Economies of Size for Conventional Tillage and No-till Wheat Production

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Abstract

Production costs and economies of size for both conventional tillage and no-till wheat production were determined. The reduction in the price of glyphosate after the patent expired improved the relative economics of no-till for continuous monoculture winter wheat. Production costs differ across farm size and by production system. Key words: wheat, tillage, size economies, cost of production

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% 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% (Oklahoma Agricultural Statistics Service).

Continuous monoculture wheat produced with conventional tillage methods has not been very profitable for farmers in the region. The USDA reported that the estimated cost of producing wheat in the Prairie Gateway region, which includes most of the southern Great Plains, exceeded the estimated returns by $74 per acre in 2001. Even after removing the $30 per acre opportunity cost of land and $17 per acre opportunity cost of unpaid labor, the estimated costs exceeded returns by $27 (U.S. Department of Agriculture). These data do not include government subsidies, but the problem of low returns from continuous monoculture wheat is evident.

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) 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% 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 with dealers and confirmed by information posted on manufacturers' websites. Table 3 includes the list prices of available tractors and machines as well as machine widths. The list prices for drills and air seeders as reported in Table 3 suggest that the relative cost difference between conventional and no-till equipment depends upon machine size. A 10-foot no-till drill costs almost three times as much as a 10-foot conventional drill. And, 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% 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% 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.

The machinery complements do not include combines and trucks. It was assumed that all wheat produced would be custom harvested and hauled, typical for the area. Custom application of herbicide, fertilizer, and insecticide was budgeted for the 320 and 640-acre farms at prices reported in Table 2. Custom application of these inputs was not assumed for the two large farms. The machinery complements for the 1,280 and 2,560-acre farms include fertilizer applicators and sprayers.

Table 4 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 5 includes estimates of machinery labor, machinery investment, and 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. These results show that 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 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 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 5 and graphed in Figure 2. The estimates are very similar across the 320, 640, 1,280, and 2,560-acre farm sizes. 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. Machinery fixed costs savings are greater for the two large farms. The no-till air seeder budgeted for the 2,560-acre farm costs only 30% more than the conventional air seeder budgeted for the conventional farm. The chart in Figure 2 illustrates the potential economies of size in machinery fixed costs per acre especially for the no-till production systems.

Labor requirements to conduct the budgeted machinery operations are reported in Table 5. The only machine operation budgeted for the no-till 320 and 640-acre farms is the use of the no-till drill. For these farms, herbicide, insecticide, and fertilizer are assumed to be custom applied. Based upon these assumptions and the machines selected, the total annual machinery labor requirement would be 93 hours for the 320-acre no-till farm and 90 hours for the 640-acre no-till farm. If the no-till drill operation could be custom hired, it might be more reasonable to assume that no-till drilling for the 320 and 640-acre farms was custom hired. However, based upon anecdotal evidence provided by the Oklahoma Farm and Ranch Custom Rates survey, custom operated no-till wheat grain drilling is not widely available (Doye, Sahs, and Kletke). Figure 3 includes a chart of the budgeted machinery labor requirements.

As shown in Table 5, 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 (4.5 pints of glyphosate) is $11.25 per acre. No herbicide is budgeted for the conventional tillage system.

Figure 4 includes a chart of total operating costs ($/acre) for both production systems across the four farm sizes. These costs are also reported in Table 5. 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 5 includes a chart of total operating plus machinery fixed costs. These costs are also reported in Table 5. 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 6 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 6 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% 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.

These results suggest that the reduction in the price of glyphosate has changed the cost of no-till relative to the cost of conventional tillage for continuous monoculture wheat production. Previous studies have found that no-till was more costly. The limited use of no-till for wheat production in the region provided credence for these earlier findings. However, the reduction in the price of glyphosate has clearly improved the relative economics of no-till.

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. Size and List Prices for Tractors and Machines.

Type of Machinery	Machinery Width (Feet)	List Price ($)
95 hp Tractor		58,167
155 hp Tractor		81,707
170 hp Tractor		101,198
255 hp Tractor		156,404
325 hp Tractor		176,151
Chisel	8.55	5,555
Chisel	18.6	9,673
Chisel	20.4	16,469
Chisel	30.6	21,982
Chisel	39	23,982
Disk	10.48	7,543
Disk	17.1	20,231
Disk	18.75	22,049
Disk	28.13	29,022
Disk	35.85	35,597
Moldboard Plow	4.75	13,921
Moldboard Plow	7.75	15,812
Moldboard Plow	8.5	18,337
Moldboard Plow	12.75	24,516
Moldboard Plow	16.25	33,820
Fertilizer Spreader	40	11,200
Sprayer	40	5,564
Sprayer	60	7,372
Conventional-Till Drill	10	9,239
Conventional-Till Drill	20	23,957
Conventional-Till Air Seeder	36	105,000
No-Till Drill	10	27,053
No-Till Drill	20	51,992
No-Till Air Seeder	36	137,500

Table 4. Machinery Complements for Conventional Tillage and No-till Wheat Production Systems for Alternative Farm Sizes

Machine	Machine Width (Feet)	Field Speed (MPH)	Field Efficiency (%)	Draft / ft. of Implement (Lbs.)	Conventional Tillage	No-till
320-Acre Farm						
95 hp Tractor					✓	✓
Moldboard Plow	4.75	4.5	85	1250	✓	
Chisel	8.55	5	85	625	✓	
Disk	10.48	6	80	425	✓	
Conventional-Till Drill	10	5	70	225	✓	
No-Till Drill	10	5	70	400		✓
640-Acre Farm						
155 hp Tractor					✓	✓
Moldboard Plow	7.75	4.5	85	1250	✓	
Chisel	18.6	5	85	625	✓	
Disk	17.1	6	80	425	✓	
Conventional-Till Drill	20	5	70	225	✓	
No-Till Drill	20	5	70	400		✓
1,280-Acre Farm						
95 hp Tractor						✓
Sprayer	40	6.5	65	200		✓
Fertilizer Spreader	40	7	70	200		✓
155 hp Tractor					✓	✓
No-Till Drill	20	5	70	400		✓
Conventional-Till Drill	20	5	70	225	✓	
Sprayer	60	6.5	65	200	✓	
Fertilizer Spreader	40	7	70	200	✓	
170 hp Tractor					✓	
Moldboard Plow	8.5	4.5	85	1250	✓	
Chisel	20.4	5	85	625	✓	
Disk	18.75	6	80	425	✓	

Table 4. Continued

Machine	Machine Width (Feet)	Field Speed (MPH)	Field Efficiency (%)	Draft / ft. of Implement (Lbs.)	Conventional Tillage	No-till
2,560-Acre Farm						
95 hp Tractor					✓	✓
Sprayer	40	6.5	65	200	✓	✓
Fertilizer Spreader	40	7	70	200	✓	✓
255 hp Tractor					✓	✓
Disk	28.13	6	80	425	✓	
Chisel	30.6	5	85	625	✓	
Conventional-Till Air Seeder	36	5	70	225	✓	
No-Till Air Seeder	36	5	70	400		✓
255 hp Tractor					✓	
Moldboard Plow	12.75	4.5	85	1250	✓	
Chisel	30.6	5	85	625	✓	
Disk	28.13	6	80	425	✓	

Table 5. Estimates of Machinery Labor, Machinery Investment, and Production Costs for Conventional Tillage and No-till Wheat Production Systems.

	Units	Conventional	No-till
All Farms			
Wheat Seed	$/ac	10.50	10.50
Fertilizer	$/ac	22.55	22.55
Herbicide	$/ac	0.00	11.25
Insecticide	$/ac	3.00	3.00
Custom Harvest and Hauling	$/ac	20.80	20.80
320-Acre Farm			
Machinery Labor	hrs/ac	1.21	0.29
Average Machinery Investment	$/ac	159.70	134.43
Interest on Operating Capital	$/ac	2.60	3.39
Fuel, Lube, and Repairs	$/ac	9.62	3.03
Custom Application Charge	$/ac	5.64	16.61
Total Operating Cost	$/ac	74.71	91.13
Machinery Fixed Cost	$/ac	34.58	27.88
Total Operating Plus Machinery Cost	$/ac	109.29	119.01
640-Acre Farm			
Machinery Labor	hrs/ac	0.68	0.14
Average Machinery Investment	$/ac	127.75	106.19
Interest on Operating Capital	$/ac	2.61	3.37
Fuel, Lube, and Repairs	$/ac	9.90	2.67
Custom Application Charge	$/ac	5.64	16.61
Total Operating Cost	$/ac	75.00	90.75
Machinery Fixed Cost	$/ac	28.09	22.49
Total Operating Plus Machinery Cost	$/ac	103.09	113.24
1,280-Acre Farm			
Machinery Labor	hrs/ac	0.72	0.43
Average Machinery Investment	$/ac	118.89	85.35
Interest on Operating Capital	$/ac	2.53	2.76
Fuel, Lube, and Repairs	$/ac	13.92	7.19
Custom Application Charge	$/ac	0.00	0.00
Total Operating Cost	$/ac	73.30	78.05
Machinery Fixed Cost	$/ac	25.37	17.92
Total Operating Plus Machinery Cost	$/ac	98.67	95.97
2,560-Acre Farm			
Machinery Labor	hrs/ac	0.51	0.37
Average Machinery Investment	$/ac	130.90	74.93
Interest on Operating Capital	$/ac	2.61	2.89
Fuel, Lube, and Repairs	$/ac	15.47	9.73
Custom Application Charge	$/ac	0.00	0.00
Total Operating Cost	$/ac	74.93	80.72
Machinery Fixed Cost	$/ac	28.45	16.07
Total Operating Plus Machinery Cost	$/ac	103.38	99.79

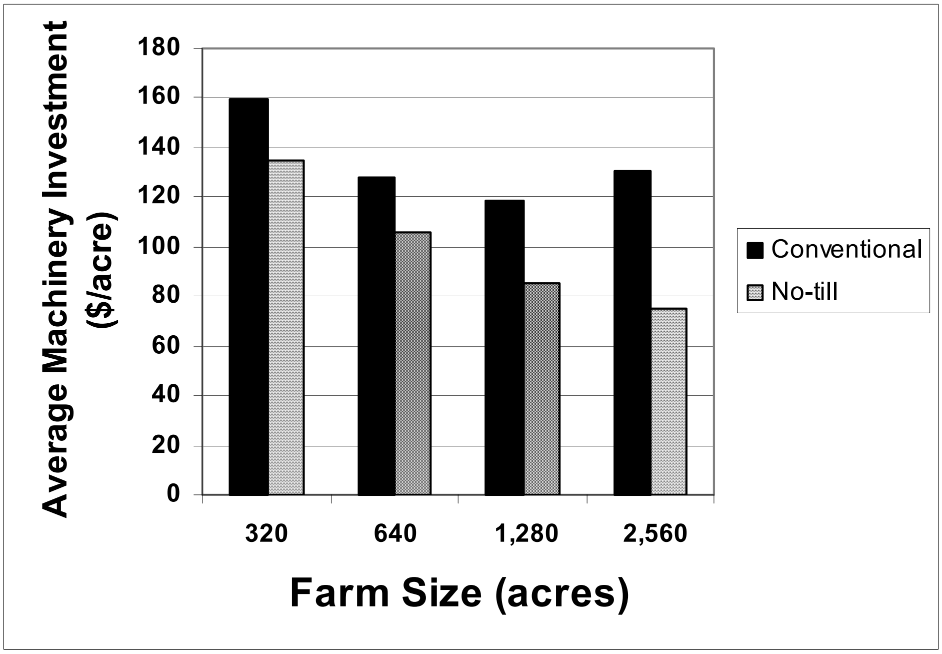

Figure 1. Average machinery investment ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes.

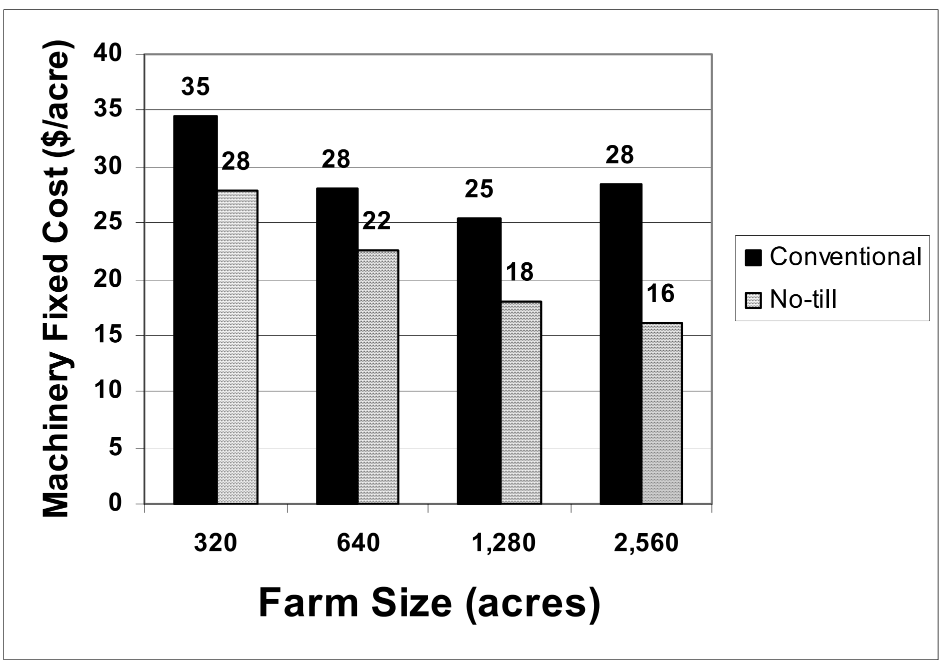

Figure 2. Machinery fixed costs ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes.

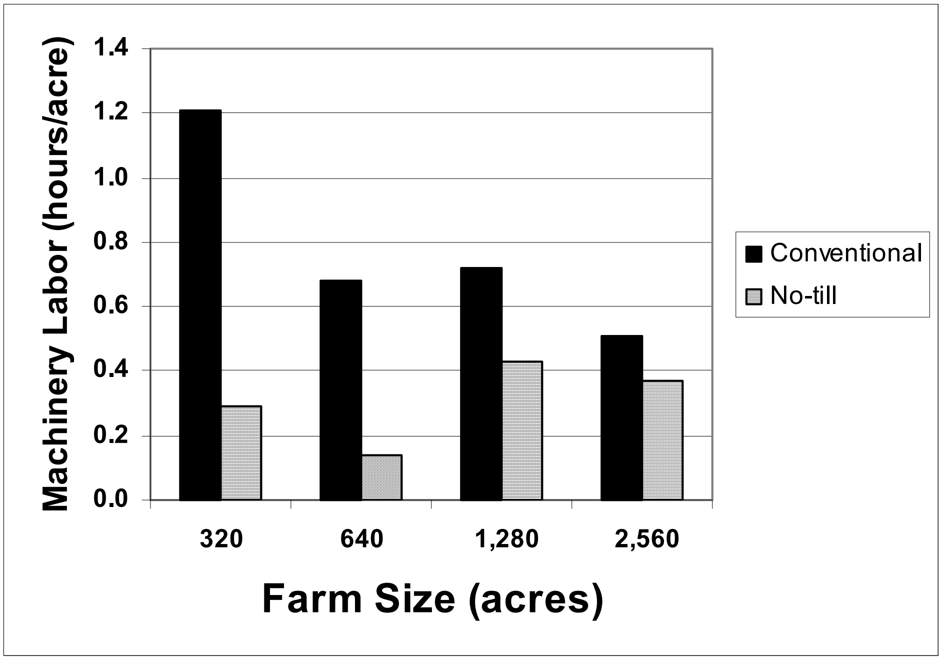

Figure 3. Machinery labor requirements (hours per acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes.

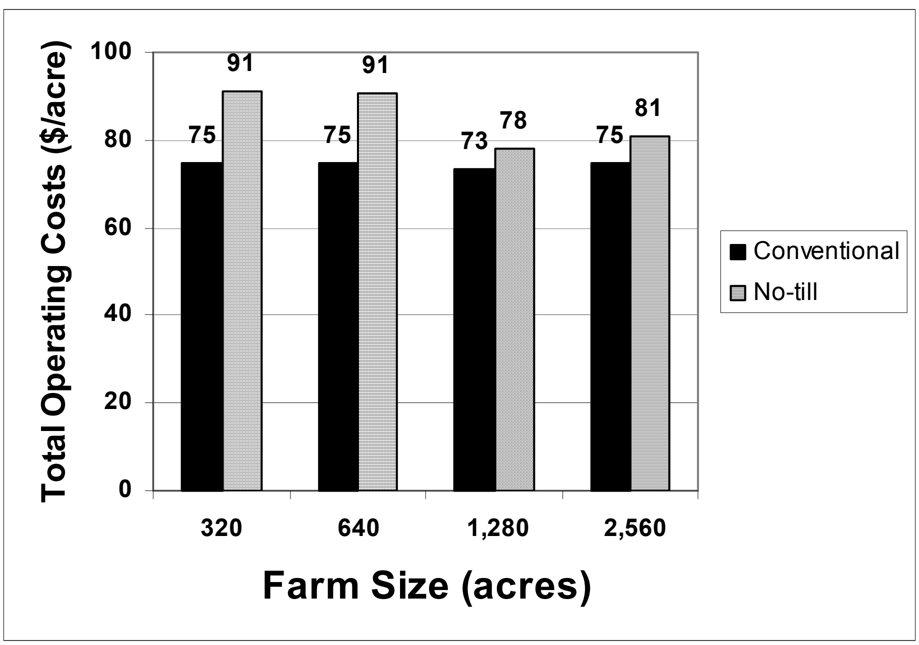

Figure 4. Total operating costs ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes.

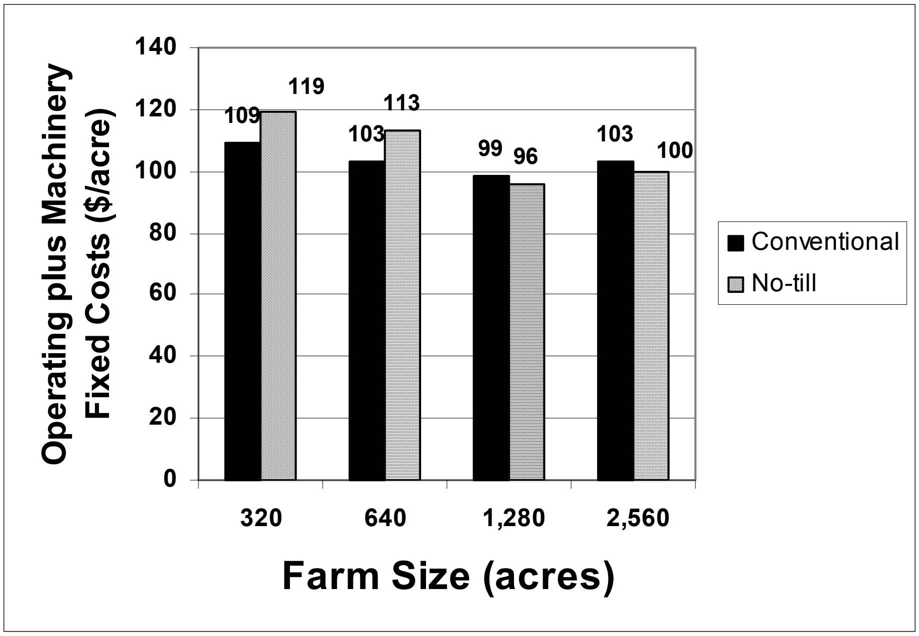

Figure 5. Total operating plus machinery fixed costs ($/acre) for both conventional tillage and no-till monoculture winter wheat for four farm sizes.

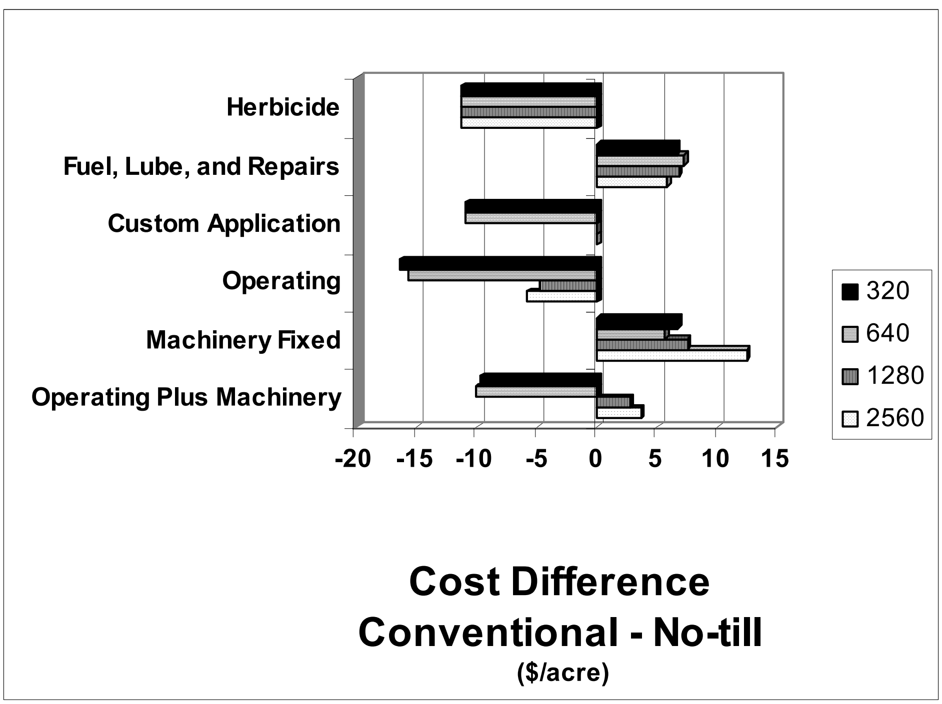

Figure 6. Cost difference ($/acre) of selected items between conventional tillage and no-till monoculture winter wheat for four farm sizes.