fertilizer, and insecticide was budgeted for the 320 and 640 acre farms. Custom application of these inputs is not assumed for the two large farms. The machinery complements of the 1,280 and 2,560-acre farms include fertilizer applicators and sprayers.*

Table 3. Machinery Complements for Conventional Tillage and No-till Wheat Production Systems for Alternative Farm Sizes

Machine	List Price ($)	Machine Width (Feet)	Conventional Tillage	No-till
320-Acre Farm				
95 hp Tractor	58,167		✰	✰
Moldboard Plow	13,921	4.75	✰	
Chisel	5,555	8.55	✰	
Disk	7,543	10.48	✰	
Conventional-Till Drill	9,239	10	✰	
No-Till Drill	27,053	10		✰
Machinery Labor (hrs/ac)			1.21	0.29
Average Machinery Investment ($/ac)			160	134
640-Acre Farm				
155 hp Tractor	81,707		✰	✰
Moldboard Plow	15,812	7.75	✰	
Chisel	9,673	18.6	✰	
Disk	20,231	17.1	✰	
Conventional-Till Drill	23,957	20	✰	
No-Till Drill	51,992	20		✰
Machinery Labor (hrs/ac)			0.68	0.14
Average Machinery Investment ($/ac)			128	106
1,280-Acre Farm				
95 hp Tractor	58,167			✰
Sprayer	5,564	40		✰
Fertilizer Spreader	11,200	40		✰
155 hp Tractor	81,707		✰	✰
No-Till Drill	51,992	20		✰
Conventional-Till Drill	23,957	20	✰	
Sprayer	7,372	60	✰	
Fertilizer Spreader	11,200	40	✰	
170 hp Tractor	101,198		✰	
Moldboard Plow	18,337	8.5	✰	
Chisel	16,469	20.4	✰	
Disk	22,049	18.75	✰	
Machinery Labor (hrs/ac)			0.72	0.43
Average Machinery Investment ($/ac)			119	85
2,560-Acre Farm				
95 hp Tractor	58,167		✰	✰
Sprayer	5,564	40	✰	✰
Fertilizer Spreader	11,200	40	✰	✰
255 hp Tractor	156,404		✰	✰
Disk	29,022	28.13	✰	
Chisel	21,982	30.6	✰	
Conventional-Till Air Seeder	105,000	36	✰	
No-Till Air Seeder	137,500	36		✰
255 hp Tractor	156,404		✰	
Moldboard Plow	24,516	12.75	✰	
Chisel	21,982	30.6	✰	
Disk	29,022	28.13	✰	
Machinery Labor (hrs/ac)			0.51	0.37
Average Machinery Investment ($/ac)			131	75

Table 4. Estimates of Machinery Labor, Machinery Investment, and Production Costs for Conventional Tillage and No-till Wheat Production Systems

	Conventional ($/ac)	No-till ($/ac)
All Farms		
Wheat Seed	10.5	10.5
Fertilizer	22.55	22.55
Herbicide	0	11.25
Insecticide	3	3
Custom Harvest and Hauling	20.8	20.8
320-Acre Farm		
Interest on Operating Capital	2.6	3.39
Fuel, Lube, and Repairs	9.62	3.03
Custom Application Charge	5.64	16.61
Total Operating Cost	74.71	91.13
Machinery Fixed Cost	34.58	27.88
Total Operating Plus Machinery Cost	109.29	119.01
640-Acre Farm		
Interest on Operating Capital	2.61	3.37
Fuel, Lube, and Repairs	9.9	2.67
Custom Application Charge	5.64	16.61
Total Operating Cost	75	90.75
Machinery Fixed Cost	28.09	22.49
Total Operating Plus Machinery Cost	103.09	113.24
1,280-Acre Farm		
Interest on Operating Capital	2.53	2.76
Fuel, Lube, and Repairs	13.92	7.19
Custom Application Charge	0	0
Total Operating Cost	73.3	78.05
Machinery Fixed Cost	25.37	17.92
Total Operating Plus Machinery Cost	98.67	95.97
2,560-Acre Farm		
Interest on Operating Capital	2.61	2.89
Fuel, Lube, and Repairs	15.47	9.73
Custom Application Charge	0	0
Total Operating Cost	74.93	80.72
Machinery Fixed Cost	28.45	16.07
Total Operating Plus Machinery Cost	103.38	99.79

Figure 1. Average machinery investment ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes

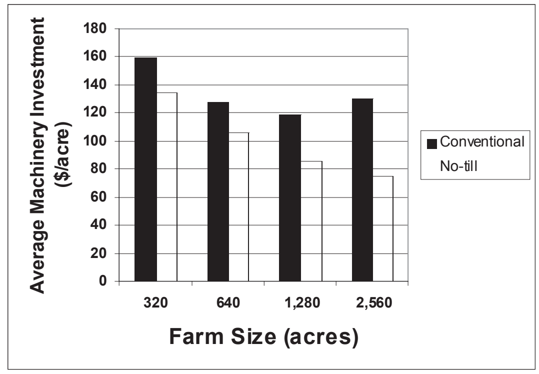

Figure 2. Machinery fixed costs ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes

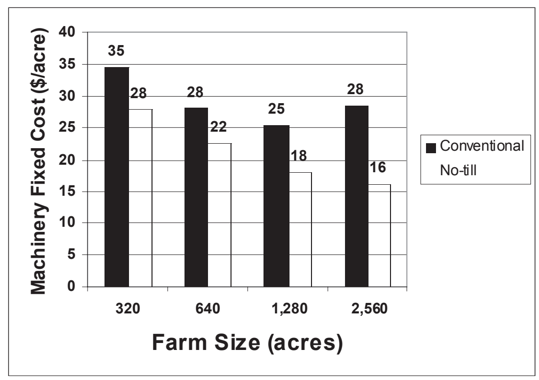

Figure 3. Total operating costs ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes

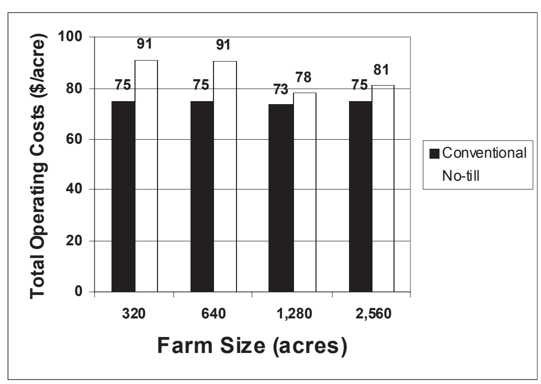

Figure 4. Total operating plus machinery fixed costs ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes

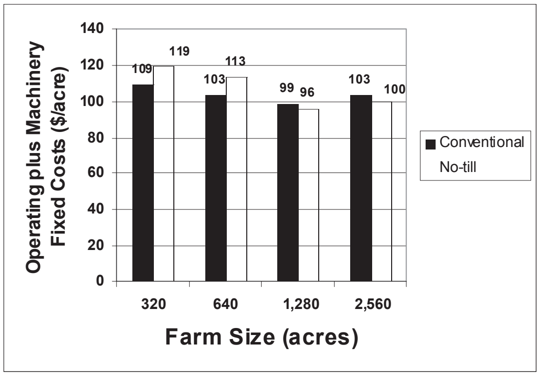

Figure 5. Cost difference ($/acre) of selected items between conventional tillage and no-till monoculture winter wheat for four farm sizes