

WINTER WHEAT CROPPING AND
TILLAGE SYSTEMS

By

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TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
Objectives	2
II. LITERATURE REVIEW	4
Agronomic Differences of No-Till Relative to Conventional-Till	6
Soil Tilth	6
Organic Matter	7
Soil Erosion	8
Air and Water Quality	9
Crop Diseases	9
Yields	9
The Economics of No-Till Relative to Conventional-Till	12
Previous Research on the Economics of No-Till Relative to Conventional-Till for Continuous Wheat	14
Adoption	15
III. PROCEDURES	18
Enterprise Wheat Budget	19
Machinery and Equipment Cost	19
Conventional-Till Field Operations	20
No-Till Field Operations	24
Machinery Ownership and Operating Costs	25
Candidate Machines	26
Wheat Production Costs	34
Wheat and Millet Production Returns	38
IV. RESULTS	45
Yields	45
Revenue	50
Operating Costs	59
Machinery Variable Costs	60
Machinery Fixed Costs	62
Total Costs	64
Machinery Labor Hours	65
Net Returns	67

Chapter	Page
V. CONCLUSIONS.....	75
Summary	78
VI. REFERENCES	82

LIST OF TABLES

Table	Page
Table III-1.	Field Operations for Alternative Wheat Production Systems. 22
Table III-2.	Tractor and Machinery Complements for a 320 and 640-Acre Farm..... 28
Table III-3.	Tractor and Machinery Complements for a 1,280-Acre Farm. 29
Table III-4.	Tractor and Machinery Complements for a 2,560-Acre Farm. 30
Table III-5.	Tractors and Machinery Complements Available for Field Operations..... 32
Table III-6.	Machinery Average Investment per Acre for a 320-Acre Farm..... 33
Table III-7.	Machinery Average Investment per Acre for a 640-Acre Farm..... 33
Table III-8.	Machinery Average Investment per Acre for a 1,280-Acre Farm..... 33
Table III-9.	Machinery Average Investment per Acre for a 2,560-Acre Farm..... 34
Table III-10.	Operating Inputs for Alternative Wheat Production Systems. 36
Table III-11.	Oklahoma City June Wheat Prices (\$/bu), 1999-2003..... 38
Table III-12.	Stocker Steer Enterprise Budget for Dual-Purpose Winter Wheat Pasture. 41
Table III-13.	Oklahoma City Purchase Price for 550-600 lb Medium/Large Frame No. 1 Steers, 1998-2002..... 42
Table III-14.	Oklahoma City Sell Price for 800-850 lb Medium/Large Frame No. 1 Steers, 1999-2003..... 42
Table IV-1.	Average Millet and Wheat Yields Per Acre. 46
Table IV-2.	Estimated Per Acre Cost and Returns for a 320-Acre Farm with Method "A" Calculation..... 51
Table IV-3.	Estimated Per Acre Cost and Returns for a 640-Acre Farm with Method "A" Calculation..... 52
Table IV-4.	Estimated Per Acre Cost and Returns for a 1,280-Acre Farm with Method "A" Calculation..... 53
Table IV-5.	Estimated Per Acre Cost and Returns for a 2,560-Acre Farm with Method "A" Calculation..... 54
Table IV-6.	Estimated Per Acre Cost and Returns for a 320-Acre Farm with Method "B" Calculation..... 55
Table IV-7.	Estimated Per Acre Cost and Returns for a 640-Acre Farm with Method "B" Calculation..... 56
Table IV-8.	Estimated Per Acre Cost and Returns for a 1,280-Acre Farm with Method "B" Calculation..... 57
Table IV-9.	Estimated Per Acre Cost and Returns for a 2,560-Acre Farm with Method "B" Calculation..... 58

LIST OF FIGURES

Figure	Page
Figure IV-1.	Average Dry Matter Millet Hay Yields per Acre. 45
Figure IV-2.	Average Dry Matter Wheat Pasture Yields per Acre. 48
Figure IV-3.	Average Dry Matter Wheat Hay Yields per Acre. 48
Figure IV-4.	Average Wheat Grain Yields per Acre. 49
Figure IV-5.	Average No-Till Fall-Winter Forage and Grain Yields Across Planting Dates. 49
Figure IV-6.	Average Total Herbicide and Pesticide Costs per Acre. 60
Figure IV-7.	Average Machinery Variable Costs per Acre for a 320-Acre Farm. 61
Figure IV-8.	Average Machinery Variable Costs per Acre for a 2,560-Acre Farm. 62
Figure IV-9.	Average Machinery Fixed Costs per Acre for a 320-Acre Farm. 63
Figure IV-10.	Average Machinery Fixed Costs per Acre for a 2,560-Acre Farm. 63
Figure IV-11.	Average Total Costs per Acre for a 320-Acre Farm. 64
Figure IV-12.	Average Total Costs per Acre for a 1,280-Acre Farm. 65
Figure IV-13.	Average Total Costs per Acre for a 2,560-Acre Farm. 65
Figure IV-14.	Average Total Machinery Labor Hours Used per Acre for a 320- Acre Farm. 66
Figure IV-15.	Average Total Machinery Labor Hours Used per Acre for a 2,560-Acre Farm. 67
Figure IV-16.	Average Net Returns for a 320-Acre Farm Using the Method “A” Fall-Winter Calculation. 68
Figure IV-17.	Average Net Returns for a 320-Acre Farm Using the Method “B” Fall-Winter Calculation. 69
Figure IV-18.	Average Net Returns for a 2,560-Acre Farm Using the Method “A” Fall-Winter Calculation. 70
Figure IV-19.	Average Net Returns for a 2,560-Acre Farm Using the Method “B” Fall-Winter Calculation. 71
Figure IV-20.	Machinery Fixed Costs per Acre for an ESDC and ESDN System by Farm Size. 74
Figure IV-21.	Net Returns per Acre for an ESDC and ESDN System by Farm Size using the Method “A” Fall-Winter Calculation. 74

CHAPTER I

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-till methods has not been very profitable for farmers in this 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 2001). These data do not include government subsidies, but the problem of low returns from continuous monoculture wheat is evident. To generate positive economic returns, wheat producers in the region must employ economically efficient production methods.

In the southern Great Plains, wheat is a multiple use crop. It may be produced either for grain-only, forage-only, or as a dual-purpose crop for both forage and grain.

Additionally, wheat can be produced with alternative production methods, such as no-till or direct seeding. No-till is defined as a system with no preplant tillage with soil disturbance limited to that created by the planting operation (Buhler, p.1247). The no-till method can prevent soil erosion, improve moisture retention, and allow the soil to retain carbon, which reduces the amount of carbon dioxide that reaches the atmosphere.

To-date, research has not been conducted to determine the most economical production system and tillage method for continuous monoculture wheat in the region. The general questions to be addressed by this research are as follows: first, what is the most economical wheat production system (grain-only, forage-only or dual-purpose), second, what is the most economical tillage system (conventional-till or no-till), and third, does farm size matter?

This research will use agronomic data produced in an experiment initiated in May 2002 on farms located near Loyal (Kingfisher County), Kremlin (Garfield County), and Cherokee (Alfalfa County), Oklahoma.

Objectives

General Objectives:

The overall objective is to determine the most economical production system (grain-only, forage-only, dual-purpose) and the most economical tillage system (conventional-till, no-till) for continuous monoculture wheat production in Oklahoma for farms of different size.

Specific Objectives:

The specific objectives are to determine the costs and returns of conventional-till and no-till management farm practices for each of four farm sizes (320, 640, 1,280, and 2,560-acres) from:

1. Wheat seeded in early September for forage-only,
2. Wheat seeded in early September for forage-only with foxtail millet seeded as a summer forage double crop,
3. Wheat seeded in early September for dual-purpose (forage plus grain),
4. Wheat seeded in late September for dual-purpose (forage plus grain), and
5. Wheat seeded in mid October for grain-only.

CHAPTER II

LITERATURE REVIEW

In 1929, 40 million acres were developed for crop production, mainly monoculture wheat, in the central and southern Great Plains through the expansion of agricultural mechanization (Johnson and Davis). Up until this time, farmers used production methods that they had learned in eastern United States or Europe. The common practice was to plow the sod and to use clean till year after year (Unger and Baumhardt). The “Dust Bowl” era of the 1930s demonstrated environmental problems resulting from clean till production in the southern Great Plains.

Conservation equipment soon followed as a result of the “Dust Bowl” era. In 1936, C.S. Noble of southern Alberta developed the Noble blade, a straight undercutting blade, which undercut the wheat stubble and left the residue on the surface reducing soil erosion (Allen and Fenster). The U.S. Soil Conservation Service bought 19 of these machines and distributed them throughout the United States for testing approximately two years later. In 1938, J.C. Russell and F.L. Duley, employees of the Soil Conservation Service research unit at Lincoln, Nebraska, met with L.W. Chase, president of the Chase Plow Company, and began manufacturing sweep plows and sold them as subsurface tillers that undercut weeds while leaving residue on the surface, making subsurface tillage a reality (Allen and Fenster, p. 12).

Russell and Duley later submitted their first subtillage manuscript to Washington, D.C. called “Noninversion Tillage”. This name was later changed to “Stubble-Mulch Tillage” by the Soil Conservation Service Director, H.H. Bennett (Langdale). With the introduction of stubble-mulch tillage in 1939 and herbicides in the 1940s and early 1950s, researchers began to experiment with no-till production while improved herbicides and equipment became available in the late 1950s (Unger and Baumhardt). Propazine and atrazine herbicides were introduced in the 1960s, which enabled farmers the option to use a combination of sweep tillage and herbicide applications (Allen and Fenster). This method was known as eco-fallow and it resulted in increased fallow season storage of soil water as compared to stubble-mulch till.

Herbicides were intended to substitute for a few tillage operations to reduce weeds resulting in less labor and time spent tilling the soil. Improved herbicides helped stubble-mulch technology spread throughout the United States and it eventually spawned the use of no-till production.

No-till acres in the United States increased from 16 million acres in 1990 to 55 million acres in 2002, which represents 19.6% of total U.S. acreage (Hellwinckel, Larson and De La Torre Ugarte; Reeder). No-till production systems were initially adopted in regions of the country where they enabled farmers to expand acres cropped. For example, no-till enabled the production of row crops such as corn on steeply sloped soils of the Midwest. Prior to no-till, row crops could not be produced on these steeply sloped soils without risking excessive soil erosion. In general, the production of row crops on these soils generated greater economic returns than alternatives such as pasture and hay.

No-till corn did not have to compete economically with conventional-till corn. No-till corn had to compete with pasture and hay.

No-till production systems also enabled farmers to expand acres cropped by making it easier to double crop soybeans after wheat in some regions of the country. Prior to no-till if farmers wanted to plant soybeans immediately after wheat harvest they were required to till the soil. This operation required time and resulted in moisture loss near the soil surface that is essential for soybean germination. With no-till systems, soybeans could be planted immediately after the combine removed the wheat grain, increasing the probability that moisture would be sufficient for germination and increasing the probability of a successful soybean crop. In this case no-till double-cropped soybean production did not have to compete economically with conventional-till soybeans. It had to compete with fallow.

Agronomic Differences of No-Till Relative to Conventional-Till

No-till production results in agronomic differences relative to conventional-till systems. These differences are related to: soil tilth; organic matter; soil erosion; air and water quality; crop diseases; and yields.

Soil Tilth

Soil tilth has to do with the compaction of the soil. Less compaction would be encountered in a no-till production due to fewer trips across the field enabling plant roots to move more freely throughout the soil. One environmental issue related to soil tilth and the choice of tillage has to do with earthworms and water infiltration. When the soil is

tilled by means of a conventional-till method, the bottom soil is brought to the surface and thus covering the wheat stalks and other vegetation on the topsoil. This limits the amount of earthworms that help the soil with water infiltration. Shipitalo and Butt found that earthworm populations frequently increased with a reduction in tillage intensity. Earthworm burrowing can redistribute nutrients to the deeper subsurface, facilitating root growth at greater depths (Christy, p. 2). With no-till, earthworms burrow under the soil and create tunnels for water to infiltrate the soil, which allows the soil to retain water longer (Wuest). This process takes a few years for these tunnel systems to be created. By tilling the land annually, earthworms are not allowed to create their tunnel systems resulting in soil moisture lost.

Organic Matter

Most United States cropland soils have lost at least one-third and some up to 60 percent of their carbon since they were first converted to crop production some 200 years ago (U.S. Department of Agriculture 2003). Research has shown that the more soil is tilled, the more carbon is released into the air limiting the amount of carbon in the soil that can be used to make organic matter necessary for crop survival. Due to this, environmentalists consider no-till methods to be a good farming technique to protect the earth from global warming. With conventional-till, each time the land is tilled, carbon dioxide is released into the atmosphere causing global warming (Karasov). With no-till, the carbon is left in the soil, which increases organic matter. A continuous no-till system is important in building up soil organic carbon since it can take several years to develop. In one study, no-till management practices generally increased soil organic carbon

content above that occurring with conventional-till if some residue was left on the soil surface (Potter, Garcia, and Torbert, p.31). Over time, soils in a no-till system become more fertile, which is why no-till production should be looked at in the long-run instead of the short-run.

Soil Erosion

The two most common types of soil erosion are from water and wind. In a study done by Harman and Martin, wind erosion caused about 30 percent of the total cropland to erode in the six plains states of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. Researchers have found that no-till systems help prevent erosion of topsoil. By not tilling the soil, stubble is left on the surface. This helps prevent soil erosion, which would reduce yields considerably. In one study, no-till reduced soil erosion by as much as 50-fold when compared with moldboard plowing on highly erodible land (Triplett and VanDoren).

Residue left on the surface not only prevents soil erosion, but it also traps soil moisture, which improves water availability to the plant. More water to the plant allows farmers to plant their crops earlier and obtain a good stand at the same time. Krenzer, Burton, and Gough found that in two out of six site years, plowed wheat plots planted in August did not produce a stand, but no-till plots did produce a satisfactory stand. Unger found that no-till treatments resulted in the greatest water storage during fallow from wheat to sorghum, therefore resulting in higher no-till yields. Soil water conservation is important in that it results in greater plant growth, which means higher grain and forage yields.

Air and Water Quality

With less runoff from no-till production, the water quality of local lakes, rivers, and streams should improve. By having residue left on the soil surface, nutrients (mainly phosphorus), pesticides, herbicides, and fertilizers will remain on the field instead of moving into nearby waters. The toxicity levels of additional chemicals used in a no-till system may, however, alter these results. Air quality will also be cleaned up with the reduction of carbon being released into the air and with the reduction of tractor emissions.

Crop Diseases

A major problem with no-till and conventional-till monoculture continuous wheat is that some diseases flourish in monocultures. For some diseases, crop rotations significantly decrease the odds of infestation. Many diseases remain from crop to crop through crop residue. With no-till, the problem could get worse since more crop residue is left on the surface than with conventional-till methods. Diseases such as tan spot, rhizoctonia root rot, and other diseases could flourish reducing no-till wheat yields considerably.

Yields

In Borovce, Slovakia, no-till yields for winter wheat, spring barley, and grain maize were lower than yields for conventional-till and minimum tillage treatments resulting in no-till being the least profitable (Gabcova).

A ten-year Kansas study found continuous conventional-till sorghum to have higher yields than the no-till sorghum practices (Williams et al.). It was also determined that a conventional-till sorghum, no-till wheat rotation had nearly the same yields as the no-till sorghum, no-till wheat rotation.

Oxner et al. reported that a conventionally drilled management system had a higher soft winter wheat average yield (34.8 bushels/acre) than the no-till system (29.0 bushels/acre) in a six-experiment study in Arkansas. There was a \$16.13 difference in net return per acre between the two systems, with conventional-till having the highest net return. The results found that no-till required more labor, money, and time per acre than any other method due to the use of a narrow width drill, which had to be operated at 4.1 mph or less. It was found however that no-till had the most stable yields over the years compared to the other three management systems.

Williams, Llewelyn, and Barnaby discovered no-till wheat fallow and continuous no-till sorghum practices yielded slightly more than the conventional systems. This was due to there being more soil moisture for the no-till crops. It was also noted that the no-till wheat/sorghum/fallow rotation yielded approximately seven more bushels to the acre for sorghum, but it yielded about 19 bushels per acre less for wheat grain compared to the conventional-till practice. Out of the five cropping systems in this study, continuous wheat for no-till and conventional-till yielded less than the other production methods.

In another study, non-irrigated wheat and barley yields in northern Utah were found to have not decreased significantly when using a no-till strategy as compared to a combination and a minimum tillage strategy (Helms, Bailey, and Glover). Krause and Black found estimated mean corn and soybean yields in Michigan to be higher for no-till

systems, but that the differences were not statistically significant. They also found mean net returns to be higher for no-till than conventional when yields were assumed to be the same.

In a North Dakota study, Swenson and Johnson surveyed 19 farmers who used the no-till method. They determined that no-till spring wheat averaged 24.2 bushels per acre compared to a county average of 24.3 bushels per acre. Average barley yields were 48 bushels per acre for no-till and 37.7 bushels per acre for the county average. No-till winter wheat also had a higher average yield of 28 bushels per acre as compared to the county average of 15.2 bushels per acre. On seven other no-till winter wheat fields, average yields were 26 bushels per acre where there were counties with no harvested acres. In this study, no-till farmers were able to expand their croppable acres. This indicates that no-till winter wheat production is possible in areas where conventional-till methods are not feasible (Swenson and Johnson, p.15).

Harman and Martin also found no-till yields and net returns in the Texas High Plains, a semiarid region, to be as high or higher than conventional-till systems for irrigated sorghum with a wheat/sorghum/fallow rotation, dryland sorghum with a wheat/sorghum/fallow rotation, and dryland cotton following an irrigated small grain crop. In all of these systems, no-till had higher variable costs but substantially smaller fixed costs. Also in this study, it was found that a conventional wheat/no-till sorghum/fallow rotation produced the highest return out of a conventional wheat/conventional sorghum/fallow rotation and a no-till wheat/no-till sorghum/fallow rotation. In the Blackland Prairie area, a high rainfall region of Texas, a conventional-till practice with a sorghum/cotton/wheat rotation had a higher net return than the no-till

systems. This study shows that when there is limited rain available, a no-till system is more economical, but when in a high rainfall area, a conventional-till system is more economical.

The Economics of No-Till Relative to Conventional-Till

Harman and Martin (p. 25) list 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, and
6. Tractor and equipment depreciation.

Operating and fixed costs of production are key factors when determining the profitability of each farm size and management practice. Labor and fuel costs are reduced with fewer trips over the field in a no-till system. Many no-till farmers say they are saving as much as \$15 an acre in labor and fuel costs (Swinn). Others are saving as much as 60 to 75 percent on fuel use and labor by reducing or eliminating preplant tillage (Buhler, p. 1247).

With no-till production systems, herbicide applications are substituted for tillage operations to control weeds. Weed and pest control can range from 10 to 30 percent of total farm costs (Allmaras and Dowdy). A weed management system has to be put in place to keep weed levels below economic thresholds. Precise timing and amount of

herbicide to apply are critical factors because weeds are successful due to their genetic diversity, and ability to adapt to and take advantage of conditions created by crop production systems (Buhler).

Farmers offset the savings they see in reduced machinery and labor costs of no-till by buying more pesticides and herbicides to reduce weeds and insects. No-till systems can discourage the growth of annual weeds by 80% in some cases (Lynons-Johnson). However, as annual species drop, winter annual, biennial, and all types of perennial weed species would increase (Buhler, p.1250).

Farmers' equipment costs with the no-till method may decrease, as the producer would not need the same equipment as is necessary with conventional-till methods. The tractor life may be extended as a result of less use thus decreasing repair costs and extending fixed costs over the additional years. In one case in which the farmer changed from a conventional-till method to a no-till operation, the farmer's capital equipment went from three tractors to two, hired help decreased from three to two workers, and time spent on the tractor was reduced by 500 hours, from 700 to 200 hours a year (Carter).

Studies have found that variable costs for no- and reduced-tillage treatments were about two to three times higher than sweep plowing, which was \$12.55 per acre (Wiese et al.). In a study in Borovce, Slovakia, Gabcova found that two no-till technologies reduced direct costs by 9% and 11%, respectively, in a grain maize system, but direct costs increased by 1% in the wheat and barley systems. Still other studies have shown that variable costs are higher for no-till production over conventional-till but that fixed costs are considerably lower (Williams et al.; Harman and Martin).

However, others have found that the costs of no-till are about the same as the costs of conventional-till. One study showed that variable costs were higher for reduced tillage wheat systems, but, when including machinery costs, the two systems were competitive among costs of production (Williams, Llewelyn, and Barnaby).

Previous Research on the Economics of No-Till Relative to Conventional-Till for Continuous Wheat

Harman and Martin in 1987 found conventional continuous wheat yields to be slightly higher in the semiarid region of the Rolling Plains of Texas, but net return to land, management, and risk for no-till was \$26 greater per acre. Variable costs for no-till were \$9 per acre greater, but machinery fixed costs were \$36 per acre less than the conventional-till treatment. Conventional-till treatments had six operations compared to no-till systems having two operations plus two custom herbicide applications.

Another study done in 1989 in the southern Plains by Heer and Krenzer reported that in two out of three years, conventional-till wheat yields were significantly greater than those obtained with a no-till system. It was also stated that when yields were limited by rainfall, no-till had the potential to have higher yields than conventional-till.

In a 1990 Kansas study, Williams, Llewelyn, and Barnaby discovered continuous no-till wheat yielded slightly more than the conventional systems. This was due to there being more soil moisture for the no-till crops.

A five-year North Dakota study done by Bauer and Black in 1992 found spring wheat yields on a moldboard plowed conventional system to be as high or higher in seven of nine comparisons than on three other systems including one no-till system.

In a 1994 Texas study, researchers found that a sweep plowing treatment yielded significantly less (425 kg/ha) than the best no-till treatment in two of four years in a continuous winter wheat production system (Wiese et al.). No-till variable costs were two to three times higher than the sweep plowing treatments. In the long run, it was found that no treatments were profitable when considering machinery use and depreciation costs.

In another 1994 study, it was found that a no-till system resulted in higher total costs than other alternative systems and that the no-till system was the least economical alternative out of all the systems in Oklahoma (Epplin, Al-Sakkaf, and Peeper). Highest yields (34 bushels/acre) for a continuous wheat system were obtained from moldboard plow based clean tillage systems, and the lowest yields (24 bushels/acre) resulted from no-till systems.

A ten-year Kansas study in 2002 found continuous conventional-till wheat to have higher yields than no-till wheat practices (Williams et al.). Positive net returns were determined for all systems except continuous no-till wheat (-\$11.80 per acre). Continuous conventional-till wheat had a net return of \$8.19 per acre.

Adoption

There are many differences between no-till and conventional-till that could affect a farmer's choice of tillage method. In an article by Sanders, three purposes to change production practices are listed:

1. To achieve improved profitability,
2. To satisfy a lifestyle of the producer, and/or

3. To improve or preserve ecosystem characteristics.

Most farmers change to a no-till production method for economic reasons rather than agronomic reasons. One study showed that the more education a farmer received, the more likely that farmer would be to use a conservation tillage technique, such as no-till. The researchers also found that the longer an individual farmed, the more likely that individual would be to use a conventional-till technique, as that method would be the method they were accustomed to (Wu and Babcock).

In some regions of the United States no-till crop production is more economical than the alternative. This is especially true when no-till corn production is compared with pasture or hay production on steeply sloped soils in the Midwest. It is also true when the double-cropped soybeans are compared with fallow. However, in prior studies in which the economics of no-till was compared with conventional-till for continuous monoculture wheat production on relatively level soils, conventional-till has been found to be more economical.

Recent developments have increased the effectiveness of no-till planters and drills. The cost of burn-down herbicides has decreased. In 1998, Monsanto reduced the price of glyphosate (Roundup) by 22% (Benbrook). From 1999-2002, the price of glyphosate has decreased by another 4.4% (National Agricultural Statistics Service). According to the same source, average price paid by U.S. farmers for glyphosate was \$44.20 per gallon from 1999-2002.

Farmers may benefit from information regarding the relative economics of conventional-till and no-till production practices. In general, farmers adopt methods that have been demonstrated to increase their net return. With the introduction of better no-

till planters and drills, and the decrease in the cost of glyphosate, and given that herbicide-tolerant wheat varieties that use the “Clearfield” technology are currently under development, another look at the economics of no-till versus conventional-till for continuous monoculture winter wheat production in the southern Great Plains is warranted.

CHAPTER III

PROCEDURES

The field experiments examined for this research project were conducted on farms located near Loyal (Kingfisher County), Cherokee (Alfalfa County), and Kremlin (Garfield County), Oklahoma. Conventional-till and no-till management practices were examined for alternative planting dates, and different wheat uses including grain-only, forage-only and dual-purpose (forage plus grain).

These experiments were conducted using the recommended procedure of wheat seeding as reported by Krenzer. Krenzer reported that seeding in early September for a dual-purpose system would result in more forage but less grain than wheat planted in early October. Therefore, if farmers want to have fall-winter grazing for their livestock, planting in early September is recommended, but if wheat is produced for grain-only production, an October planting date is recommended.

Other important recommended practices for dual-purpose winter wheat include placing livestock on wheat only after the plant roots are well anchored and removing livestock prior to the first hollow stem of wheat development. First hollow stem is defined as the stage at which hollow stem can first be identified above the crown where it occurs prior to the growing point reaching the soil surface (Redman et al.). Livestock left on after the first hollow stem will result in wheat yields decreasing substantially.

The procedures of this research focus on determining the costs and returns of both tillage treatments for five production systems (wheat seeded in early September for forage-only; wheat seeded in early September for forage-only with German foxtail millet seeded as a summer forage double crop; wheat seeded in early September for dual-purpose (forage plus grain); wheat seeded in late September for dual-purpose (forage plus grain); and wheat seeded in mid October for grain-only) for four farm sizes (320, 640, 1,280, and 2,560-acres).

Enterprise Wheat Budget

A wheat enterprise budget was used to determine the returns to land, labor, and management for each system. The enterprise budgets include gross receipts minus operating costs and fixed costs. Gross receipts include revenue from millet hay, fall-winter wheat grazing, wheat hay in May, and wheat for grain. The operating costs include millet and wheat seed, fertilizer, herbicide, pesticide, custom application, custom millet and wheat hay harvest, custom grain harvest and hauling, operating capital, and machinery fuel, lubrication, and repair costs. Fixed costs consist of machinery interest, taxes, insurance, and depreciation costs.

Machinery and Equipment Cost

The first step in determining the net returns was to estimate the number and type of field operations (tillage, seeding, herbicide application, pesticide application, fertilizer application and harvest) for each of the ten treatments (2 tillage systems by 5 wheat

production alternatives). Average field operations used at the three locations were used to determine one representative list of operations for each treatment.

Conventional-Till Field Operations

Each acronym contains the following components. ES, LS, and O are used to denote early September, late September, and October wheat planting dates, respectively. F, FM, D, and G are used to differentiate among forage-only, forage plus German foxtail millet, dual-purpose, and grain-only. Finally, C is used to refer to conventional-till and N to no-till.

Acronyms were developed for each system. Acronyms for conventional-till are ESFC for wheat seeded in early September for forage-only, ESFMC for wheat seeded in early September for forage-only with German foxtail millet seeded as a summer forage double crop, ESDC for wheat seeded in early September for dual-purpose (forage plus grain), LSDC for wheat seeded in late September for dual-purpose (forage plus grain), and OGC for wheat seeded in mid October for grain-only.

Table III-1 includes a list of field operations used for each treatment. Machinery complements for the conventional-till treatments include a moldboard plow, chisel, disk, and drill. The ESFMC system did not however include a moldboard plow complement. A fertilizer spreader and a sprayer were included for the 1,280 and 2,560-acre farm sizes. After wheat hay harvest in May, a chisel and a disk operation were performed for the ESFC system. This was followed by a moldboard plow used on 20 percent of the acres and a chisel on the other 80 percent. A disk operation in June was then used, followed by another disk operation in August and early September, and then OK 101 wheat was

planted around September 5th at a rate of 90 pounds per acre. Urea (46-0-0) was broadcast in August at the rate of 196 pounds per acre and diammonium phosphate (18-46-0) was banded with the wheat seed at 50 pounds per acre. Dimethoate was applied in April at a rate of 0.75 pints per acre to control ground cherry oat aphids.

A chisel and a disk operation were also performed after wheat hay harvest in May for the ESFMC system. Urea was broadcast in May at 170 pounds per acre, followed by foxtail millet being planted at a rate of 17 pounds per acre with diammonium phosphate banded at 50 pounds per acre. In August, millet hay was harvested from the plots, and the plots were disked and fertilized with urea at 196 pounds per acre. The plots were disked once more and planted to OK 101 wheat with a seeding rate of 90 pounds per acre. Fifty pounds of diammonium phosphate were banded with the wheat seed. In April, Dimethoate was applied to control ground cherry oat aphids. This system did not have a moldboard plow since there is insufficient time to use a plow between wheat hay harvest in May and planting foxtail millet also in May.

The ESDC, LSDC, and OGC systems have the same field operations but different planting dates. After grain harvest in June, a moldboard plow operation was performed on 20 percent of the acres and a chisel on the other 80 percent. This was then followed by a disk operation in August and September. Wheat seed was then drilled at a rate of 90 pounds per acre with diammonium phosphate banded with the seed following urea broadcast in August. LSDC and OGC systems had another disk operation before they were planted to wheat and banded with diammonium phosphate fertilizer around September 20th and October 15th, respectively. In April, Dimethoate was applied to the three systems.

Table III-1. Field Operations for Alternative Wheat Production Systems.

Field Operations	Date	Systems									
		ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
Chisel	May	✓	✓								
Disk	May	✓	✓								
Broadcast Fertilizer (46-0-0)	May		✓					✓			
Band Fertilizer (18-46-0)	May		✓					✓			
Apply Herbicide Roundup Ultra Max	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 Roundup Ultra Max	June						✓		✓	✓	✓
Harvest Millet Forage	August		✓					✓			
Apply Herbicide R. T. Master	August						✓		✓	✓	✓
Disk	August	✓	✓	✓	✓	✓					
Broadcast Fertilizer (46-0-0)	August	✓	✓	✓	✓	✓		✓	✓	✓	✓
Apply Herbicide Roundup Ultra Max & Pesticide Lorsban	August						✓	✓	✓		
Disk	Early Sept.	✓	✓	✓	✓	✓					
Band Fertilizer (18-46-0)	Early Sept.	✓	✓	✓			✓	✓	✓		
Plant OK 101 Wheat (Conventional-Till Drill)	Early Sept.	✓	✓	✓							
Plant OK 101 Wheat (No-Till Drill)	Early Sept.						✓	✓	✓		

Table III-1. Field Operations for Alternative Wheat Production Systems Continued.

Field Operations	Date	Systems									
		ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
Apply Herbicide Roundup Ultra Max	Late Sept.									✓	
Disk	Late Sept.				✓						
Band Fertilizer (18-46-0)	Late Sept.				✓					✓	
Plant OK 101 Wheat (Conventional-Till Drill)	Late Sept.				✓						
Plant OK 101 Wheat (No-Till Drill)	Late Sept.									✓	
Apply Herbicide Roundup Ultra Max	October					✓					✓
Disk	October										
Band Fertilizer (18-46-0)	October					✓					✓
Plant OK 101 Wheat (Conventional-Till Drill)	October					✓					
Plant OK 101 Wheat (No-Till Drill)	October										✓
Harvest Wheat Forage	February	✓	✓	✓	✓		✓	✓	✓	✓	
Apply Pesticide Dimethoate	April	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Harvest Wheat Hay	May	✓	✓				✓	✓			
Harvest Wheat Grain	June			✓	✓	✓		✓	✓	✓	✓
ESFC = Conventional-till wheat seeded in early September for forage-only											
ESFMC = Conventional-till wheat seeded in early September for forage-only with German foxtail millet seeded as a summer forage double crop											
ESDC = Conventional-till wheat seeded in early September for dual-purpose (forage plus grain)											
LSDC = Conventional-till wheat seeded in late September for dual-purpose (forage plus grain)											
OGC = Conventional-till wheat seeded in mid October for grain-only											
ESFN = No-till wheat seeded in early September for forage-only											
ESFMN = No-till wheat seeded in early September for forage-only with German foxtail millet seeded as a summer forage double crop											
ESDN = No-till wheat seeded in early September for dual-purpose (forage plus grain)											
LSDN = No-till wheat seeded in late September for dual-purpose (forage plus grain)											
OGN = No-till wheat seeded in mid October for grain-only											

No-Till Field Operations

ESFN is wheat seeded in early September for forage-only, ESFMN is wheat seeded in early September for forage-only with German foxtail millet seeded as a summer forage double crop, ESDN is wheat seeded in early September for dual-purpose (forage plus grain), LSDN is wheat seeded in late September for dual-purpose (forage plus grain), and OGN is wheat seeded in mid October for grain-only.

Machinery complements for the 1,280 and 2,560-acre no-till farm sizes include tractors, fertilizer spreaders, sprayers, and no-till drills. The machinery complements for the 320 and 640-acre farm sizes include only tractors and no-till drills.

After wheat hay harvest in May, the ESFN treatment was sprayed with Roundup Ultra Max at a rate of 1.5 pints per acre. Another Roundup Ultra Max application at 1.5 pints per acre in June, a R.T. Master application of 1.0 quart per acre in August, and a Roundup Ultra Max plus Lorsban application at a rate of 1.0 pint per acre each in August followed this. Lorsban was used to control grasshoppers. In September, wheat was drilled at 90 pounds per acre with diammonium phosphate banded at 50 pounds per acre. Urea was broadcast in August at 196 pounds per acre and Dimethoate was applied in April at 0.75 pints per acre due to a ground cherry oat aphid breakout.

After wheat hay harvest in May, the ESFMN treatment was sprayed with Roundup Ultra Max at a rate of 1.5 pints per acre. Urea was then broadcast at 170 pounds per acre and German foxtail millet was planted at 17 pounds per acre with diammonium phosphate banded at 50 pounds per acre. Roundup Ultra Max and Lorsban were applied at a rate of 1.0 pint per acre each following the millet hay harvest in August. Wheat was then planted in September with diammonium phosphate banded with the seed

after urea was broadcast in August. In April, Dimethoate was applied to control ground cherry oat aphids.

The ESDN, LSDN, and OGN treatments were sprayed with Roundup Ultra Max at a rate of 1.5 pints per acre after the harvest of wheat grain in June. This was followed by a R.T. Master application of 1.0 quart per acre and urea broadcast at 196 pounds per acre in August. The ESDN treatment was sprayed with Roundup Ultra Max and Lorsban in August and then planted to wheat and banded with diammonium phosphate around September 5th. The LSDN and OGN treatments each had a Roundup Ultra Max application of 1.0 pint per acre before they were planted around September 20th and October 15th, respectively. All three were then sprayed in April with Dimethoate.

Machinery Ownership and Operating Costs

MACHSEL, a machinery complement selection software program developed by Kletke and Sestak, was used to determine the machinery ownership and operating costs for 320, 640, 1,280, and 2,560-acre farms for representative (1) conventional-till and (2) no-till methods. The 320 and 640-acre farms were assumed to have the fertilizer, herbicide and pesticide applications done by custom operators. The 1,280 and 2,560-acre farms were assumed to own the fertilizer, herbicide and pesticide application equipment. When establishing candidate machines, machinery parameters were key components into determining which machines were an appropriate match with each farm size and production scheme. Diesel fuel price was set at \$1.00 per gallon, interest rate at \$0.09 per dollar per year borrowed, insurance rate at 0.006 of average value, and a tax rate of 0.01 of purchase price was assumed. Tractor time equaled 1.10 multiplied by implement

time and labor hours equaled 1.10 multiplied by tractor time. Dollars per labor hour were set to zero since producers have different values of labor, especially for family labor. It was also assumed that eighty-five percent of the time, work would get done in the amount of days available each month for a central clay loam soil.

Candidate Machines

After the required field operations and parameters were determined, candidate machines were chosen through the MACHSEL software. Machinery complement list prices in MACHSEL were determined from new John Deere equipment through the products and equipment section on the www.deere.com website and from personal interviews with John Deere dealers. Parameters, including field efficiency, draft, speed, repair factors, and depreciation costs, were updated from the American Society of Agricultural Engineers (ASAE) Agricultural Machinery Management Data Standards.

Candidate machines were selected based on farm sizes, production systems, machinery complements, times across the field, and on the machinery and equipment assumptions. For each of the conventional-till systems except for the ESFMC system, moldboard plow operations were assumed to be used on 20 percent of the acres. A chisel was used on the other 80 percent. Table III-2 lists the tractor and machinery complements for a 320 and 640-acre conventional-till and no-till farms. The conventional-till farms are assumed to have a 155 horsepower tractor with a chisel, disk, moldboard plow, and a twenty-foot drill. The ESFMC system does not have a moldboard plow. The no-till systems have a 155 horsepower tractor and a twenty-foot no-till drill.

Spray and fertilizer equipment are not included for the 320 and 640-acre farms since it was assumed that these applications are done by custom work.

Table III-3 lists the tractor and machinery complements for a 1,280-acre conventional-till and no-till farms. Two tractors were needed instead of one to finish the required fieldwork on time. A 155 horsepower tractor with a sprayer, fertilizer spreader and a twenty-foot drill along with a 325 horsepower tractor with a moldboard plow, chisel and disk are used for the conventional-till farms. For a no-till farm, a 95 horsepower tractor with a sprayer and a fertilizer spreader along with a 155 horsepower tractor with a 20-foot no-till drill are budgeted.

Table III-4 contains the tractor and machinery complements for a 2,560-acre conventional-till and no-till farms. For the conventional-till farms, a 95 horsepower tractor with a sprayer, fertilizer spreader and a ten-foot drill plus a 255 horsepower tractor with a disk, chisel and a thirty-six foot air seeder along with a 325 horsepower tractor with a moldboard plow, chisel and a disk were assumed to finish the required fieldwork in the time allotted. It was also assumed that the chisel and disk for the 325 horsepower tractor were used to complete 60 percent of the acres while the chisel and disk for the 255 horsepower tractor were used on 40 percent of the field acres. The thirty-six foot air seeder was assumed to be used on 75 percent of the acres and the ten-foot drill was to be used on 25 percent of the acres. A 95 horsepower tractor with a fertilizer spreader, a 155 horsepower tractor with a sprayer, and a 255 horsepower tractor with a thirty-six foot no-till air seeder were assumed for the no-till farm.

Table III-2. Tractor and Machinery Complements for a 320 and 640-Acre Farm.

Type of Machinery	Systems														
	Machinery Width (Feet)	Field Speed (MPH)	Field Efficiency (%*100)	Draft / ft. of Implement (Lbs.)	Machinery Complement Used (%*100)	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
155 hp Tractor						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Moldboard Plow	7.75	4.5	0.85	1250	1.00	✓		✓	✓	✓					
Chisel	18.60	5.0	0.85	625	1.00	✓	✓	✓	✓	✓					
Disk	17.10	6.0	0.80	425	1.00	✓	✓	✓	✓	✓					
Conventional-Till Drill	20.00	5.0	0.70	225	1.00	✓	✓	✓	✓	✓					
No-Till Drill	20.00	5.0	0.70	400	1.00						✓	✓	✓	✓	✓

Table III-3. Tractor and Machinery Complements for a 1,280-Acre Farm.

Type of Machinery	Systems									
	Machinery Width (Feet)	Field Speed (MPH)	Field Efficiency (%*100)	Draft / ft. of Implement (Lbs.)	Machinery Complement Used (%*100)	ESFC	ESFMC	ESDC	LSDC	OGC
95 hp Tractor										
						ESFN	ESFMN	ESDN	LSDN	OGN
Sprayer	40.00	6.5	0.65	200	1.00			✓	✓	✓
Fertilizer Spreader	40.00	7.0	0.70	200	1.00			✓	✓	✓
155 hp Tractor										
						✓	✓	✓	✓	✓
No-Till Drill	20.00	5.0	0.70	400	1.00					✓
Conventional-Till Drill	20.00	5.0	0.70	225	1.00	✓	✓	✓	✓	
Sprayer	60.00	6.5	0.65	200	1.00	✓	✓	✓	✓	✓
Fertilizer Spreader	40.00	7.0	0.70	200	1.00	✓	✓	✓	✓	✓
325 hp Tractor						✓	✓	✓	✓	✓
Moldboard Plow	16.25	4.5	0.85	1250	1.00	✓		✓	✓	✓
Chisel	39.00	5.0	0.85	625	1.00	✓	✓	✓	✓	✓
Disk	35.85	6.0	0.80	425	1.00	✓	✓	✓	✓	✓

Table III-4. Tractor and Machinery Complements for a 2,560-Acre Farm.

Type of Machinery	Systems									
	Machinery Width (Feet)	Field Speed (MPH)	Field Efficiency (%*100)	Draft / ft. of Implement (Lbs.)	Machinery Complement Used (%*100)	ESFC	ESFMC	ESDC	LSDC	OGC
95 hp Tractor						✓	✓	✓	✓	✓
Conventional-Till Drill	10.00	5.0	0.70	225	0.25	✓	✓	✓	✓	✓
Sprayer	40.00	6.5	0.65	200	1.00	✓	✓	✓	✓	✓
Fertilizer Spreader	40.00	7.0	0.70	200	1.00	✓	✓	✓	✓	✓
155 hp Tractor										
Sprayer	60.00	6.5	0.65	200	1.00					
255 hp Tractor						✓	✓	✓	✓	✓
Disk	28.13	6.0	0.80	425	0.40	✓	✓	✓	✓	✓
Chisel	30.60	5.0	0.85	625	0.40	✓	✓	✓	✓	✓
Conventional-Till Air Seeder	36.00	5.0	0.70	225	0.75	✓	✓	✓	✓	✓
No-Till Air Seeder	36.00	5.0	0.70	400	1.00					
325 hp Tractor						✓	✓	✓	✓	✓

Table III-4. Tractor and Machinery Complements for a 2,560-Acre Farm Continued.

Type of Machinery	Systems														
	Machinery Width (Feet)	Field Speed (MPH)	Field Efficiency (%*100)	Draft / ft. of Implement (Lbs.)	Machinery Complement Used (%*100)	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
Moldboard Plow	16.25	4.5	0.85	1250	1.00	✓		✓	✓	✓					
Chisel	39.00	5.0	0.85	625	0.60	✓	✓	✓	✓	✓					
Disk	35.85	6.0	0.80	425	0.60	✓	✓	✓	✓	✓					

Table III-5 lists the tractors and machinery complements list prices and widths that were used for each farm size.

Table III-5. Tractors and Machinery Complements Available for Field Operations.

Type of Machinery	Machinery Width (Feet)	List Price (\$)
95 hp Tractor		58,167
155 hp Tractor		81,707
255 hp Tractor		156,404
325 hp Tractor		176,151
Chisel	18.60	9,673
Chisel	30.60	21,982
Chisel	39.00	23,982
Disk	17.10	20,231
Disk	28.13	29,022
Disk	35.85	35,597
Moldboard Plow	7.75	15,812
Moldboard Plow	16.25	33,820
Fertilizer Spreader	40.00	11,200
Sprayer	40.00	5,564
Sprayer	60.00	7,372
Conventional-Till Drill	10.00	6,894
Conventional-Till Drill	20.00	23,957
Conventional-Till Air Seeder	36.00	105,000
No-Till Drill	20.00	47,000
No-Till Air Seeder	36.00	137,500

Tables III-6, III-7, III-8, and III-9 contain the machinery average investment per acre for a 320, 640, 1,280, and 2,560-acre farm. To determine machinery average investment (MAI_1) per acre from the MACHSEL software, the machinery interest cost can be divided by the interest rate. The equation to find MAI_1 is as followed:

$$(1) \quad MAI_1 = (MIC / IR)$$

where MIC is the total machinery interest cost and IR is the interest rate. Machinery average investment can also be found by taking purchase price plus salvage value divided

by two and summed across all machinery for each system. The equation to find MAI_2 is found by

$$(2) \quad MAI_2 = \sum ((PP + SV) / 2)$$

where PP is machinery purchase value and SV is machinery salvage value.

Table III-6. Machinery Average Investment per Acre for a 320-Acre Farm.

System	Average Investment	System	Average Investment
ESFC	\$256	ESFN	\$197
ESFMC	\$230	ESFMN	\$197
ESDC	\$256	ESDN	\$197
LSDC	\$256	LSDN	\$197
OGC	\$256	OGN	\$197

Table III-7. Machinery Average Investment per Acre for a 640-Acre Farm.

System	Average Investment	System	Average Investment
ESFC	\$128	ESFN	\$98
ESFMC	\$115	ESFMN	\$98
ESDC	\$128	ESDN	\$98
LSDC	\$128	LSDN	\$98
OGC	\$128	OGN	\$98

Table III-8. Machinery Average Investment per Acre for a 1,280-Acre Farm.

System	Average Investment	System	Average Investment
ESFC	\$180	ESFN	\$81
ESFMC	\$163	ESFMN	\$81
ESDC	\$180	ESDN	\$81
LSDC	\$180	LSDN	\$81
OGC	\$180	OGN	\$81

Table III-9. Machinery Average Investment per Acre for a 2,560-Acre Farm.

System	Average Investment	System	Average Investment
ESFC	\$147	ESFN	\$92
ESFMC	\$139	ESFMN	\$92
ESDC	\$147	ESDN	\$92
LSDC	\$147	LSDN	\$92
OGC	\$147	OGN	\$92

Annual hours of tractor use were calculated after the candidate machines were established through MACHSEL and then compared between conventional-till and no-till systems. 4,000 hours (third life of total tractor life of 12,000) was divided into each of the systems annual hours of tractor use to determine an estimate of years of tractor life on the farm. Twelve years owned per tractor was then used for all conventional-till farms and 20 years owned for the no-till farms. The 95 horsepower tractor for 1,280-acre no-till farms and the 155 horsepower tractor for 2,560-acre no-till farms were found to have an on-farm life of ten years. By this method, for the 320 and 640-acre farms, tractor life on the farm exceeded 20 years owned, but it was assumed that farmers would not want to own their tractors more than 20 years due to technology advances and depreciation. By extending the years owned, repair and fixed costs will be extended over more years resulting in a decrease in costs per year for no-till farms.

Wheat Production Costs

Table III-10 includes a list of the operating input prices and application rates per acre for each production system. Herbicides, Roundup Ultra Max and R.T. Master, prices of \$20 per gallon were provided by Michael Marlow (Monsanto Retail Sales Manager). Roundup Ultra Max price was set equivalent to R.T. Master price.

Application rates were based on labeled rates used in the field trials. A custom rate charge of \$3.66 per acre was assessed for the 320 and 640-acre farms. This rate is based upon average custom rates used across east, central and western Oklahoma (Kletke and Doye).

Pesticides, Dimethoate and Lorsban, prices were obtained from Helena Chemical Company, El Reno, Oklahoma. Dimethoate is priced at \$32.00 a gallon and Lorsban at \$34.00 a gallon. Application rates were based on labeled rates. A custom rate charge of \$3.04 per acre was assessed for the 320 and 640-acre farms (Kletke and Doye).

Fertilizers, diammonium phosphate and urea, prices were obtained from the Oklahoma State University (OSU) Enterprise Budgets. Urea was broadcast once for all treatments at 196 pounds per acre at \$176 per ton in August. The ESFMC and ESFMN systems had an extra application in May at 170 pounds per acre. Custom application for the 320 and 640-acre farms was budgeted at \$2.60 per acre (Kletke and Doye). Diammonium phosphate was banded with the millet and wheat seed in each drilling application at a 50-pound per acre rate. The budgeted price is \$212 per ton.

A millet seed price of \$940 per ton or \$0.47 per pound was obtained from Stillwater Milling Company. Millet was seeded at 17 pounds per acre at a cost of \$7.99 per acre. A wheat seed price of \$7.00 per bushel or \$0.12 per pound is from the OSU Enterprise Budgets. Wheat seeding rate was at 90 pounds per acre at a cost of \$10.50 per acre.

Custom wheat grain harvest was budgeted at \$13.00 per acre; with a \$0.13 per bushel charge for each additional bushel over 20 bushels per acre. Transportation costs are set at \$0.13 per bushel (OSU Enterprise Budgets).

Table III-10. Operating Inputs for Alternative Wheat Production Systems.

Operating Inputs	Date	Unit	Price (\$)	Systems											
				ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN		
Urea (46-0-0)	May	Lbs.	0.09		170										
Custom Application		Acre	2.60		1							170			
Diammonium Phosphate (18-46-0)	May	Lbs.	0.11		50							50			
Roundup Ultra Max	May	Pt.	2.50						1.5	1.5					
Custom Application		Acre	3.66						1	1		1			
Roundup Ultra Max	June	Pt.	2.50						1.5	1.5					
Custom Application		Acre	3.66						1	1		1			
R.T. Master	August	Qt.	5.00						1.0	1.0					
Custom Application		Acre	3.66						1	1		1			
Urea (46-0-0)	August	Lbs.	0.09	196	196	196	196	196	196	196	196	196	196	196	196
Custom Application		Acre	2.60	1	1	1	1	1	1	1	1	1	1	1	1
Roundup Ultra Max	August	Pt.	2.50						1.0	1.0					
Lorsban		Pt.	4.25						1.0	1.0					
Custom Application		Acre	3.66						1	1		1			
Diammonium Phosphate (18-46-0)	Early Sept.	Lbs.	0.11	50	50	50	50	50	50	50	50	50	50	50	50

Table III-10. Operating Inputs for Alternative Wheat Production Systems Continued.

Operating Inputs	Date	Unit	Price (\$)	Systems									
				ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
Roundup Ultra Max	Late Sept.	Pt.	2.50									1.0	
Custom Application		Acre	3.66									1	
Diammonium Phosphate (18-46-0)	Late Sept.	Lbs.	0.11				50					50	
Roundup Ultra Max	October	Pt.	2.50										1.0
Custom Application		Acre	3.66										1
Diammonium Phosphate (18-46-0)	October	Lbs.	0.11					50					50
Dimethoate	April	Pt.	4.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Custom Application		Acre	3.04	1	1	1	1	1	1	1	1	1	1
Millet Seed		Bu.	7.99		1.0					1.0			
Wheat Seed		Bu.	7.00	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

* Roundup Ultra Max price is set at \$2.50 / pint or \$20.00 / gallon. Price is set the same as R.T. Master due to personal communication with Michael Marlow, Monsanto Retail Sales Manager, April 5, 2004.

* As formulated R.T. Master contains 4 pounds of glyphosate and 0.4 pounds of 2,4-D per gallon. Roundup Ultra Max contains 5.5 pounds of glyphosate per gallon.

Wheat and Millet Production Returns

A \$2.67 June grain value was found by taking a five-year average of Oklahoma City market wheat grain prices. Table III-11 shows the Oklahoma City June wheat prices per bushel from 1999-2003.

Table III-11. Oklahoma City June Wheat Prices (\$/bu), 1999-2003.

Year	Price
1999	2.31
2000	2.50
2001	2.82
2002	2.91
2003	2.82

The value of foxtail millet hay was calculated on a \$50 per ton as fed basis. The per ton as fed basis was divided by the percentage of dry matter (87%) of hay sun-cured foxtail millet to establish a \$57.47 per ton of dry matter (National Research Council).

The per pound dry matter price of German foxtail millet hay (P_{MH}) was found by

$$(3) \quad P_{MH} = (fedprice_{MH} / \%DM_{MH}) / 2000$$

where $fedprice_{MH}$ is the per ton as fed price for foxtail millet hay and $\%DM_{MH}$ is the percent of dry matter of foxtail millet hay as noted through the National Research Council. Dividing by 2000 converts the price from tons to pounds for a \$0.029 per pound of dry matter.

A cutting, raking, and baling charge of large (800-1500 pounds) round bales was estimated to be \$0.013 per pound dry matter. This harvest cost was determined from the average cost (\$13.09) per bale in west, central, and eastern Oklahoma as reported by Kletke and Doye. The \$13.09 (bale cost) was then divided by average pounds of dry matter per bale (1000.5 pounds) for a price of \$0.013 per pound of dry matter. The

average pounds of dry matter per bale were found by taking the average of the 800 and 1500 pounds of large round bales multiplied by the percent dry matter of foxtail millet.

The equation to find harvest cost is as followed:

$$(4) \quad hrvst \ cos \ t = bale \ cost / DMbale$$

where *balecost* is the average harvest cost per bale and *DMbale* is the average pounds of dry matter per bale.

The \$0.013 harvest cost per pound of dry matter price was then subtracted from the \$0.029 per pound of dry matter to derive a net value of \$0.016 per pound of foxtail millet dry matter. The net value of foxtail millet hay per pound of dry matter (NV_{MH}) is found by

$$(5) \quad NV_{MH} = P_{MH} - hrvst \ cos \ t .$$

The net value of foxtail millet hay per pound was multiplied by the pounds of dry matter millet forage clipped to determine a dollar per acre return for each system.

Two methods were used to estimate returns to fall-winter forage production. Net returns from forage can be calculated in many different ways depending on whom the research is being directed to and what initial and final data are available such as stocker gain or amount of forage consumed. Two methods were used to estimate the value of fall-winter forage.

Method “A” was calculated using a stocker budget. The stocker budget is included in Table III-12. Stockers were stocked on the Kremlin test plot on December 15th at 550 lbs and removed on March 1st at 802 lbs. Steer purchase and sell prices were based on prices paid on a five-year average at Oklahoma City. December and March prices for medium/large frame No. 1 steers for December 1998 and March 2003 are listed

in Table III-13 and III-14, respectively. Net return per head was found by subtracting operating plus fixed cost by gross receipts. Stocking rate (0.39 head/acre) was then multiplied by net return per head to find a net return per acre. Net stocker return per acre (*stkrvalue*) is calculated by

$$(6) \quad stkrvalue = (\pi_s - oc_s - fc_s) / stkrate$$

where π_s is gross receipts from sell of stockers, oc_s is the operating costs to run stockers, fc_s is the fixed costs of stocker production, and *stkrate* is the stocking density per acre.

This number was then multiplied by a forage consumption ratio for each production system. The ratio was found by using forage clippings taken from the treatments. A weighted average was taken over the treatments and the late September for dual-purpose wheat systems were used as the base system. This production method was chosen as a base system since over 90 percent of the field (the portion of the field not included in the experiments) was planted to wheat in September for a dual-purpose wheat production system. The average wheat forage was then taken from the LSDN and LSDC systems. All ten production methods, five no-till and five conventional-till, were divided by the base system average to determine the forage consumption ratio that showed the expected forage to be consumed for that practice in relation to the base system. The fall-winter forage return for method “A” is estimated by

$$(7) \quad FWP_A = frgratio * stkrvalue$$

where *frgratio* is the forage consumption ratio for each system.

Table III-12. Stocker Steer Enterprise Budget for Dual-Purpose Winter Wheat Pasture.

Item	Unit	Price	Quantity	Value
Gross Receipts:				
Steers (based on death loss of 2%)	cwt/hd	77.74	8.02	611.02
Operating Costs:				
Steer Calves	cwt	88.96	5.50	489.28
Order Buyer Fee	cwt	0.50	5.50	2.75
Shipping to Pasture	head	2.10	1.00	2.10
Receiving Program (21 days)				
Veterinary and Medicine	head	10.00	1.00	10.00
Hay (8 lb/str/day)	lb	0.03	128.00	3.84
Soybean Meal Based Supplement (2lb/str/day)	lb	0.09	32.00	2.88
Hay during Inclement Weather (assume 2 bad days)	lb	0.06	24.00	1.44
High Calcium Mineral Mixture	lb	0.09	8.40	0.76
Other:				
Shipping to Market, Sales Commission, etc.	cwt	2.00	8.02	16.04
Operating Capital Interest	\$	0.0675	128.26	8.66
Labor	hour	0.00	1.25	
Machinery Fuel, Lube, and Repairs	\$			10.00
Total Operating Costs, \$/head				547.74
Fixed Costs for Steer Production:				
Machinery and Equipment – Interest				2.50
Machinery and Equipment – Depr., Taxes and Insurance				5.50
Total Fixed Costs, \$/head				8.00
Total Costs, \$/head				555.74
Net Return, \$/head				55.28
Net Return, \$/acre				21.68

Table III-13. Oklahoma City Purchase Price for 550-600 lb Medium/Large Frame No. 1 Steers, 1998-2002.

Purchase Date	Base Price (\$/cwt)
12/12/1998	77.67
12/18/1999	94.07
12/16/2000	93.11
12/15/2001	91.80
12/14/2002	88.15

Table III-14. Oklahoma City Sell Price for 800-850 lb Medium/Large Frame No. 1 Steers, 1999-2003.

Sell Date	Base Price (\$/cwt)
2/27/1999	70.77
3/4/2000	80.28
3/3/2001	83.46
3/2/2002	78.25
3/1/2003	75.95

Method “B” uses the same forage consumption ratio, but uses a price per pound of stocker gain instead of looking at a stocker budget. A \$0.31 per pound of stocker gain price (Doye et al.) was multiplied by the average pounds of stocker gain times the stocking density rate per acre times the system forage consumption ratio to estimate a dollar per acre return for fall-winter forage. The fall-winter forage return for method “B” is estimated by

$$(8) \quad FWP_B = frgratio * stkrrate * \$0.31 * stkrgrn.$$

where *stkrgrn* is the average pounds of stocker gain.

The value of wheat hay harvested in May was estimated in the same way as the foxtail millet hay except that wheat hay was valued at \$40 per ton as fed instead of \$50 per ton. This was assumed because sun-cured foxtail millet hay is slightly more nutritious than sun-cured wheat hay (National Research Council). A net value of \$0.010

per pound of dry matter of wheat hay was found. The per pound dry matter price of wheat hay (P_{WH}) was found by

$$(9) \quad P_{WH} = (fedprice_{WH} / \%DM_{WH}) / 2000$$

where $fedprice_{WH}$ is the per ton as fed price for wheat hay and $\%DM_{WH}$ is the percent of dry matter of wheat hay as noted through the National Research Council. Harvest costs were assumed to be the same as foxtail millet hay. The net value of wheat hay per pound of dry matter (NV_{WH}) is found by

$$(10) \quad NV_{WH} = P_{WH} - hrvt \text{ cost} .$$

The dry matter net value of wheat hay was then taken by the pounds of dry matter wheat forage clipped to determine per acre return for each production system.

After the yield data were determined, a total of forty budgets were generated. One for each of the five wheat production systems times the two tillage systems and four farm sizes. The net returns for each system in regards to farm size with fall-winter forage calculated with method “A” were found by

$$(11) \quad \pi = P_{WG}(Y_{WG}) + P_{MH}(Y_{MH}) + P_{WH}(Y_{WH}) + FWP_A - OC - FC .$$

Where π is the net returns to land, labor, and management, P_{WG} is the price of wheat grain, Y_{WG} is the yield of grain, P_{MH} is the price of millet hay per pound of dry matter, Y_{MH} is the pound of dry matter of millet, P_{WH} is the price of wheat hay per pound of dry matter, Y_{WH} is the pound of dry matter of wheat, FWP_A is the net return of fall-winter grazing for method “A”, OC is the operating costs, and FC is the fixed costs of the machinery management operation. The net return, which includes the method “B” of fall-winter forage, is found by

$$(12) \quad \pi = P_{WG}(Y_{WG}) + P_{MH}(Y_{MH}) + P_{WH}(Y_{WH}) + FWP_B - OC - FC$$

where FWP_B is the net return of fall-winter grazing for method “B”.

Net returns to land, labor, and management were then compared to determine which system for each farm size for both tillage methods produced the greatest net return to producers.

CHAPTER IV

RESULTS

Yields

The forage and grain yields were produced at the three locations and averaged to acquire one average yield for each representative production system. Cattle were removed from grazing on March 1st, before first hollow stem. Table IV-1 includes the millet and wheat forage yields and the wheat grain yields per acre for each system in relation to field experiment location. Average yields are also listed. Figure IV-1 shows the millet forage yields per acre for the ESFMC and ESFMN systems. An average of 4,875 pounds per acre of dry matter millet forage were produced in the no-till system, 627 pounds more than the conventional-till system.

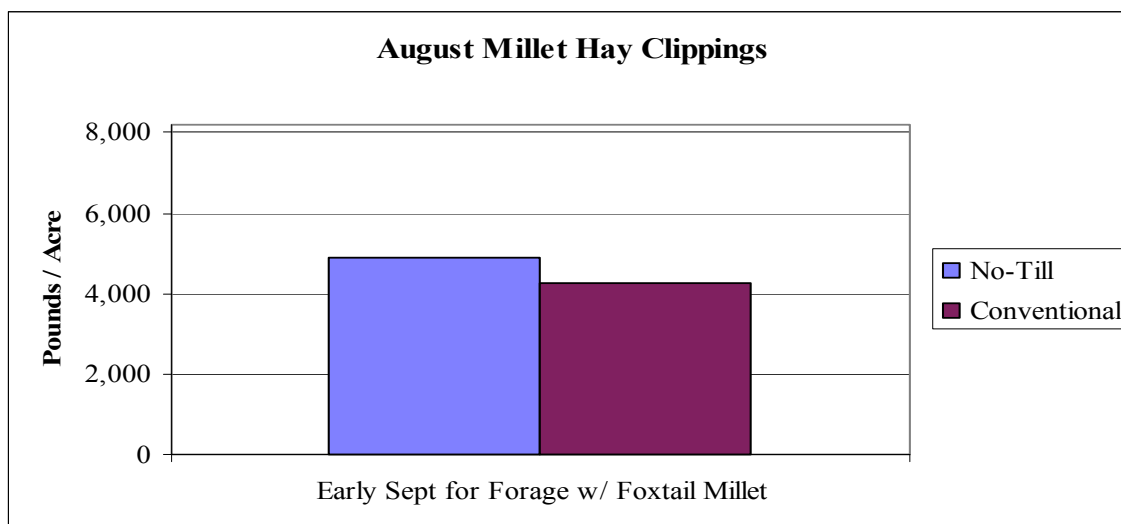


Figure IV-1. Average Dry Matter Millet Hay Yields per Acre.

Table IV-1. Average Millet and Wheat Yields Per Acre.

	Units	Systems									
		ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
CHEROKEE											
Millet Forage	Lbs.		2515					3453			
Wheat Forage (February)	Lbs.	1568	971	1958	1277		2085	1074	2480	1381	
Wheat Forage (May)	Lbs.	4292	5406				6867	4379			
Wheat Grain	Bu.			49	50	54			41	49	48
HUNTER											
Millet Forage	Lbs.		8035					6979			
Wheat Forage (February)	Lbs.	3675	2826	4187	2207		3494	3100	4104	2064	
Wheat Forage (May)	Lbs.	6266	5491				6670	6311			
Wheat Grain	Bu.			44	49	36			38	42	36
LOYAL											
Millet Forage	Lbs.		2196					4193			
Wheat Forage (February)	Lbs.	1936	1743	2240	2064		2310	2020	2967	1210	
Wheat Forage (May)	Lbs.	4500	4222				4241	3982			
Wheat Grain	Bu.			45	54	40			36	40	21
AVERAGES											
Millet Forage	Lbs.		4248					4875			
Wheat Forage (February)	Lbs.	2393	1847	2795	1849		2630	2065	3184	1552	
Wheat Forage (May)	Lbs.	5019	5040				5926	4891			
Wheat Grain	Bu.			46	51	43			38	44	35

Figure IV-2 reveals the average wheat forage yields per acre in late February found on the ungrazed plots of each treatment. Wheat forage yields were higher for the no-till systems than the conventional-till systems except for the late September dual-purpose system. The ESDN system had the highest fall-winter wheat forage yield of 3,184 pounds per acre while the ESDC system produced 2,795 pounds per acre. The lowest yields for the early September systems were produced from the ESFMN and ESFMC systems. The ESFMN system produced 2,065 pounds per acre of fall-winter forage compared to 1,847 pounds per acre from the ESFMC system. Yields were probably lower in these two systems because the summer millet crop reduced the available moisture in the soil profile. The ESN and ESFC systems produced 2,630 and 2,393 pounds per acre of fall-winter wheat forage, respectively. The LSDC system forage yields were higher for the late September seeding date compared to the LSDN system. The LSDN and LSDC systems yielded 1,552 and 1,849 pounds per acre of fall-winter wheat forage, respectively. The wheat forage yields are consistent with the pattern reported by Krenzer that expected fall-winter wheat forage yields are less for later planted wheat.

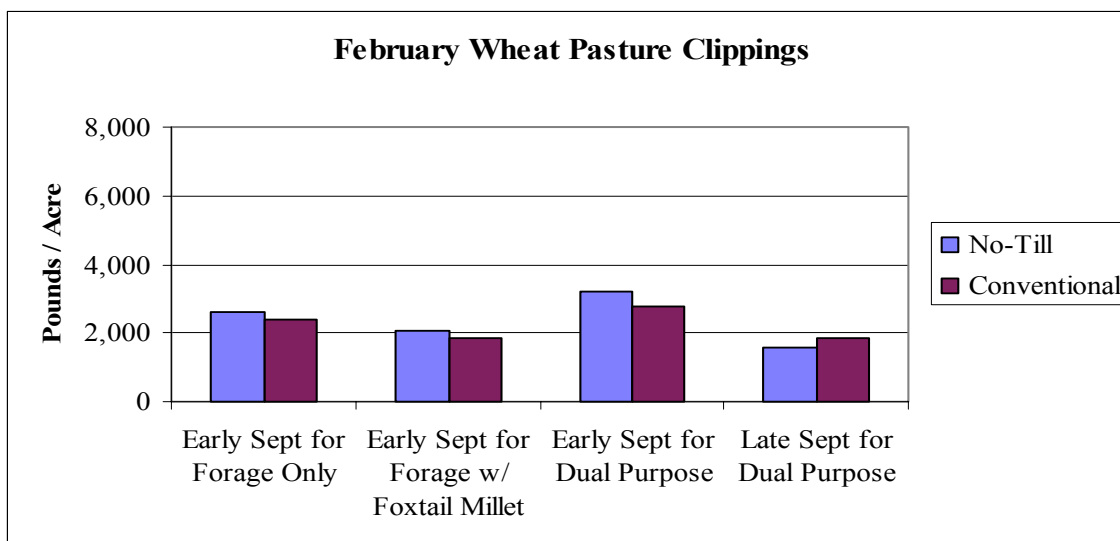


Figure IV-2. Average Dry Matter Wheat Pasture Yields per Acre.

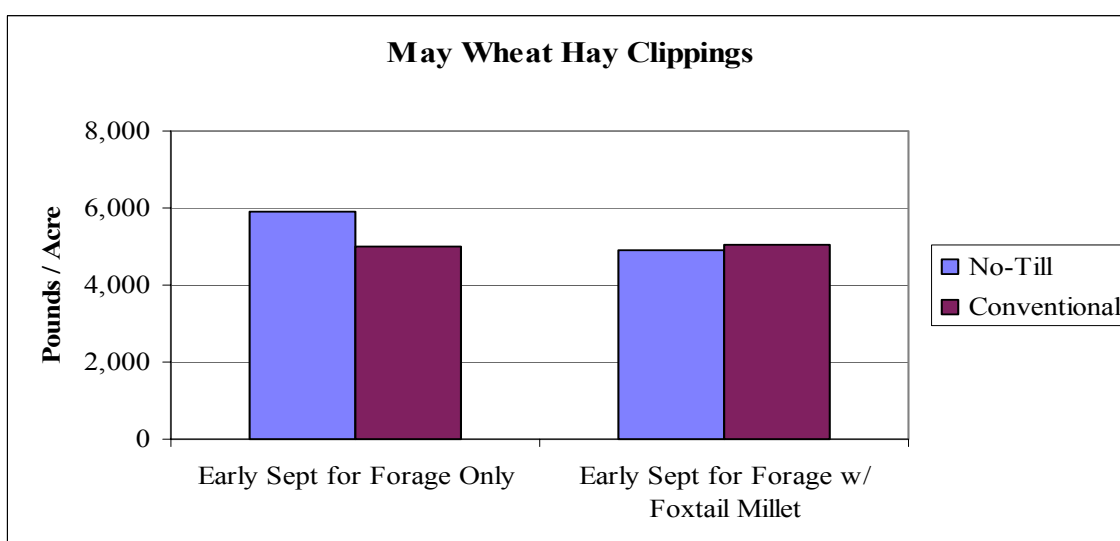


Figure IV-3. Average Dry Matter Wheat Hay Yields per Acre.

Average wheat grain yields per acre are displayed in Figure IV-4. Conventional-till wheat grain yields were approximately eight bushels per acre more than the no-till yields. The ESDN and ESDC systems yielded 38 and 46 bushels to the acre while the LSDN and LSDC systems produced 44 and 51 bushels per acre. The OGN system yielded only 35 bushels per acre as compared to the OGC system that had 43 bushels per acre. This was about eight bushels less than the late September dual-purpose systems.

This finding is inconsistent with that reported by Krenzer that expected wheat grain yields are greater from early October planted wheat than from September planted wheat. This inconsistency is displayed in Figure IV-5, which displays the no-till production systems. Conventional-till forage and grain yields follow the same inconsistent pattern. Readers who are interested in more detail regarding differences in forage and grain yield across treatments and locations are referred to Bushong.

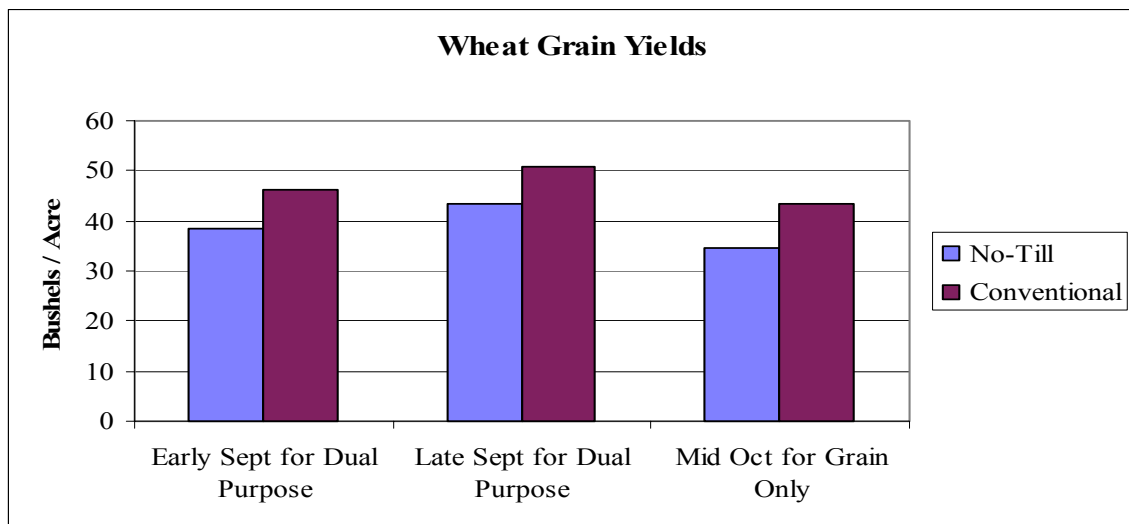


Figure IV-4. Average Wheat Grain Yields per Acre.

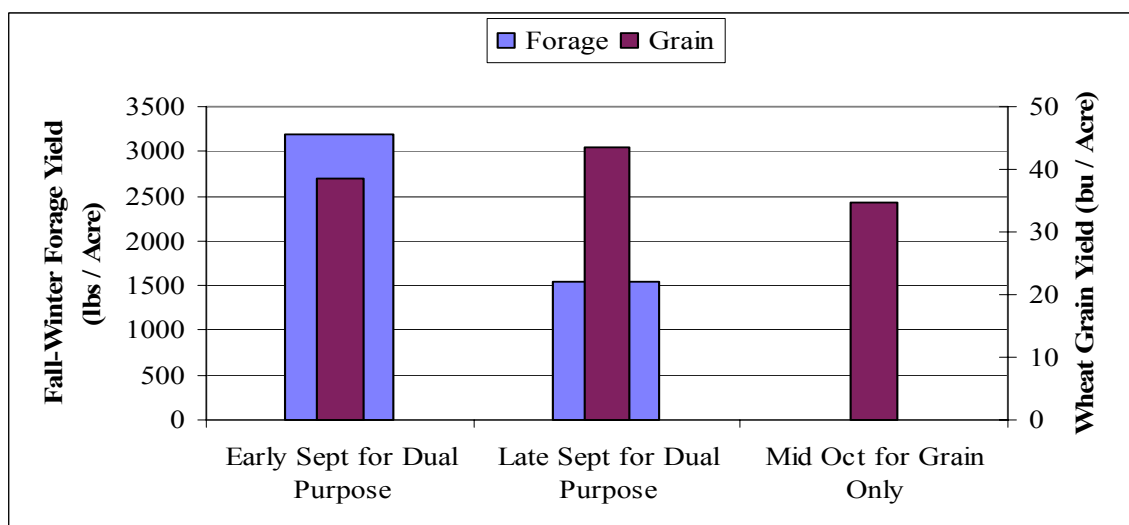


Figure IV-5. Average No-Till Fall-Winter Forage and Grain Yields Across Planting Dates.

Revenue

Net returns to land, labor, and management were found for each system. Tables IV-2, IV-3, IV-4, and IV-5 list the per acre costs and returns for 320, 640, 1,280, and a 2,560-acre farms, respectively, using method “A” of valuing fall-winter pasture. Tables IV-6, IV-7, IV-8, and IV-9 list the per acre costs and returns using method “B” for valuing fall-winter pasture. The ESN and ESMN systems were approximately \$24 and \$18 per acre higher, respectively, in total revenue than the ESFC and ESMC practices for both methods of valuing fall-winter pasture. The ESDC, LSDC, and OGC systems had higher total revenue than the comparable no-till systems. The ESDC, LSDC, and OGC systems were \$16, \$24, and \$23 per acre higher, respectively, than the no-till systems when using the method “A” to value fall-winter pasture. Method “B” estimation only changed the total revenue by a few dollars for the dual-purpose systems. The conventional systems had higher total revenues because of the greater wheat grain yields. Fall-winter pasture value under method “B” was approximately \$8 to \$17 per acre higher than with method “A”. Method “B” uses a \$0.31 per pound of stocker gain price times average pounds of stocker gain instead of a stocker steer enterprise budget. Of all the systems ESMN had the highest revenue with both fall-winter pasture methods.

Table IV-2. Estimated Per Acre Cost and Returns for a 320-Acre Farm with Method “A” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	30.51	23.54	35.63	23.57		33.53	26.32	40.59	19.78	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	144.58	260.17	158.84	159.84	116.14	168.21	277.56	143.15	136.12	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Fertilizers										
Urea	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Diammonium Phosphate	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Herbicides										
Roundup Ultra Max	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
R.T. Master	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Pesticides										
Lorsban	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	0.00	0.00
Dimethoate	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Custom Application Charge	5.64	8.25	5.64	5.64	5.64	20.27	15.56	16.61	16.61	16.61
Custom Millet and Wheat Hay Harvest	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Custom Grain Harvest and Hauling	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Annual Operating Capital (6.75%)	2.70	4.17	2.41	2.51	2.51	3.91	4.82	3.54	3.32	3.32
Machinery Fuel, Lube, and Repair	11.56	9.88	6.01	7.85	7.85	1.72	4.83	1.72	1.72	1.72
TOTAL OPERATING COSTS	120.86	207.34	72.51	75.71	73.75	157.83	227.01	93.80	90.68	88.39
FIXED COSTS:										
Interest (9.00%)	23.00	20.69	23.00	23.00	23.00	17.71	17.71	17.71	17.71	17.71
Taxes (1.00%)	4.13	3.69	4.13	4.13	4.13	3.37	3.37	3.37	3.37	3.37
Insurance (0.60%)	1.53	1.38	1.53	1.53	1.53	1.18	1.18	1.18	1.18	1.18
Depreciation	27.51	24.38	27.51	27.51	27.51	18.87	18.87	18.87	18.87	18.87
TOTAL FIXED COSTS	56.17	50.13	56.17	56.17	56.17	41.13	41.13	41.13	41.13	41.13
TOTAL COSTS	177.03	257.47	128.68	131.88	129.92	198.96	268.14	134.93	131.80	129.51
NET RETURNS	(32.45)	2.69	30.17	27.96	(13.78)	(30.75)	9.42	8.22	4.32	(36.70)

Table IV-3. Estimated Per Acre Cost and Returns for a 640-Acre Farm with Method “A” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	30.51	23.54	35.63	23.57		33.53	26.32	40.59	19.78	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	144.58	260.17	158.84	159.84	116.14	168.21	277.56	143.15	136.12	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed										
Fertilizers	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Urea										
Diammonium Phosphate	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Herbicides	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Roundup Ultra Max										
R.T. Master	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
Pesticides	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Lorsban										
Dimethoate	3.00	3.00	3.00	3.00	3.00	4.25	4.25	4.25	0.00	0.00
Custom Application Charge	5.64	8.25	5.64	5.64	5.64	20.27	15.56	16.61	16.61	16.61
Custom Millet and Wheat Hay Harvest	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Custom Grain Harvest and Hauling	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Annual Operating Capital (6.75%)	2.87	4.35	2.49	2.61	2.61	3.95	4.97	3.57	3.36	3.36
Machinery Fuel, Lube, and Repair	14.92	13.32	7.41	9.90	9.90	2.41	7.77	2.41	2.41	2.41
TOTAL OPERATING COSTS	124.38	210.96	73.97	77.86	75.91	158.56	230.11	94.53	91.40	89.11
FIXED COSTS:										
Interest (9.00%)	11.50	10.34	11.50	11.50	11.50	8.85	8.85	8.85	8.85	8.85
Taxes (1.00%)	2.06	1.84	2.06	2.06	2.06	1.69	1.69	1.69	1.69	1.69
Insurance (0.60%)	0.77	0.69	0.77	0.77	0.77	0.59	0.59	0.59	0.59	0.59
Depreciation	13.76	12.19	13.76	13.76	13.76	9.43	9.43	9.43	9.43	9.43
TOTAL FIXED COSTS	28.09	25.06	28.09	28.09	28.09	20.56	20.56	20.56	20.56	20.56
TOTAL COSTS	152.46	236.02	102.06	105.95	103.99	179.12	250.67	115.09	111.97	109.68
NET RETURNS	(7.88)	24.14	56.79	53.89	12.15	(10.92)	26.89	28.06	24.15	(16.87)

Table IV-4. Estimated Per Acre Cost and Returns for a 1,280-Acre Farm with Method “A” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	30.51	23.54	35.63	23.57		33.53	26.32	40.59	19.78	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	144.58	260.17	158.84	159.84	116.14	168.21	277.56	143.15	136.12	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Fertilizers										
Urea	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Diammonium Phosphate	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Herbicides										
Roundup Ultra Max	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
R.T. Master	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Pesticides										
Lorsban	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	0.00	0.00
Dimethoate	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Custom Application Charge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom Millet and Wheat Hay Harvest	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Custom Grain Harvest and Hauling	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Annual Operating Capital (6.75%)	2.56	4.15	2.26	2.36	2.36	3.17	4.65	2.95	2.73	2.73
Machinery Fuel, Lube, and Repair	14.52	17.70	8.65	10.60	10.60	7.33	16.97	6.64	6.64	6.64
TOTAL OPERATING COSTS	118.04	206.89	69.35	72.67	70.71	142.43	223.42	81.51	78.39	76.10
FIXED COSTS:										
Interest (9.00%)	16.16	14.64	16.16	16.16	16.16	7.33	7.33	7.33	7.33	7.33
Taxes (1.00%)	2.67	2.43	2.67	2.67	2.67	1.35	1.35	1.35	1.35	1.35
Insurance (0.60%)	1.08	0.98	1.08	1.08	1.08	0.49	0.49	0.49	0.49	0.49
Depreciation	14.52	13.37	14.52	14.52	14.52	7.79	7.79	7.79	7.79	7.79
TOTAL FIXED COSTS	34.42	31.41	34.42	34.42	34.42	16.96	16.96	16.96	16.96	16.96
TOTAL COSTS	152.46	238.30	103.77	107.09	105.13	159.38	240.38	98.47	95.35	93.06
NET RETURNS	(7.87)	21.87	55.07	52.75	11.01	8.82	37.18	44.68	40.77	(0.25)

Table IV-5. Estimated Per Acre Cost and Returns for a 2,560-Acre Farm with Method “A” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	30.51	23.54	35.63	23.57		33.53	26.32	40.59	19.78	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	144.58	260.17	158.84	159.84	116.14	168.21	277.56	143.15	136.12	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Fertilizers										
Urea	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Diammonium Phosphate	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Herbicides										
Roundup Ultra Max	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
R.T. Master	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Pesticides										
Lorsban	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	0.00	0.00
Dimethoate	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Custom Application Charge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom Millet and Wheat Hay Harvest	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Custom Grain Harvest and Hauling	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Annual Operating Capital (6.75%)	2.69	4.54	2.34	2.45	2.45	3.30	5.21	3.08	2.86	2.86
Machinery Fuel, Lube, and Repair	17.07	25.41	10.18	12.43	12.43	9.98	28.14	9.27	9.27	9.27
TOTAL OPERATING COSTS	120.71	215.00	70.96	74.59	72.64	145.22	235.16	84.28	81.16	78.87
FIXED COSTS:										
Interest (9.00%)	13.23	12.47	13.23	13.23	13.23	8.25	8.25	8.25	8.25	8.25
Taxes (1.00%)	2.26	2.14	2.26	2.26	2.26	1.53	1.53	1.53	1.53	1.53
Insurance (0.60%)	0.88	0.83	0.88	0.88	0.88	0.55	0.55	0.55	0.55	0.55
Depreciation	13.65	13.07	13.65	13.65	13.65	8.99	8.99	8.99	8.99	8.99
TOTAL FIXED COSTS	30.01	28.51	30.01	30.01	30.01	19.32	19.32	19.32	19.32	19.32
TOTAL COSTS	150.72	243.51	100.97	104.61	102.65	164.54	254.48	103.60	100.47	98.18
NET RETURNS	(6.14)	16.66	57.87	55.23	13.49	3.67	23.08	39.55	35.65	(5.38)

Table IV-6. Estimated Per Acre Cost and Returns for a 320-Acre Farm with Method “B” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	43.12	33.27	50.35	33.31		47.38	37.20	57.36	27.96	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	157.19	269.89	173.57	169.58	116.14	182.06	288.44	159.92	144.29	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Fertilizers										
Urea	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Diammonium Phosphate	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Herbicides										
Roundup Ultra Max	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
R.T. Master	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Pesticides										
Lorsban	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	0.00	0.00
Dimethoate	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Custom Application Charge	5.64	8.25	5.64	5.64	5.64	20.27	15.56	16.61	16.61	16.61
Custom Millet and Wheat Hay Harvest	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Custom Grain Harvest and Hauling	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Annual Operating Capital (6.75%)	2.70	4.17	2.41	2.51	2.51	3.91	4.82	3.54	3.32	3.32
Machinery Fuel, Lube, and Repair	11.56	9.88	6.01	7.85	7.85	1.72	4.83	1.72	1.72	1.72
TOTAL OPERATING COSTS	120.86	207.34	72.51	75.71	73.75	157.83	227.01	93.80	90.68	88.39
FIXED COSTS:										
Interest (9.00%)	23.00	20.69	23.00	23.00	23.00	17.71	17.71	17.71	17.71	17.71
Taxes (1.00%)	4.13	3.69	4.13	4.13	4.13	3.37	3.37	3.37	3.37	3.37
Insurance (0.60%)	1.53	1.38	1.53	1.53	1.53	1.18	1.18	1.18	1.18	1.18
Depreciation	27.51	24.38	27.51	27.51	27.51	18.87	18.87	18.87	18.87	18.87
TOTAL FIXED COSTS	56.17	50.13	56.17	56.17	56.17	41.13	41.13	41.13	41.13	41.13
TOTAL COSTS	177.03	257.47	128.68	131.88	129.92	198.96	268.14	134.93	131.80	129.51
NET RETURNS	(19.84)	12.42	44.89	37.70	(13.78)	(16.90)	20.30	25.00	12.49	(36.70)

Table IV-7. Estimated Per Acre Cost and Returns for a 640-Acre Farm with Method “B” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	43.12	33.27	50.35	33.31		47.38	37.20	57.36	27.96	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	157.19	269.89	173.57	169.58	116.14	182.06	288.44	159.92	144.29	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Fertilizers										
Urea	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Diammonium Phosphate	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Herbicides										
Roundup Ultra Max	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
R.T. Master	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Pesticides										
Lorsban	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	0.00	0.00
Dimethoate	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Custom Application Charge	5.64	8.25	5.64	5.64	5.64	20.27	15.56	16.61	16.61	16.61
Custom Millet and Wheat Hay Harvest	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Custom Grain Harvest and Hauling	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Annual Operating Capital (6.75%)	2.87	4.35	2.49	2.61	2.61	3.95	4.97	3.57	3.36	3.36
Machinery Fuel, Lube, and Repair	14.92	13.32	7.41	9.90	9.90	2.41	7.77	2.41	2.41	2.41
TOTAL OPERATING COSTS	124.38	210.96	73.97	77.86	75.91	158.56	230.11	94.53	91.40	89.11
FIXED COSTS:										
Interest (9.00%)	11.50	10.34	11.50	11.50	11.50	8.85	8.85	8.85	8.85	8.85
Taxes (1.00%)	2.06	1.84	2.06	2.06	2.06	1.69	1.69	1.69	1.69	1.69
Insurance (0.60%)	0.77	0.69	0.77	0.77	0.77	0.59	0.59	0.59	0.59	0.59
Depreciation	13.76	12.19	13.76	13.76	13.76	9.43	9.43	9.43	9.43	9.43
TOTAL FIXED COSTS	28.09	25.06	28.09	28.09	28.09	20.56	20.56	20.56	20.56	20.56
TOTAL COSTS	152.46	236.02	102.06	105.95	103.99	179.12	250.67	115.09	111.97	109.68
NET RETURNS	4.73	33.87	71.51	63.63	12.15	2.94	37.77	44.83	32.33	(16.87)

Table IV-8. Estimated Per Acre Cost and Returns for a 1,280-Acre Farm with Method “B” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	43.12	33.27	50.35	33.31		47.38	37.20	57.36	27.96	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	157.19	269.89	173.57	169.58	116.14	182.06	288.44	159.92	144.29	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed										
Fertilizers	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Urea										
Diammonium Phosphate	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Herbicides	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Roundup Ultra Max										
R.T. Master	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
Pesticides	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Lorsban										
Dimethoate	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	0.00	0.00
Custom Application Charge	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Custom Millet and Wheat Hay Harvest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom Grain Harvest and Hauling	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Annual Operating Capital (6.75%)	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Machinery Fuel, Lube, and Repair	2.56	4.15	2.26	2.36	2.36	3.17	4.65	2.95	2.73	2.73
	14.52	17.70	8.65	10.60	10.60	7.33	16.97	6.64	6.64	6.64
TOTAL OPERATING COSTS	118.04	206.89	69.35	72.67	70.71	142.43	223.42	81.51	78.39	76.10
FIXED COSTS:										
Interest (9.00%)	16.16	14.64	16.16	16.16	16.16	7.33	7.33	7.33	7.33	7.33
Taxes (1.00%)	2.67	2.43	2.67	2.67	2.67	1.35	1.35	1.35	1.35	1.35
Insurance (0.60%)	1.08	0.98	1.08	1.08	1.08	0.49	0.49	0.49	0.49	0.49
Depreciation	14.52	13.37	14.52	14.52	14.52	7.79	7.79	7.79	7.79	7.79
TOTAL FIXED COSTS	34.42	31.41	34.42	34.42	34.42	16.96	16.96	16.96	16.96	16.96
TOTAL COSTS	152.46	238.30	103.77	107.09	105.13	159.38	240.38	98.47	95.35	93.06
NET RETURNS	4.73	31.60	69.80	62.49	11.01	22.68	48.06	61.45	48.95	(0.25)

Table IV-9. Estimated Per Acre Cost and Returns for a 2,560-Acre Farm with Method “B” Calculation.

	Systems									
	ESFC	ESFMC	ESDC	LSDC	OGC	ESFN	ESFMN	ESDN	LSDN	OGN
REVENUE:										
Millet Hay		122.08					140.08			
Wheat (\$2.67)			123.21	136.26	116.14			102.56	116.34	92.81
Pasture (February)	43.12	33.27	50.35	33.31		47.38	37.20	57.36	27.96	
Hay (May)	114.07	114.54				134.68	111.15			
TOTAL REVENUE	157.19	269.89	173.57	169.58	116.14	182.06	288.44	159.92	144.29	92.81
OPERATING INPUTS:										
Millet Seed		7.99					7.99			
Wheat Seed										
Fertilizers	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Urea										
Diammonium Phosphate	17.25	32.21	17.25	17.25	17.25	17.25	32.21	17.25	17.25	17.25
Herbicides	5.30	10.60	5.30	5.30	5.30	5.30	10.60	5.30	5.30	5.30
Roundup Ultra Max										
R.T. Master	0.00	0.00	0.00	0.00	0.00	10.00	6.25	6.25	6.25	6.25
Pesticides	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00	5.00	5.00
Lorsban										
Dimethoate	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	0.00	0.00
Custom Application Charge	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Custom Millet and Wheat Hay Harvest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Custom Grain Harvest and Hauling	64.90	120.74	0.00	0.00	0.00	76.63	127.01	0.00	0.00	0.00
Annual Operating Capital (6.75%)	0.00	0.00	22.39	23.66	21.70	0.00	0.00	20.38	21.72	19.43
Machinery Fuel, Lube, and Repair	2.69	4.54	2.34	2.45	2.45	3.30	5.21	3.08	2.86	2.86
	17.07	25.41	10.18	12.43	12.43	9.98	28.14	9.27	9.27	9.27
TOTAL OPERATING COSTS	120.71	215.00	70.96	74.59	72.64	145.22	235.16	84.28	81.16	78.87
FIXED COSTS:										
Interest (9.00%)	13.23	12.47	13.23	13.23	13.23	8.25	8.25	8.25	8.25	8.25
Taxes (1.00%)	2.26	2.14	2.26	2.26	2.26	1.53	1.53	1.53	1.53	1.53
Insurance (0.60%)	0.88	0.83	0.88	0.88	0.88	0.55	0.55	0.55	0.55	0.55
Depreciation	13.65	13.07	13.65	13.65	13.65	8.99	8.99	8.99	8.99	8.99
TOTAL FIXED COSTS	30.01	28.51	30.01	30.01	30.01	19.32	19.32	19.32	19.32	19.32
TOTAL COSTS	150.72	243.51	100.97	104.61	102.65	164.54	254.48	103.60	100.47	98.18
NET RETURNS	6.47	26.39	72.60	64.97	13.49	17.53	33.96	56.33	43.82	(5.38)

Operating Costs

Operating costs include the costs of millet and wheat seed, fertilizer, herbicide, pesticide, custom application, custom millet and wheat hay harvest, custom grain harvest and hauling, operating capital, and machinery fuel, lubricants, and repair costs. All five no-till systems had higher operating costs than their comparable conventional-till systems for each farm size. The average difference in operating costs over the five systems for the 320 and 640-acre no-till farms was approximately \$22 and \$20 per acre higher than the conventional-till systems, respectively. The 1,280-acre and 2,560-acre no-till farms averaged a difference of \$13 and \$14 per acre higher costs, respectively. The 320 and 640-acre farm sizes had higher operating costs than the two larger size farms.

One of the major reasons for the high operating costs of no-till has to do with the increased herbicide and pesticide use. Figure IV-6 shows the herbicide and pesticide costs per acre between the no-till and conventional-till systems. The no-till systems ranged from \$11 to \$19 per acre higher than the conventional systems. The ESFN system herbicide and pesticide costs were the highest at \$22 per acre due to an extra Roundup Ultra Max application. The three no-till systems that were seeded in early September also had an extra pesticide application to control grasshoppers. All conventional-till systems had a herbicide/pesticide cost of \$3 per acre, which was Dimethoate to control ground cherry oat aphids.

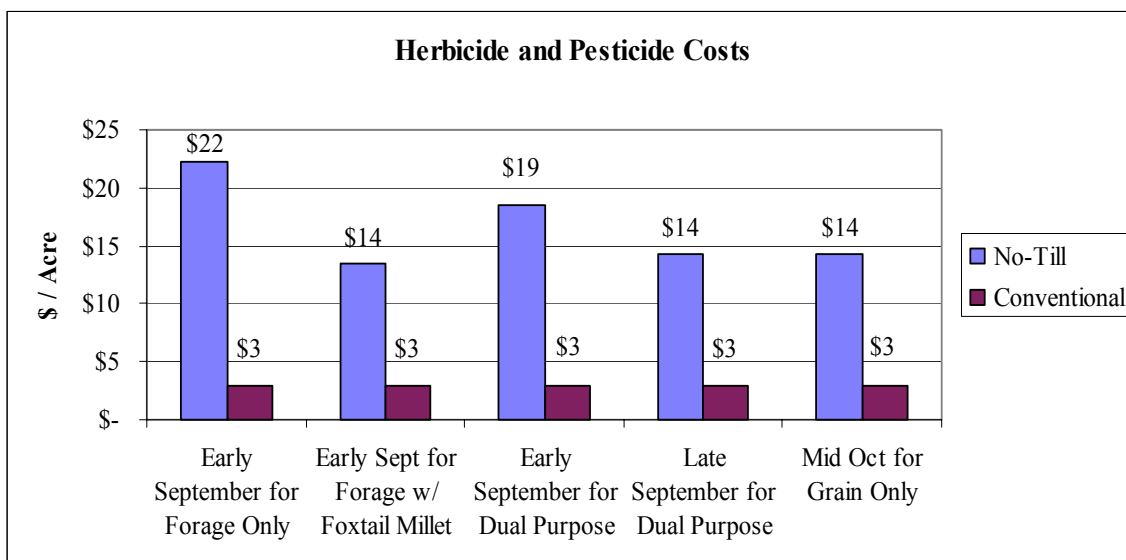


Figure IV-6. Average Total Herbicide and Pesticide Costs per Acre.

Machinery Variable Costs

Machinery variable costs (fuel, lubrication, and repair) were also another factor in determining total operating costs. Figure IV-7 shows the machinery variable costs per acre for a 320-acre farm. No-till machinery variable costs were lower than conventional-till costs for every system and farm size except for the 2,560-acre ESFMN farms. The two small farm no-till systems had lower variable costs than the conventional-till systems due to only having a 155 horsepower tractor and a 20-foot no-till drill. Conventional-till systems had higher machinery variable costs because they spend more time going over the field while the small farm no-till systems hired custom applicators to apply fertilizers, herbicides, and pesticides. The 1,280 and 2,560-acre farms were assumed to own fertilizer spreaders and sprayers to perform these operations.

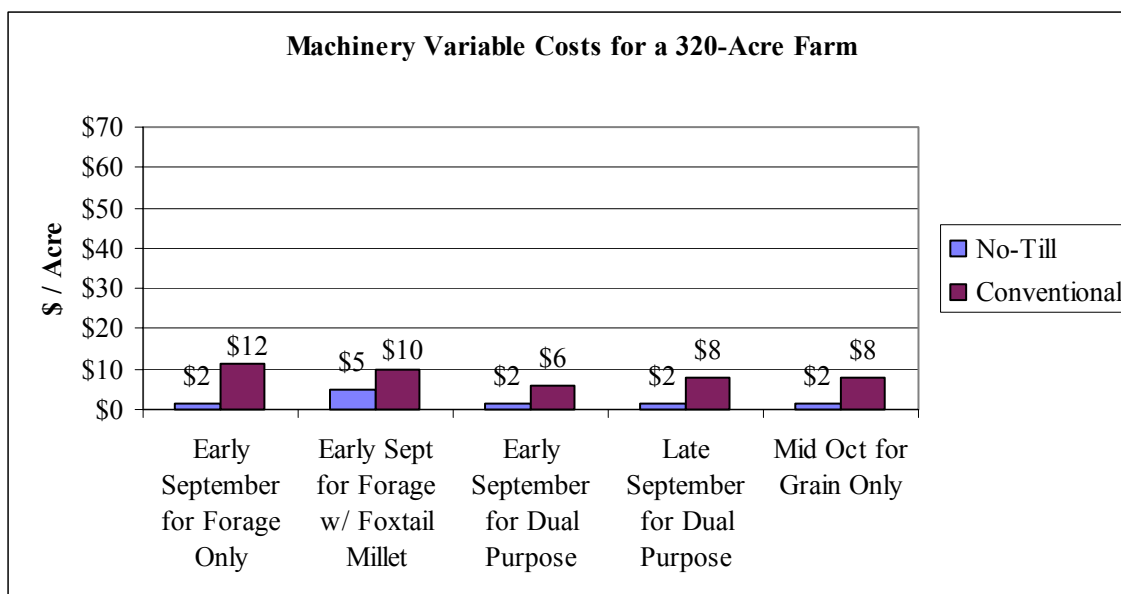


Figure IV-7. Average Machinery Variable Costs per Acre for a 320-Acre Farm.

The ESDN system was \$2 per acre lower than then ESDC system while the LSDN and OGN systems were \$4 per acre lower than the comparable conventional-till systems in a 1,280-acre farm. The ESN treatment was \$8 per acre lower than the ESFC treatment. For a 2,560-acre farm, machinery variable costs were \$1 per acre higher for the conventional-till and \$2 per acre higher for the no-till farms as compared to the 1,280-acre farm for the two dual-purpose systems and the October for grain-only system. The ESFC treatment was \$7 per acre higher than the ESN treatment, but the ESFMN treatment was \$28 per acre, \$3 higher than the ESFC system. The reason for the higher machinery variable cost was the two trips with the \$137,500 no-till air seeder (once to seed millet and once to seed wheat). Figure IV-8 shows the machinery variable costs per acre for a 2,560-acre farm.

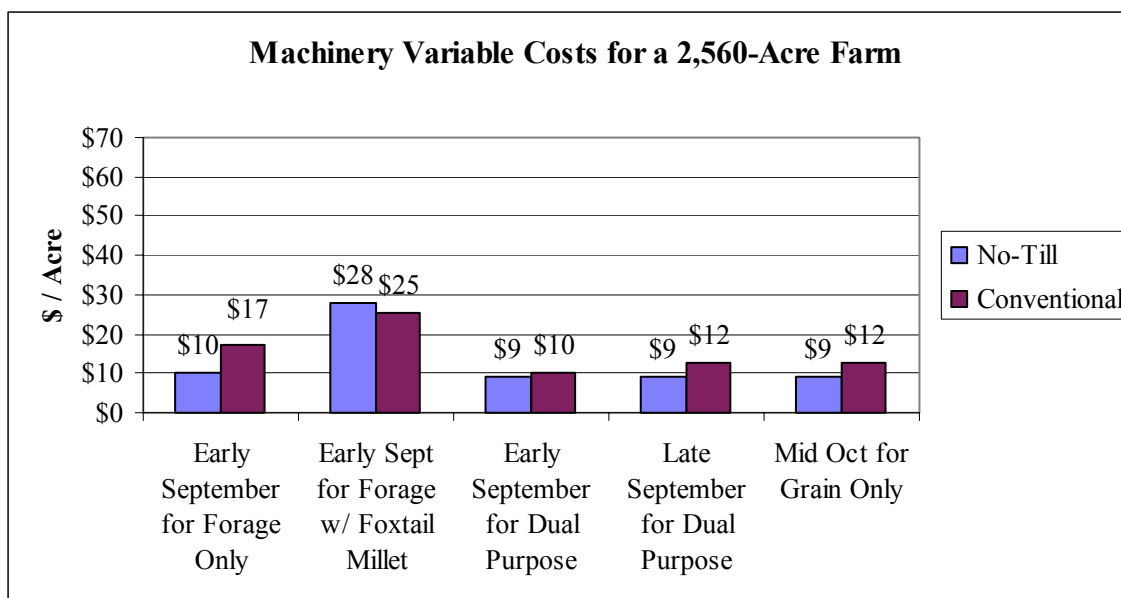


Figure IV-8. Average Machinery Variable Costs per Acre for a 2,560-Acre Farm.

Machinery Fixed Costs

Machinery fixed costs were lower for all no-till systems compared to the conventional-till systems. The reason for this was due to no-till tractors having their years owned stretched out over more years. Machinery fixed costs for a 320-acre farm ranged from \$50 per acre for the ESFMC system to \$56 per acre for the other four conventional-till systems. All no-till farms had machinery fixed cost of \$41 per acre. Figure IV-9 shows the machinery fixed costs per acre for a 320-acre farm.

Fixed costs were nearly cut in half for 640-acre farms but increased to \$31 per acre for the ESFMC system and \$34 per acre for the other four conventional-till systems for a 1,280-acre farm. No-till farms decreased to \$17 per acre for each system. Estimated machinery fixed costs for the 2,560-acre farms were approximately \$30 and \$19 per acre for conventional-till and no-till systems, respectfully. Figure IV-10 shows the machinery fixed costs per acre for a 2,560-acre farm.

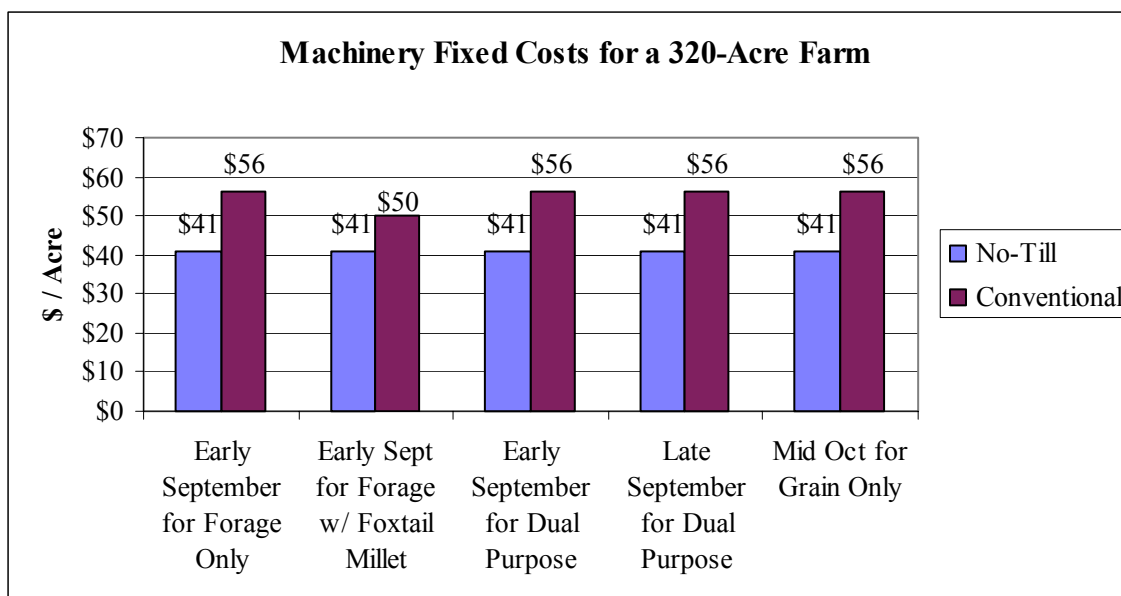


Figure IV-9. Average Machinery Fixed Costs per Acre for a 320-Acre Farm.

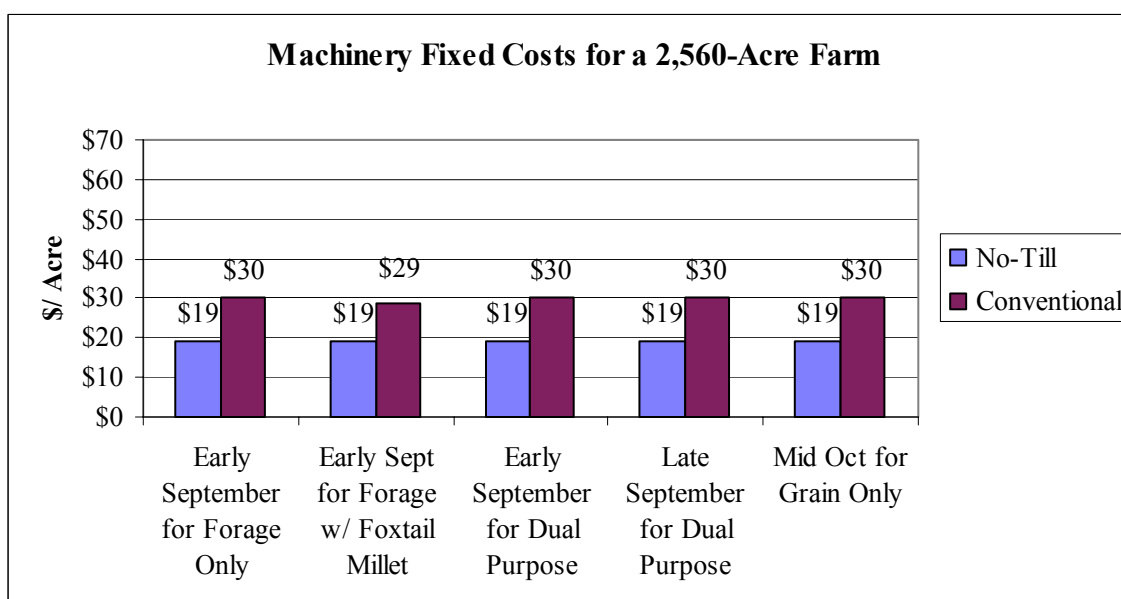


Figure IV-10. Average Machinery Fixed Costs per Acre for a 2,560-Acre Farm.

Total Costs

Total costs (excluding land, labor, and land management) were higher for all ESFN, ESFMN, and ESDN systems and farm sizes compared to the conventional-till systems except for the early September dual-purpose system for a 1,280-acre farm. The LSDN and OGN systems had approximately the same total costs as the LSDC and OGC systems for a 320-acre farm and \$6 per acre higher for a 640-acre farm. For a 1,280 and 2,560-acre farm, the two conventional-till farms were \$12 and \$5 per acre higher, respectively. For all size farms the ESFMN system resulted in higher costs than all the other systems with the ESFMC system having the second highest total cost. Figures IV-11, IV-12, and IV-13 show the average total costs per acre for a 320, 1,280, and 2,560-acre farm, respectively.

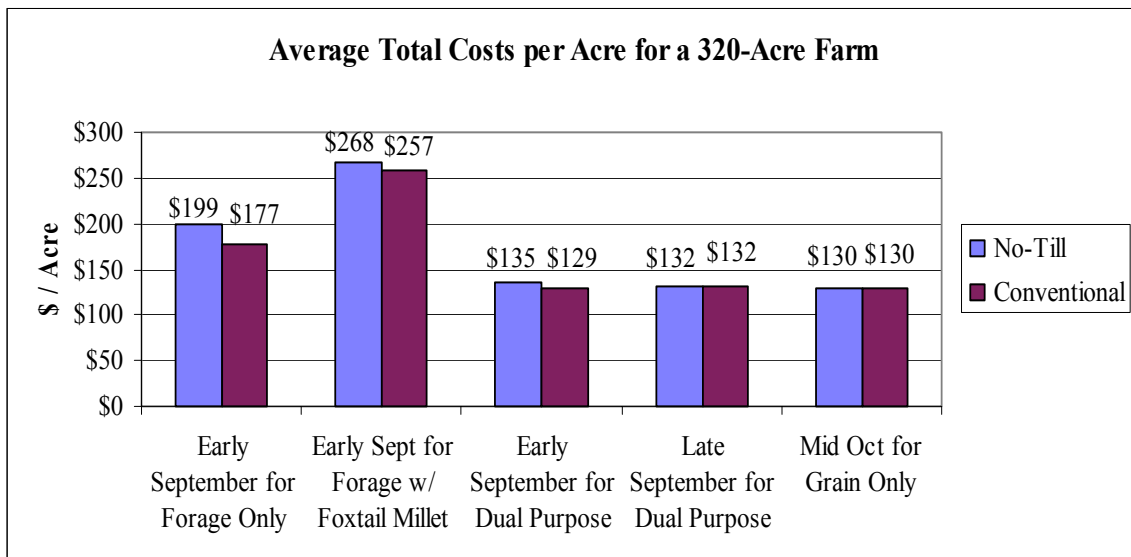


Figure IV-11. Average Total Costs per Acre for a 320-Acre Farm.

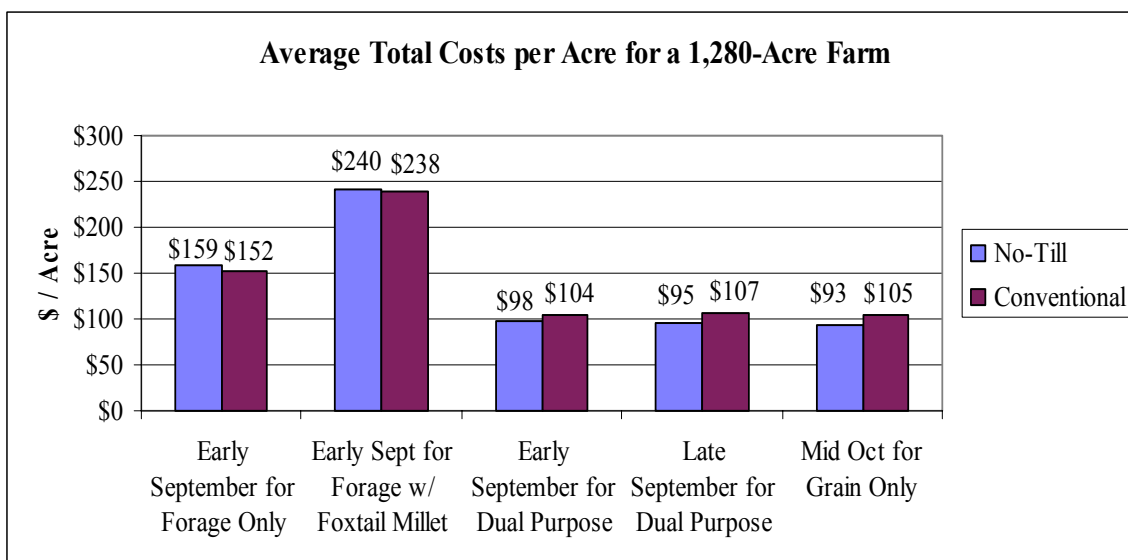


Figure IV-12. Average Total Costs per Acre for a 1,280-Acre Farm.

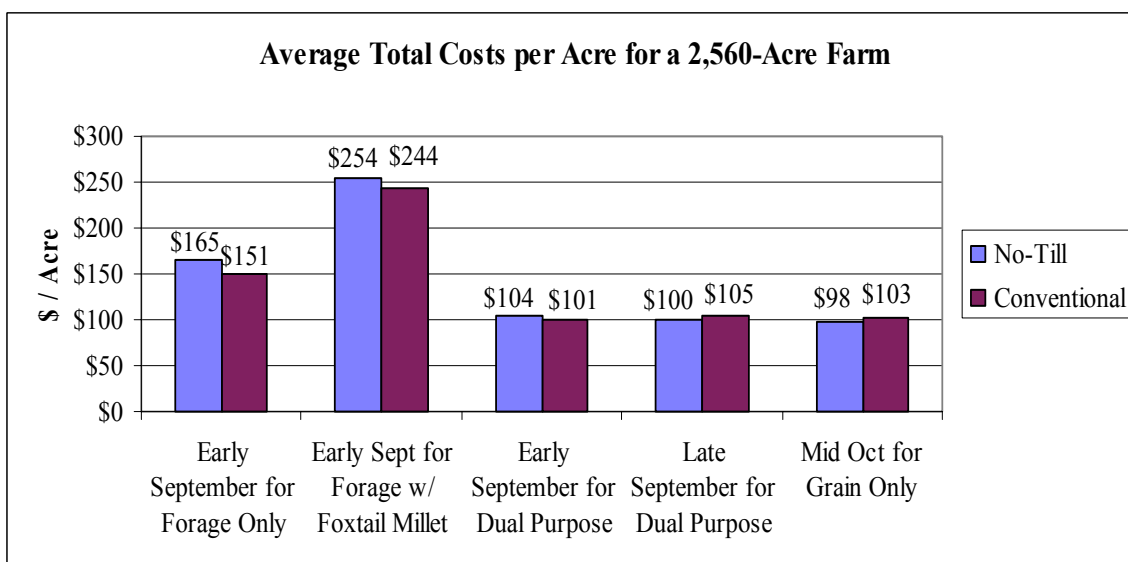


Figure IV-13. Average Total Costs per Acre for a 2,560-Acre Farm.

Machinery Labor Hours

Machinery labor hours are displayed in Figure IV-14 for a 320-acre farm. The labor hours account for machinery labor for the budgeted machine operations and not labor associated with forage or grain harvest, taking care of livestock, fixing fences and

water gaps, or any other management practices. It was assumed that hay and grain harvest costs including labor would not change across tillage systems. Costs for custom harvest of hay and grain were included in the budgets.

No-till labor hours were 0.14 hours per acre for each system excluding the ESFMN system, which had 0.29 hours per acre. The ESFC system used 0.92 hours per acre, and the ESFMC system used 0.78 hours per acre. The ESDC system used 0.55 hours per acre and the LSDC and OGC systems used 0.68 hours per acre. By using the ESDN method for a 320 acre-farm that has all of the herbicide, pesticide, and fertilize applications done by custom work, a farmer could save 25 minutes an acre. 32 minutes per acre are saved using the LSDN and OGN systems. If a farmer did the ESFN system instead of the ESFC practice, the farmer could save 47 minutes per acre. With this extra time, farmers could farm more land or spend more time with their families.

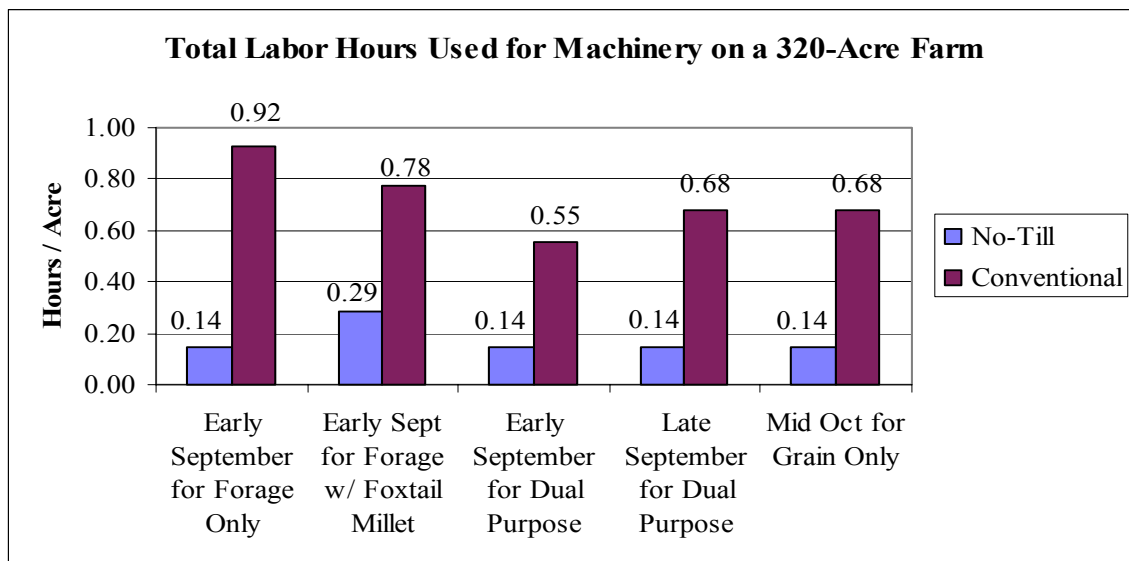


Figure IV-14. Average Total Machinery Labor Hours Used per Acre for a 320-Acre Farm.

For the 2,560-acre farm, no-till machinery labor hours were 0.29 hours per acre for the ESDN, LSDN, and OGN treatments, 0.33 hours per acre for the ESFN system,

and 0.38 hours per acre for the ESFMN method. Conventional-till labor hours were 0.46 hours per acre for the ESDC, 0.52 hours per acre for the LSDC and OGC systems, 0.65 hours per acre for the ESFC system, and 0.75 hours per acre for the ESFMC systems. A farmer could save 19 minutes an acre using the ESN practice, 10 minutes per acre using the ESDN practice, and 14 minutes per acre using the LSDN and OGN practices. Figure IV-15 shows the labor hours for a 2,560-acre farm.

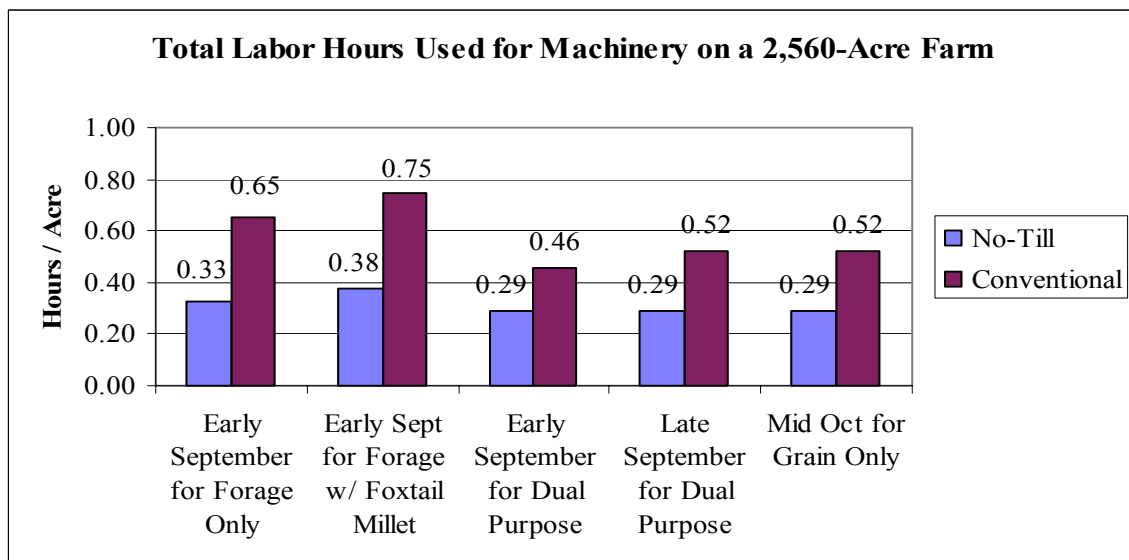


Figure IV-15. Average Total Machinery Labor Hours Used per Acre for a 2,560-Acre Farm.

Net Returns

The ESDC system had the highest net returns for a 320-acre farm. Net returns to land, labor, and management under method “A” were \$30.17 per acre for the ESDC system but with method “B” the ESDC system had a return of \$44.89 per acre. The LSDC method had a return of \$27.96 and \$37.70 per acre under method “A” and “B”, respectively. The ESDN and LSDN practices had returns of \$8.22 and \$4.32 per acre under method “A” and \$25 and \$12.49 per acre under method “B”. The net returns from

the grain-only and wheat for forage-only systems were negative for both tillage methods. The OGN system had returns of -\$36.70 per acre while the OGC practice had a net return of -\$13.78 per acre. The ESN system had net returns of -\$30.75 and -\$16.90 per acre for method “A” and ”B”, respectively. The ESFC system was about one to three dollars more than the no-till production methods. The ESFMN production method had a higher net return than the corresponding conventional-till system. The ESFMN system had the highest net return under method “A” for all no-till systems but was slightly less than ESDN under method “B”. Figure IV-16 and IV-17 display the average net returns for a 320-acre farm using method “A” and method “B” fall-winter calculations, respectively.

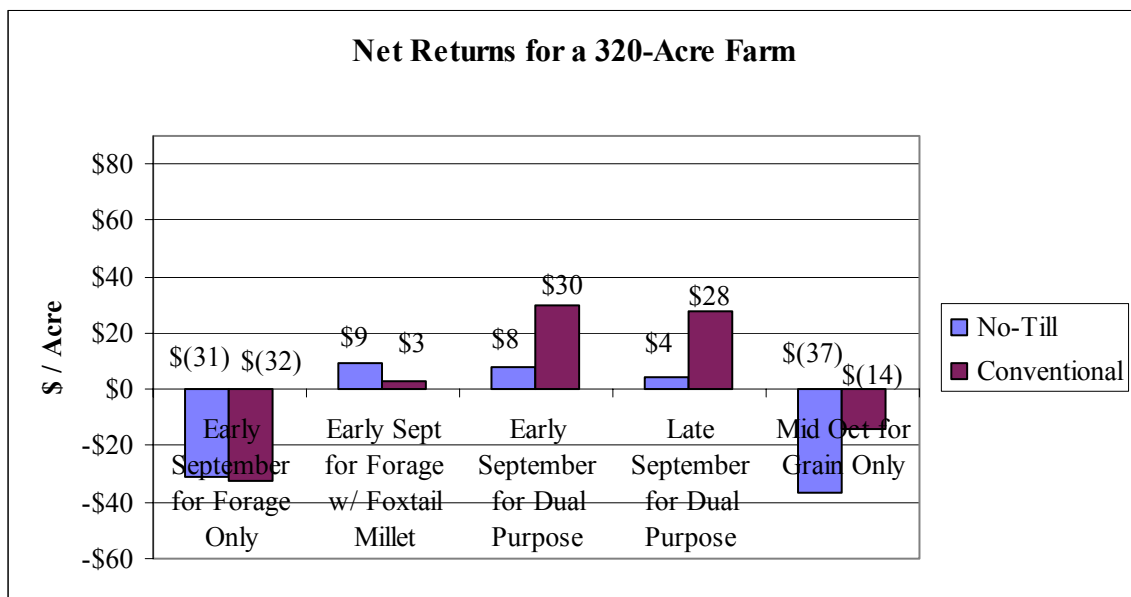


Figure IV-16. Average Net Returns for a 320-Acre Farm Using the Method “A” Fall-Winter Calculation.

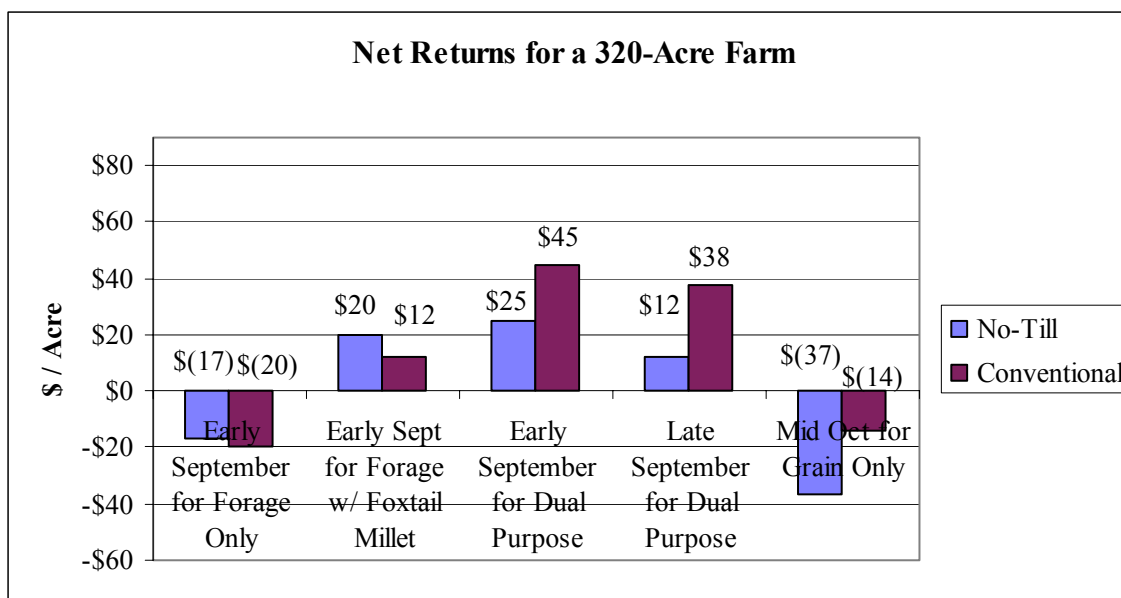


Figure IV-17. Average Net Returns for a 320-Acre Farm Using the Method “B” Fall-Winter Calculation.

For a 640-acre farm, the conventional-till systems had higher net returns than the no-till systems except for the ESFMN practice. Under method “A”, ESFC, ESNF, and OGN systems were negative. The OGN system was also negative under method “B”. The ESDC system had the highest net return for all systems under both method “A” and “B” fall-winter calculations. The ESDN production method had the highest return for the no-till methods, but it was about \$28 per acre less than the comparative conventional-till system.

Net returns to land, labor, and management for a 1,280-acre no-till farm are \$10 to \$20 per acre higher than for the 640-acre farm for all systems. Net returns for the OGN treatment are negative at -\$0.25 per acre. Under method “A”, the ESFC system is -\$7.87 per acre. The ESDC system has the highest net return of \$55.07 and \$69.80 per acre for method “A” and “B”, respectively, with the LSDC system having the second

highest. No-till systems, ESN and ESNM, had net returns of \$15 to \$18 per acre higher than their comparable conventional-till systems.

For a 2,560-acre farm using the OGN production system, net returns are negative at -\$5.38 per acre while the OGC system return is a positive \$13.49 per acre. The ESDC system generated the greatest net returns to land, labor, and management, which was \$18 to \$17 per acre more than the ESDN system when using method “A” and “B”, respectively. The ESN and the ESNM systems generated higher net returns than the corresponding conventional-till systems, ESN and ESNM. The ESN system had a net return of -\$6.14 under method “A”. Figures IV-18 and IV-19 list the net returns to land, labor, and management for a 2,560-acre farm using the method “A” and method “B” fall-winter calculations, respectively.

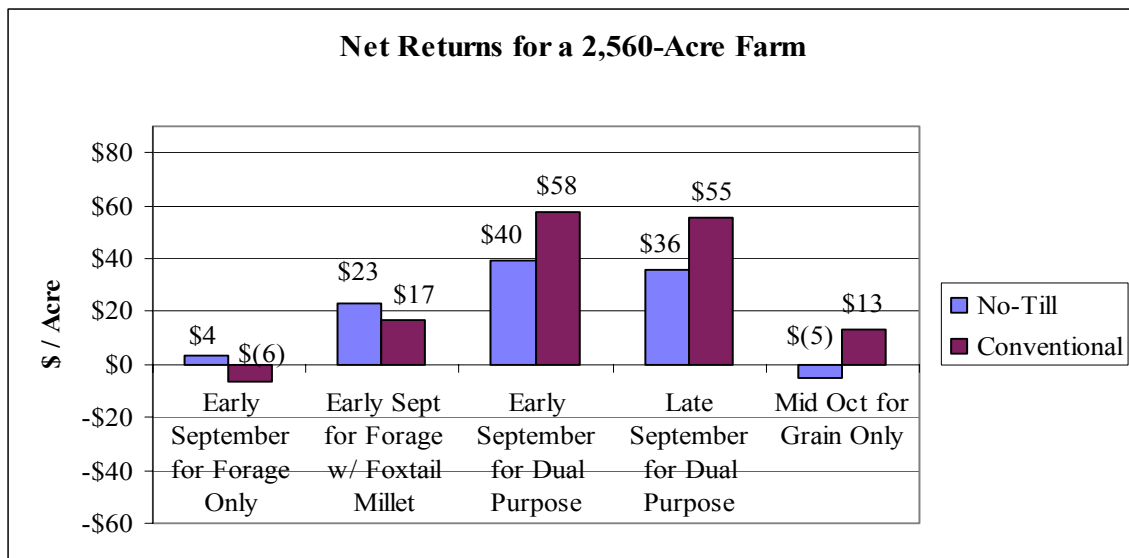


Figure IV-18. Average Net Returns for a 2,560-Acre Farm Using the Method “A” Fall-Winter Calculation.

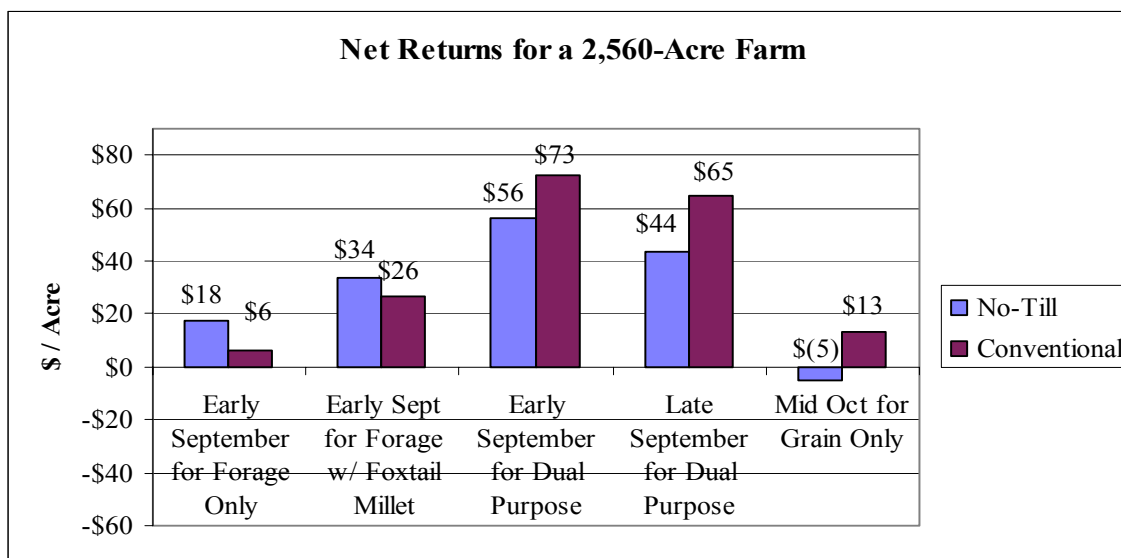


Figure IV-19. Average Net Returns for a 2,560-Acre Farm Using the Method “B” Fall-Winter Calculation.

The first objective was to determine which wheat production system is the most economical. The study found that the ESDC system is the most economical production system with the LSDC system coming in second. For the environmental conditions that occurred during the year of the study on the three farms, it was determined that the most economical system was to plant wheat in September for dual-purpose use. This system was more economical than each of the alternatives, namely, planting wheat in early September for forage-only, planting wheat in early September for forage-only followed by a summer double crop of foxtail millet for forage-only, and planting wheat in October for grain-only. For a 320-acre farm, under the method “B” fall-winter forage calculation, the ESDC system with a net return of \$45 per acre generated \$7 per acre more income than the LSDC system, \$59 per acre more than the OGC system, and \$65 per acre more than the ESFC system.

The ESN system produced \$3 more income per acre than the ESFC system but still had negative returns. The most profitable no-till system, ESDN, produced

approximately \$20 per acre less than the highest conventional-till system, ESDC. The OGN treatment netted \$82 per acre less than the ESDC system and was found to be the least economical production system. Under the method “A” calculation, the ESDC system had the highest net return of approximately \$30 per acre. The LSDC system had the second highest at \$28 per acre followed by the ESFMN system that generated a return that was \$21 per acre less than the ESDC system. The ESN and ESFC systems netted about \$61 per acre less and the OGN system generated \$67 per acre less net income than the ESDC system.

For a 640-acre farm the same pattern of results relative to wheat production system occurred as on a 320-acre farm. The ESDC system had the highest net return of \$72 per acre under the method “B” calculation and \$57 per acre under the method “A” calculation. All no-till systems are approximately \$20 per acre higher on a 640-acre farm than on a 320-acre farm and conventional-till systems are about \$25 per acre higher. Of all the systems, the OGN system is still negative and the least economical.

For a 1,280-acre farm, net returns were highest for the ESDC system under method “B” and “A”. Net returns for the ESDC system under method “B” are \$70 per acre, \$8 higher than the LSDC system, \$9 higher than the comparable ESDN system, and \$21 higher than the LSDN system. The ESN treatment was \$47 per acre lower than the ESDC system, and the OGN treatment was \$70 per acre lower. The net return was \$55 per acre for the ESDC system under the method “A” fall-winter forage calculation. The OGN system is the least economical of all the production methods.

Results for the 2,560-acre farm were consistent with those of other farm sizes. The ESDC system was found to be the most economical production system under both

methods. The net return is \$73 and \$58 per acre under method “B” and “A”, respectively. The LSDC system is the second most economical production system, and the OGN system is the least economical production system under method “A”. The ESFC system is the least economical production system under method “B” with a return of -\$6.14 per acre with the OGN system having a return of -\$5.38 per acre.

The second objective was to determine which tillage system is the most economical. The conventional-till systems are more economical in the dual-purpose and grain-only systems by a considerable margin. For the two forage-only systems, no-till is generally more economical than the conventional-till systems, especially with the two larger farm sizes.

The third objective was to determine whether farm size matters. Farm size does not change the relative rankings of the five production systems. Conventional-till systems were found to be more economical for all dual-purpose and grain-only systems for all farm sizes and no-till systems are more economical for forage-only systems for all farm sizes except on a 640-acre farm.

Farm size does influence net returns per acre. In general, economies of size prevail over the range of farm sizes considered such that production costs per acre decline with size with several exceptions. The 320-acre farm had the smallest net return per acre, and the 2,560-acre conventional-till farms had the highest net return per acre. But, the 1,280-acre farm had the highest net return across all farm sizes for no-till. It was also determined that the 640-acre farm had higher conventional-till net returns per acre than the 1,280-acre farm. Figure IV-20 shows the machinery fixed costs per acre for an ESDC and ESDN system on a 320, 640, 1,280, 2,560-acre farm, while Figure IV-21 includes a

chart of the net returns per acre to land, labor, and management for an ESDC and ESDN system using the method “A” fall-winter forage calculation.

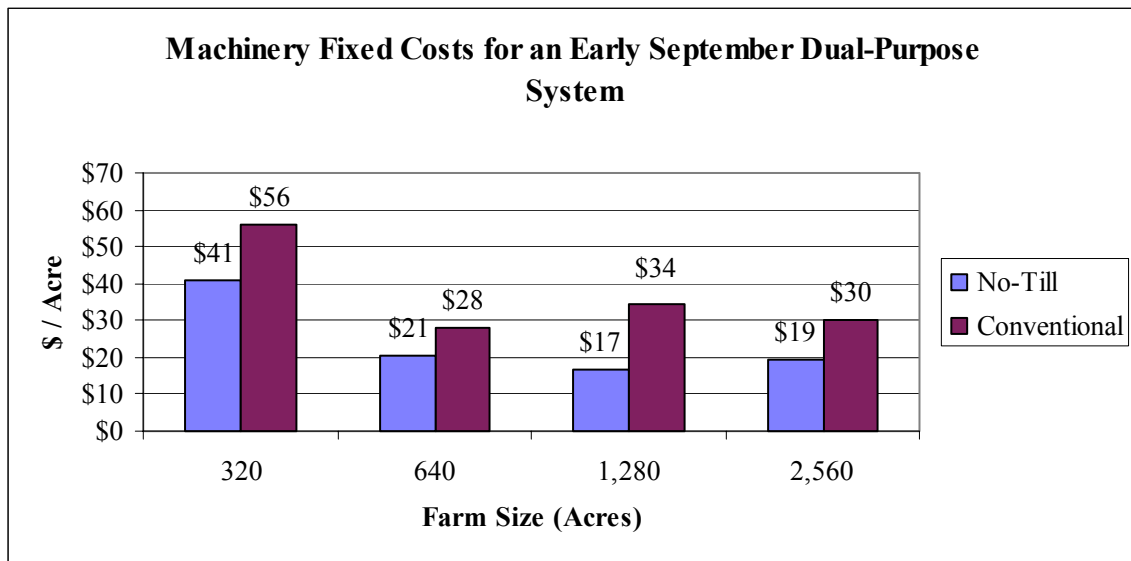


Figure IV-20. Machinery Fixed Costs per Acre for an ESDC and ESDN System by Farm Size.

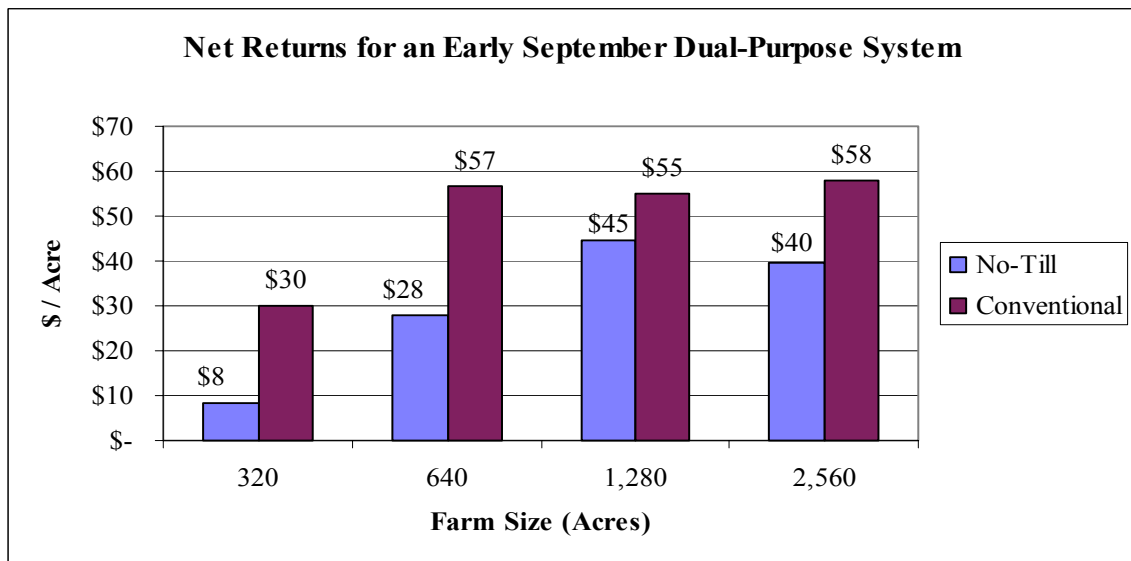


Figure IV-21. Net Returns per Acre for an ESDC and ESDN System by Farm Size using the Method “A” Fall-Winter Calculation.

CHAPTER V

CONCLUSIONS

In the southern Great Plains, wheat is a multiple use crop. It may be produced either for grain-only, forage-only, or as a dual-purpose crop for both forage and grain. Research was conducted to determine the most economical production system across five cropping alternatives and two tillage methods for four farm sizes. The five cropping alternatives included: (1) wheat seeded in early September for forage-only; (2) wheat seeded in early September for forage-only with foxtail millet seeded as a summer forage double crop; (3) wheat seeded in early September for dual-purpose (forage plus grain); (4) wheat seeded in late September for dual-purpose (forage plus grain); and (5) wheat seeded in mid October for grain-only. The two tillage methods included conventional-till and no-till. The four farm sizes were 320, 640, 1,280, and 2,560-acres.

Yield data, input requirements, and required field operations were obtained from a designed replicated experiment conducted on three Oklahoma farms. The farms are located near Loyal (Kingfisher County), Cherokee (Alfalfa County), and Kremlin (Garfield County), Oklahoma.

Forage and grain yields were gathered for the 2002-2003 crop. Millet dry matter forage yields were 627 pounds per acre greater for the ESFMN system than the ESFMC system. February wheat dry matter forage yields were greater for the ESN, ESFMN, ESDN, and LSDN systems than the comparable conventional-till systems. The ESN

treatment yielded the most February wheat forage of the eight systems (four no-till and four conventional-till). May dry matter wheat forage yields were approximately 907 pounds per acre greater for the ESFN system relative to the ESFC system. The ESFMC system had a slightly greater forage yield than the ESFMN system. The ESFMC system was the only conventional-till production method that had a greater forage yield than the comparative no-till system. The data show that for September planted wheat in the region, during the year of the field research, forage yields were not decreased by no-till.

Grain yields were harvested from each of the dual-purpose and grain-only systems. Across the six systems and three farms, grain yields from the no-till plots were an average of eight bushels per acre less than yields from the conventional-till systems. It is not clear as to why, on average, forage yields were enhanced but grain yields depressed in the no-till environment.

The MACHSEL machinery complement selection program was used to prepare machinery complements for each system for each farm size. It was assumed that grain and hay would be custom harvested on all farms so the machinery complements did not include grain and forage harvesting machinery and equipment. Average machinery investment ranged from \$256 per acre for all conventional-till systems except the ESFMC system that lacked a moldboard plow complement for a 320-acre farm to \$147 per acre for a 2,560-acre farm. In general, average machinery investment was found to be lower for the no-till systems. It ranged from \$197 per acre for all no-till systems for a 320-acre farm to \$92 per acre for a 2,560-acre farm.

A wheat enterprise budget was used to determine the returns to land, labor, and management for each system for each farm size. The no-till systems had overall greater

operating costs then the conventional-till systems. No-till operating costs were \$22 and \$14 per acre higher than conventional-till systems on a 320 and 2,560-acre farm, respectively. Herbicide and pesticide costs were a major factor for the increased operating costs. Herbicide and pesticide costs ranged from \$11 to \$19 per acre higher for the no-till systems.

No-till systems had lower machinery variable costs for all size farms, especially for the 320 and 640-acre farms since they lacked spray and fertilizer application equipment. The exception to this is the 2,560-acre ESFMN system where the machinery variable costs were \$3 per acre greater than the conventional-till systems. This was mainly due to two seed plantings (once to seed millet and once to seed wheat) with a \$137,500 thirty-six foot no-till air drill. Machinery fixed costs were also lower for all no-till systems and farm sizes when compared to conventional-till farms. No-till machinery fixed costs were \$14 and \$10 per acre lower than conventional-till for a 320 and 2,560-acre farm, respectively.

Total costs are greater for the ESN, ESFMN, and ESDN farms relative to the comparable conventional-till farms. The exception is the ESDC system, which is \$6 per acre higher than the ESDN system in a 1,280-acre farm. In a 320-acre farm, the LSDN and OGN systems have approximately the same total costs. In a 640-acre farm, the no-till farms are \$6 per acre higher, but in a 1,280-acre farm, the conventional-till farms are \$12 per acre higher. The LSDC and OGC systems are \$5 per acre higher than the LSDN and OGN systems in a 2,560-acre farm.

Farmers could save 47 minutes per acre using an ESN system, 25 minutes per acre using an ESDN system, and 32 minutes per acre using an LSDN and OGN systems

rather than using the comparable conventional-till systems in a 320-acre farm. In a 2,560-acre farm, 19 minutes per acre were saved using the ESN system, 10 minutes per acre using the ESDN, and 14 minutes per acre using the LSDN, and OGN systems. Minutes saved are for machinery labor for budgeted machine operations and not labor associated with forage or grain harvest, taking care of livestock, fixing fences and water gaps, or any other management practices.

For all farm sizes, the ESDC system had the greatest net return to land, labor, and management. The LSDC system had the second highest net return followed by the ESDN, LSDN, and ESN systems, not necessarily always in that order. The net returns from the ESN system were greater than the net returns from the ESDC system for all farm sizes. The ESN system generated more net income than the ESFC system for all farm sizes except for the 640-acre farm. The ESFC system netted negative income for all farm sizes under the method “A” fall-winter forage calculation. The OGN system generated negative net returns across all farm sizes for both fall-winter forage methods.

Summary

The first objective of this thesis was to determine the most economical wheat production system. The ESDC system was the most economical of all production systems followed by the LSDC system. This was especially true when the value of fall-winter wheat forage is \$0.31 per pound of gain. For a 320-acre farm, the ESDC system had a net return of \$45 per acre, which was \$7 per acre more than the LSDC system, \$20 more than the highest no-till system, ESDN, \$25 more than the ESFC system, and \$59

more than the OGC system. The OGN treatment netted \$82 per acre less than the ESDC system. The OGN treatment was the least economical. It generated \$23 per acre less than the comparable conventional-till system. The ESN treatment netted \$3 per acre more than the ESFC system. Under the stocker budgeting to determine the value of fall-winter forage, the same relative findings result. However, the ESDC system generated the highest net return of approximately \$30 per acre.

Net returns are greatest for the ESDC system for both methods of valuing fall-winter forage, and the ESDC system produces the most net return per acre for the 2,560-acre farm. The LSDC system has the second greatest net return across all the systems. Net returns for the ESDC system are estimated to be \$77 and \$63 per acre depending upon the method of valuing fall-winter wheat forage. The OGN system netted \$79 and \$65 per acre less than the ESDC system, depending upon the method of valuing fall-winter wheat forage.

The second objective was to determine the most economical tillage system. No-till systems had \$29 to \$98 per acre lower average machinery investment than conventional-till systems depending on farm size. No-till systems, however, had \$22 and \$14 per acre higher operating costs than conventional-till systems for a 320 and 2,560-acre farm, respectively. Herbicide and pesticide costs were a major contributor for the higher operating cost. The LSDN and OGN systems had an \$11 per acre herbicide/pesticide difference over the LSDC and OGC systems while the ESN system had a \$19 per acre difference over the ESFC system. The no-till early September planting dates had an extra pesticide application to control grasshoppers.

As a result of an eight-bushel per acre grain yield advantage for convention-till, the conventional-till systems produced more net income for the dual-purpose and grain-only production systems. The conventional tillage systems had higher average net returns over farm sizes with both methods of fall-winter forage of \$20.45 per acre over no-till farms. The no-till systems were more economical for the forage-only systems because of the higher clipped pounds of forage. The no-till forage-only treatments averaged \$7.65 per acre more than the corresponding conventional-till systems

The third objective was to determine if farm size matters. Net returns per acre to land, labor, and management were smallest for a 320-acre farm. Net returns per acre were greatest for a 2,560-acre farm for conventional-till farms but a 1,280-acre farm had the highest no-till returns. For an ESDN system using the stocker steer budget method to determine the value of fall-winter wheat forage, net returns increased \$20 per acre from a 320 to a 640-acre farm, \$16 to a 1,280-acre farm, and decreased \$5 for a 2,560-acre farm. The ESDC system using the same method had net returns increase \$27 per acre from a 320 to a 640-acre farm, decreased \$2 for a 1,280-acre farm, and then increased \$3 for a 2,560-acre farm.

Through the enterprise wheat budgets, it was found that an ESDC system is the most profitable of the ten production systems with the LSDC system being the second most profitable. The grain-only and wheat forage-only systems were the less profitable with the OGN treatment being the least profitable.

The conventional-till systems were found to be more economical for the dual-purpose and grain-only systems, while the no-till systems were more economical for the two forage-only systems. Farm size does matter when determining net returns but not

necessarily when determining production or tillage systems. The ESDC system was always the most economical while the OGN system was the least economical over each farm size. In a 1,280 and 2,560-acre farm under the method “A” fall-winter forage calculation, the ESFC system was the least economical production system. Conventional systems were more economical for the dual-purpose and grain-only systems over each farm size, and no-till systems were more economical for the forage-only systems. More research is needed to determine if the relative differences in forage and grain yields are consistent across years.

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