EFFECTS OF TILLAGE SYSTEM, GRAZING, AND SEEDING DATE ON GRAIN YIELD OF HARD RED WINTER WHEAT (*TRITICUM AESTIVUM)* AND EFFECT OF PRODUCTION OBJECTIVE AND TILLAGE SYSTEM ON FORAGE PRODUCTION

By

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INTRODUCTION

This thesis is a manuscript to be submitted for publication in Agronomy Journal, published by the American Society of Agronomy.

EFFECTS OF TILLAGE SYSTEM, GRAZING, AND SEEDING DATE ON GRAIN YIELD OF HARD RED WINTER WHEAT (*TRITICUM AESTIVUM)* AND EFFECT OF PRODUCTION OBJECTIVE AND TILLAGE SYSTEM ON FORAGE PRODUCTION

Effects of Tillage System, Grazing, and Seeding Date on Grain Yield of Hard Red Winter Wheat (*Triticum aestivum)* and Effect of Production Objective and Tillage System on Forage Production[*]

Deena L. Morley[†]

ABSTRACT

More than two thirds of the winter wheat (*Triticum aestivum*) seeded annually in Oklahoma is grown for forage and grain in the same growing season (dual-purpose). Experiments were conducted at three sites in north central Oklahoma to evaluate the effect of conventional tillage and no-till on forage and grain production in various production objectives. The five production objectives ranged from harvesting wheat for forage, doublecropping foxtail millet (*Setaria italica)*, wheat produced for forage and grain, and grain only. In the first year, foxtail millet forage yield was greatest at two of the three locations with no-till than with conventional tillage. For most years, wheat hay was unaffected by tillage and the years where there was an effect wheat hay yields were greater with no-till than with conventional tillage. Typically grain yield was 310 to 960 kg ha^{-1} less with no-till than with conventional tillage. For most years planting date did not affect grain yield.

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Introduction

Continuous hard red winter wheat (*Triticum aestivum* L.) is the primary crop grown in Oklahoma. Wheat is not typically rotated with other crops, but it is grown for grain-only, forage-only, or forage plus grain (dual-purpose). More than two-thirds of the wheat produced is grown either for forage-only or dual-purpose. However, the percentage for forage-only has increase from nine to 22 % over the last decade (Hossain et al, 2004). The percentage in no-till has increased over the last twenty years to about ten percent, but even though no-till hectares have increased considerably over the last few years, no-till production in Oklahoma is still far behind the national average (CTIC, 2004).

In northern Oklahoma, wheat can be planted as early as 1 September to maximize fall forage or as late as 20 October for grain production (Krenzer, 2000). Fall forage production is typically maximized when wheat is planted in late August to early-September and production steadily declines as wheat is planted later in the season. Averaged over six years, forage production decreased 90% when planting was delayed from 28 August until 30 September. The optimum planting date for maximizing grain yield is between late September and early October after which grain yields begin to decline (Heer and Krenzer, 1989; Krenzer, 2000; Lyon et al., 2001).

Two-thirds of Oklahoma's farm income is derived from cattle (*Bos taurus*) and wheat (Epplin et al., 1998). Wheat grazing typically begins in late October. Cattle are removed in late February and wheat grain is harvested in June. In a dual-purpose system where fall forage and grain are both considered important, growers traditionally compromise and plant wheat in mid-September (Krenzer, 2000).

Net returns from wheat that was not grazed by cattle were slightly higher than when cattle are allowed to graze up to two weeks prior to first hollow stem (growth stage when the stem is hollow above the root zone and below the developing wheat spike) (Krenzer, 2000). Removing cattle one and two weeks after the first hollow stem stage can reduce net returns by 40% and 96%, respectively (Krenzer and Horn, 1997). In another study, grain yields were reduced up to 84% by removing wheat forage after jointing (Dunphy et al., 1982).

Heer and Krenzer (1989) reported that tillage method affected grain production only in years when precipitation was limited. In drier years, yields were higher with no-till. In a more recent study, no-till reduced grain yield by 470 kg ha^{-1}, which caused negative net returns (Epplin et al., 1991).

In a ten-year study that compared the economics of six tillage systems in a continuous wheat system, the no-till system produced lower wheat grain yields than the conventional systems (Epplin et al., 1994). Net returns were higher in conventional tillage systems primarily due to the high cost of glyphosate used in no-till plots. Earlier studies have shown that no-till did lower fuel and labor cost, but the cost of herbicide to control weeds was greater than the money saved on fuel and labor (Epplin et al., 1993; Williams et al., 1989).

A common practice for Oklahoma farmers is to have a three month fallow period between crops of winter wheat with the intent to increase the amount of water stored in the soil for the next crop. Foxtail millet is a short season, summer annual grown primarily for forage that could be doublecropped with wheat if moisture is not limited. From planting the foxtail millet to harvesting it for hay requires approximately 60 days, which fits the three month summer fallow period (Baker, 2003). Foxtail millet has a low water requirement and can produce 2240 kg ha^{-1} with 6.35 cm of water, which makes it capable of producing forage during hot, dry summers typical of most Oklahoma (Baker, 2003; Koch, 2002).

Bromus species, jointed goatgrass (*Aegilops cylindrica*), and Italian ryegrass (*Lolium multiflorum*) are commonly found in continuous monoculture wheat systems and are especially hard to control in no-till (Cleary and Peeper, 1983; Lyon and Baltensperger, 1995; Olson et al., 2000). Until recently there have been no effective methods to control these weeds in wheat fields (Kelley and Peeper, 2003). Olson et al. (2000) examined the effects of MON 37500 application timing on cheat (*Bromus secalinus*), jointed goatgrass, and downy brome (*Bromus tectorum*). MON 37500 controlled cheat 87%, downy brome 50 to 99% but only stunted jointed goatgrass. In an application timing study, MON 37500 controlled cheat 75% when applied preemergnce and 88% when applied postemergence. Wheat yields were reported to be higher with a fall postemergence application of MON 37500 than a late-winter postemergence application (Kelley and Peeper, 2003).

The use of herbicides to control weeds during the fallow period between wheat crops is becoming a common practice (Wicks et al., 2003). Since its introduction in 1974, glyphosate has been the herbicide of choice for most no-till farmers. Glyphosate is preferred by farmers because of its effective control on a broad spectrum of weed species, and it is safe for humans and the environment. Also, glyphosate over the last 30 years has become less expensive (Baylis, 2000; Franz et al., 1997; Muller et al., 2005).

In a study that evaluated postharvest weed control and tillage methods glyphosate was efficient in controlling large crabgrass (*Digitaria sangiunalis*), seedling kochia (*Kochia* sp.) and *Amaranthus* species. Although control was good, a second application was required to control weeds that emerged after application. Also, volunteer wheat (*Triticum* sp.) was more dense in September, especially in the no-till (Rushing, 1981). In another study, weeds were more dense when glyphosate was applied only once during the summer. Once again, an additional application was needed to control weeds between wheat crops (Cleary and Peeper, 1983). Lyon and Baltensperger (1995) also applied glyphosate plus 2,4-D postharvest to control weeds and found that an additional application was required two weeks prior to planting.

With the introduction of genetically modified crops, glyphosate use is increasing faster than any other agrochemical (Baylis, 2000; Franz et al., 1997; Muller et al., 2005; Woodburn, 2000). Thus, there are increasing concerns with the emergence of resistant biotypes, especially for horseweed (*Conyza canadensis*) (Main et al., 2004; Muller et al., 2005). Of 50 horseweed samples collected from Illinois, Kentucky, Mississippi, Ohio, and Missouri to evaluate glyphosate resistance, four samples were resistant to glyphostate applied at 0.84 kg ha^{-1} and nine were resistant to glyphosate applied at 3.36 kg ha^{-1}. Environmental factors may also influence glyphosate activity (Main et al., 2004). However, there have been no reports of glyphosate resistant horseweed.

With fuel prices continuously rising and the cost of glyphosate decreasing, there is need to reevaluate the feasibility of continuous no-till wheat production and consider production objectives not previously researched including: forage-only, dual-purpose, and grain-only production systems (USDA-NASS, 2005). Although the effect of tillage system on wheat grain yield and net returns have been researched, no studies have been found that evaluated the effects of tillage system on wheat forage production. The objective of this study was to evaluate the effect of tillage system and planting date on wheat forage production and the effect of planting date, grazing, and tillage system on wheat grain yield.

MATERIALS AND METHODS

From 2002 to 2005, an experiment was conducted in wheat fields in three north central Oklahoma counties (Alfalfa, Garfield, and Kingfisher) to determine the effect of no-till versus conventional tillage management and five crop production objectives on wheat forage and grain yields.

The five production objectives included: wheat grain; traditional wheat forage and grain production (dual-purpose); dual-purpose with emphasis on wheat forage; wheat forage plus wheat hay; wheat forage plus wheat hay and foxtail millet hay. Each production objective was examined continuously using conventional and no-till management for the three year duration of the experiment. Dates for all field activities are in Table 1.

Individual plots were 9.1 by 13.7 m. Each treatment was replicated four times and maintained the same for the duration of the experiment. Agronomic data including forage yield, grain yields, and grain quality were collected from each appropriate plot in a randomized complete block design with a factorial arrangement of treatments. Factors were tillage (conventional tillage and no-till) and production objective.

The soil at Alfalfa County was a Dale Silt Loam (fine-silty, mixed, superactive, thermic, Pachic Haplustolls) with a capability classification of I (Williams, 1975). The soil at Garfield County was a Kirkland silt loam (fine, mixed, superactive, thermic, Udertic Paleustolls) with a capability classification of IIs-1 (Swafford, 1967). The soil at Kingfisher County was a Milan fine sandy loam with capability class of IIe (fine-loamy, mixed, superactive, thermic, Udic-Agriustolls) (Fisher, 1962).

Monthly rainfall data were collected from the mesonet weather station nearest each site (Appendix A). The nearest mesonet station in Alfalfa County was located approximately 6.5 km southwest of the experiment in Cherokee, OK, in Garfield County it was located approximately eight km south of the experiment in Breckenridge, OK, and in Kingfisher County it was located approximately 29 km southeast of the Kingfisher OK.

In 2002, wheat that was seeded by the cooperating farmer in the fall of 2001 was harvested as hay from appropriate plots in April (Alfalfa County) or early May (Garfield and Kingfisher Counties) using a forage harvester. Hand clipped samples from a 0.4 m^2 area per plot were weighed and dried at 60°C for seven days to determine dry forage weights.

One to 30 days after wheat hay was harvested, glyphosate at 840 g ai ha^{-1} was applied to all no-till plots. Conventional plots were tilled with a field cultivator with chisel standards followed by an s-tine field cultivator with double rolling baskets.

Wheat grain was harvested in June from 19.5 m^2 in appropriate plots using a small plot harvester. Yields from this wheat crop were collected to normalize future data for variation across the plot area, but after normalizing the data from subsequent years the coefficient of variation increased. Thus, wheat grain data were not normalized with the yields from the farmer-seeded crop.

In 2002 and 2004, conventional tillage plots harvested for grain were plowed 15 to 20 cm deep with a moldboard plow then cultivated with an s-tine field cultivator with double rolling baskets in June and August (disked in 2003). At planting, appropriate plots were tilled with the same cultivator, a field cultivator with chisel standards, a disk or a combination of these tools, as required.

All pesticides were applied using either a CO^2-pressurized backpack sprayer or a tractor sprayer equipped with flat fan nozzles spaced 51 cm apart delivering 187 L ha^{-1}. Applicator speed was 5.8 km hr^{-1} or 6.4 km hr^{-1} with the backpack and tractor sprayers, respectively.

In all no-till plots, target weed species were volunteer wheat, kochia, horseweed, and *Amaranthus* species which are typical for this region (Rushing, 1981; Cleary and Peeper, 1983). During the summer, no-till plots were treated with glyphosate at 1120 g ai ha^{-1} plus 2,4-D at 112 g ai ha^{-1} followed by an application of glyphosate at 840 g ai ha^{-1} except in 2002, the application order was reversed. In 2002 Garfield County was not treated with the first application of glyphosate, because weeds were not present. At planting, glyphosate was reapplied at 840 g ai ha^{-1} to appropriate plots (Anonymous, 2003b; 2003c). For treatments seeded in early September the first year, chlorpyrifos at

560 g ai ha^{-1} was tank mixed with the final glyphosate application for grasshopper (order: Orthoptera) control.

In 2002 and 2003, prior to planting the wheat in early September, granular urea was applied at 109 kg ha^{-1} to the entire experiment using a spinner type spreader, except at Garfield County in 2002 where a no-till anhydrous ammonia applicator was used to apply 90 kg nitrogen ha^{-1} to the entire experiment. In 2004, granular urea was applied by drilling it into the soil three cm deep using a no-till drill traveling perpendicular to the direction of seeding. Diammonium phosphate at 57 kg ha^{-1}was banded in the row with the wheat at planting.

Stocker cattle provided by the cooperators were released in mid-November each year except that the grain only production objective plots were not grazed. An electric fence excluded cattle from a 3 by 9.1 m portion of all other plots. Also at Garfield County in year three cattle were not released. Thus, to simulate grazing a 9.1 by 10.7 m portion of each plot was mowed to a height of 2.5 cm in December. Grazed areas were topdressed with 67 kg of nitrogen ha^{-1} in the form of urea ammonium nitrate in late January to mid-February. Stocking density and duration are in Appendix D.

To estimate wheat forage available when stockers were released and the amount of forage consumed by cattle, forage was hand clipped from a randomly selected 0.34 or 0.38 m^2 quadrant per plot (conventional tillage or no-till, respectively) in mid-November. In mid-March (or mid-February year two) forage samples were collected from grazed and ungrazed portions of each plot in the spring. Wheat forage samples were oven dried at 60°C for seven days to determine dry weights. Samples from the grazed (ungrazed from the grain only) portions of the plots were sent to Ward Laboratories Kearny, Nebraska, to determine crude protein content, in 2004 and 2005. The amount of forage consumed by cattle was estimated as the difference between the grazed and ungrazed spring forage.

Crop stands were counted in each plot for all crops, except foxtail millet in 2003. Weed densities and dryland root rot (*Fussarium* spp.) pressure were estimated just prior to wheat grain harvest. Winter annual grass spike densities were estimated by counting spikes in one m^2. Jointed goatgrass, cheat, and rescuegrass were the primary cool season weeds at Alfalfa, Garfield, and Kingfisher Counties, respectively. Dryland root rot incidence was estimated by counting dead and discolored wheat spikes in one m^2. Weed density and dryland root rot incidence data were analyzed after square root transformation, but transformation did not affect data interpretation. Thus, original data are reported with means separated in accordance with least significant difference.

Insects and foliar diseases were controlled on an as needed basis. In April 2004, dimethoate at 420 g ai ha^{-1} was applied at Garfield and Kingfisher Counties for control of bird cherry oat aphid (Order: Homoptera). In April 2005 at Garfield County, propiconazole at 126 g ai ha^{-1} and azoxystrobin at 75 g ai ha^{-1} were applied for leaf rust (*Puccinia triticina*) control (Anonymous, 2003a).

In November 2004, sulfosulfuron was applied at 35 g ai ha^{-1} to a 3.0 by 9.1 m portion of each plot to evaluate the effect on weed control and effect on yield. Wheat hay was harvested from the sulfosulfuron treated portion of each plot harvested for hay. Wheat grain yields were obtained separately from grazed-sprayed, grazed-unsprayed, ungrazed-sprayed, and ungrazed-unsprayed portions of each plot at Alfalfa and Kingfisher Counties. At Garfield County, yield data were utilized from the sulfosulfuron treated portions of the plots.

Stubble fires are a hazard for wheat farmers with no-till fields, especially during the dry, windy summers that are typical in western Oklahoma. In 2003 at Alfalfa County, all wheat stubble burned in August. The stand foxtail millet did not burn.

Production Objective

Wheat grain. The purpose of this production objective was to optimize wheat grain production with no forage utilization. Hard red winter wheat 'OK101' was planted on October 15 (±5days) at 101 kg ha^{-1} (Lyon et al., 2001; Kenzer 2000; Heer and Krenzer 1989).

At planting each year, conventional plots were tilled with an s-tine cultivator with double rolling baskets. In 2003, conventional plots were disked prior to using the cultivator. Conventional plots were then seeded using a single disk grain drill with 17-cm row spacing.

Each year, glyphostate was broadcast to appropriate no-till plots, as previously mentioned, two hours to three days prior to planting except that no herbicide was applied at Alfalfa County in 2003 because no weeds were present. No-till plots were seeded using a no-till drill with double disk openers and 19-cm row spacing.

Since the wheat that was planted in October was not grazed, it was not topdressed. Also, forage available for grazing in November was not collected from these plots due to lack of significant fall growth. Forage was sampled in the spring when forage yields were estimated for the other treatments.

Grain yields were estimated by harvesting a 13 m^2 area from each plot, except in 2005 where two (unsprayed-ungrazed and sprayed-ungrazed) samples were harvested from each plot using the methods previously described. Harvested samples were cleaned using a small commercial type seed cleaner. Grain volume weight was obtained from the cleaned samples. An additional sample was collected by harvesting a 23 m^2 area from each plot. Grain quality was obtained from the samples.

Grain quality, including official grade, test weight, crude protein, and dockage, were determined in 2003 and 2004 by Enid Grain Inspection, Enid, Oklahoma. U.S. grade is a number based on physical and biological factors. Grades range from one to five plus sample grade where one is the highest and sample grade the lowest quality (USDA, 2005). Test weight is reported in pounds per bushel to avoid distorting official data.

Traditional dual-purpose. In this production objective dual-purpose system wheat was planted on September 20 (±5 days) to obtain the traditional balance of forage and grain production (Krenzer 2000). At planting, conventional tillage plots were tilled with an s-tine field cultivator with double rolling baskets (twice at Alfalfa County in 2003) or with a field cultivator with chisel standards (2004) to prepare a clean seedbed. Plots were seeded using the same equipment and methods as described above.

Glyphosate was applied to no-till plots from two hours to two days prior to planting the wheat using the same procedures as above. Other procedures for no-till plots were the same as described above. Grain yield and quality were estimated using the procedures described above.

Dual-purpose forage emphasis. To emphasize forage production, wheat was planted on September 5 (±5 days) (Krenzer, 2000). Conventional tillage plots were tilled with an s-tine field cultivator with double rolling baskets (twice at Alfalfa County in 2003) each year, except at Garfield County in 2003 where the plots were disked. Prior to the light field cultivation in 2004, all plots were disked. Remaining procedures were the same as for the previous two production objectives.

Wheat forage plus wheat hay. The goal of this production objective was to emphasize fall forage production by seeding wheat on September 5 (±5 days) and harvesting wheat for hay in the spring rather than for grain. All other procedures including winter grazing were the same as the for previous production objective.

Yields of wheat hay were estimated by harvesting and weighing forage in the field from a 13.7 m^2 area with a plot-size forage harvester. Remaining forage was harvested and removed from the plots. Samples were oven dried at 60°C for seven days and reweighed to determine dry weights. Wheat hay was harvested in late-April (2003) or early May (2004 and 2005). In 2003, crude protein content of each dried sample was determined by the Soil, Water and Forge Analytical Laboratory, Oklahoma State University, Stillwater, OK. Wheat hay quality was not determined in 2004 and 2005.

After wheat hay was harvested in the spring, conventional tillage plots were tilled with a field cultivator with chisel standards (disked in 2004). Subsequent tillage was with an s-tine field cultivator with double rolling baskets. No-till plots were sprayed with glyphosate at 840 g ai ha^{-1} one to 30 days following hay harvest.

Maximize forage production. All wheat management procedures were the same as for the previous production objective. Foxtail millet was doublecropped with the wheat for three consecutive years and harvested as hay.

Foxtail millet was seeded at 19 kg ha^{-1} using a no-till drill with double disk openers with 19-cm row spacing. Diammonium phosphate at 52 kg ha^{-1} was banded with foxtail millet seed. During the first year, grasshoppers (order: Orthoptera) consumed all foxtail millet seeded in May at Garfield County and it was replanted in June.

Granular urea at 89 kg nitrogen $ha^{-1}$was broadcast on foxtail millet plots using a spinner type spreader in 2002. Prior to planting the foxtail millet in 2003 and 2004, 67 kg nitrogen ha^{-1} was applied as urea ammonium nitrate. This solution also served as a carrier for the glyphosate on the no-till plots.

In 2002, 2,4-D was applied at 840 g ai ha^{-1} for broadleaf weed control at Kingfisher County. In 2003, 2,4-D was applied at the same rate at all three sites. *Amaranthus* species were the primary target weeds.

Foxtail millet hay was harvested once in late July or August using the procedures for wheat hay above except at Alfalfa County in 2002 foxtail millet was harvested twice. Data from the two harvests were summed. Weeds present were harvested with the foxtail millet.

Following foxtail millet harvest, conventional tillage plots were tilled with an s-tine cultivator (2002), field cultivator with chisel standards (2003), or disked (2004). No-till plots were sprayed with glyphosate 840 g ai ha^{-1}.

Since it was suspected that cattle might choose to bed down on the no-till plots, the farmer cooperators were asked to seed 16 hectares of no-till wheat surrounding each experiment to dissipate the effect of bedding.

In the tables and discussion below, wheat data are presented by the year of crop harvest. Thus, wheat seeded in 2002 is presented as 2003. Foxtail millet data is also presented by year of harvest.

RESULTS

Wheat plant densities. Caution must be exercised in comparing wheat stand densities, because stand densities were determined at various lengths of time after seeding. Typically, stand densities for wheat seeded in September were estimated at the next date for seeding. Thus, the data are most useful for comparing conventional tillage and no-till within a production objective (Table 2). At Alfalfa and Kingfisher Counties in 2003 and 2005, wheat densities were often greater in no-till than in conventional tillage plots planted in early September. But the advantage of no-till for stand density was not apparent with later planting dates. The increase in plant densities with early planted wheat may be attributed to greater moisture and lower soil temperatures typically found in no-till (Streit et al., 2003; Unger et al., 1977).

At Kingfisher County in 2005, wheat stand densities were very low in conventional plots planted in early September. These stand counts, obtained 14 days after seeding, again demonstrate the advantage of no-till for obtaining rapid wheat emergence for early September seeded wheat.

Production of foxtail millet hay as a doublecrop reduced wheat stand density of early September planted wheat only at Garfield County in 2004. The lack of effect of the foxtail millet on wheat stand density was attributed to rainfall between foxtail millet harvest and wheat seeding.

Fall forage. When compared to the traditional dual-purpose production objective, emphasizing forage by planting wheat earlier approximately doubled fall forage production for most years at all locations (Table 3). Forage production increases due to earlier planting dates have previously been reported (Krenzer, 2000).

In four of the five possible comparisons between harvesting early seeded wheat for grain versus for wheat hay in conventional tillage, fall wheat forage the succeeding fall was lower where hay was harvested. This suggests that removal of hay removed nutrients not replaced by annual applications of diammonium phosphate or urea or that removal of hay negatively affected soil tilth or water holding capacity which in turn reduced fall forage growth. Since soil tests collected in August 2002 and 2004 did not indicate potassium deficiencies, the negative effect of not having straw to till into the soil must be considered (Appendix B and C).

Within a site, a year, and a production objective, no-till increased fall wheat forage in six of the 36 possible comparisons and decreased fall forage production only at Garfield County in 2005 in the maximum forage production objective. These data suggest that growers who emphasize fall forage production should seriously consider adopting no-till management

In six of the nine possible comparisons where wheat hay was harvested, seeding foxtail millet as a doublecrop reduced fall forage of the following crop. This could be attributed to drier soils where foxtail millet was grown. It would seem logical that in years where precipitation was limited in the fall, wheat forage yield will be reduced by doublecropping with foxtail millet. However, in a region where annual rainfall is unpredictable, doublecropped foxtail millet hay could be especially beneficial to growers when fall conditions are not conducive to obtaining wheat pasture.

Forage consumed by cattle. Tillage system did not affect forage consumed by cattle ($P = 0.17$ to 0.56). Pooled across years, forage consumed by cattle at Alfalfa and Kingfisher Counties was increased by seeding in early September (Table 4). This was not true at

Garfield County in 2003. Producing foxtail millet as a doublecrop reduced wheat forage consumption by a mean of 330 kg ha^{-1} at Alfalfa County. However, the effect of foxtail millet was not consistent at other sites and years.

Averaged over the two years that data were obtained, crude protein of wheat forage in the spring was less with no-till than with conventional tillage at Alfalfa County (Table 5). At Kingfisher County averaged over the two years that data were obtained, crude protein was unaffected by tillage.

At Alfalfa County averaged over years, crude protein content of wheat forage in the spring was greater in wheat planted in October for grain (which was not grazed) than in wheat seeded in early or late September and grazed (Table 6). Averaged over years at Kingfisher County, crude protein content was lowest with wheat planted in early September and harvested for grain. This suggest that plant needs for nitrogen may not have been satisfied when wheat was seeded early to increase wheat forage

There was a year by production objective by tillage system interaction at Garfield County (Table 6). In 2004, forage protein was higher in conventional tillage production objectives wherein wheat had not been harvested for hay the previous year. Also within production objectives wherein wheat was harvested for grain, protein was higher in conventional tillage plots than in no-till. In 2005 at Garfield County, plots were not grazed by cattle but were mowed in December. The mowed forage was not removed from the plots. Thus, the effects of actual forage removal could not be determined and that data is not shown.

Wheat hay. In the production objectives where wheat was harvested for hay, hay yields varied widely with location and year (Table 7). Yields were unaffected by tillage except at Garfield County in 2003 and Kingfisher County in 2005, where wheat hay yield was greater with no-till than conventional tillage. The advantage of no-till was not apparent in situations where hay yield exceeded 8000 kg ha^{-1}.

The only year where production objective affected wheat hay yield was at Garfield County in 2003 (Table 8). At that site, wheat hay yield was reduced about 10% where foxtail millet was doublecropped. In the same year, spring wheat forage yield was also less in the production objective doublecropped with foxtail millet.

In 2003 at Alfalfa and Garfield Counties, wheat hay crude protein content was unaffected by tillage ($P = 0.94$ and 0.65) and production objective ($P = 0.19$ and 0.99). Mean crude protein was 8.5% to 12.2% at Alfalfa and Garfield, respectively. At Kingfisher County, crude protein was less ($P = 0.02$) with no-till (8.8%) than with conventional tillage (12.2%). Pooled over location, tillage, and production objective, wheat hay crude protein averaged 11.0% in 2003, the only year when it was determined.

Wheat grain. Grain yields varied considerably with site and year, which offered the opportunity to compare the production objectives in contrasting years (Table 9). The data do not support prior findings that seeding in early September reduces grain yield (Krenzer, 2000). At Alfalfa County, averaged over production objectives, no-till did not affect yield in 2003, substantially increased yield in 2004 (the year the stubble burned before seeding), and reduced yield in 2005 (Table 10). These data suggest that additional research with straw management could increase wheat yields under no-till. At Garfield County no-till reduced grain yields in 2003, 2005, and when averaged across years. These data support previous research (Epplin et al., 1991).

At Kingfisher County, an interaction was found with years, tillage system, and production objective (Table 11). In 2003 and 2004, grain yields of grain only and traditional dual-purpose were sharply reduced by no-till. Also, in 2003 grain yield was especially low with no-till dual-purpose emphasizing forage. However, in 2004 and 2005 within no-till, yields were higher with dual-purpose emphasizing forage than grain only suggesting that no-till wheat should be seeded before mid October.

By fencing cattle out of portions of each plot from the two dual-purpose production objectives, the effect of grazing on grain yields of wheat planted in early and mid-September was determined. However, only the grazed portions of plots were topdressed. Effects of grazing on grain yield are presented as percent of ungrazed. In many situations, grazing together with topdressing had relatively little effect on grain yield. At Alfalfa County, grazing conventional tillage wheat reduced grain yield more than grazing no-till wheat. In contrast, pooled over production objective and year at Garfield County, tillage system did not affect yield of grazed wheat (Table 12).

There was a tillage system by year interaction at Kingfisher County. Grazing and tillage system had no significant effect on yield in 2003 or 2004. In 2005, a year with a very dry spring at Kingfisher County, grazing conventional tillage wheat was very beneficial to yield. Pooled over tillage and year, production objective did not affect grain yield of grazed wheat when expressed as a fraction of ungrazed at Alfalfa or Garfield Counties (Table 13). However, there was a year by production objective interaction at Kingfisher County which again suggests that with seeding date held constant grazing could increase yield in a dry year.

Official test weight was unaffected by tillage in 2003 at Alfalfa County, but in 2004 official test weight was greater with no-till than with conventional tillage (Table 14). At Garfield County in 2003, official test weight was less with no-till than conventional tillage and was unaffected by tillage system in 2004. Thus, it was not possible to conclude that no-till affects test weight.

At Alfalfa County for both years, test weight was unaffected by production objective (Table 15). At Garfield County official test weight was greater with traditional dual-purpose that with the other production objective harvested for grain, but the next year official test weight was greater with dual-purpose emphasizing forage than traditional dual-purpose and grain only.

There was a tillage system by production objective interaction each year at Kingfisher County. In the traditional dual-purpose in 2003, official wheat grain test weight was lower with no-till than with conventional tillage and unaffected by tillage the next year. Each year official wheat grain test weight was higher in no-till than conventional tillage, but test weight in the dual-purpose emphasis on forage production objective was less with no-till than with conventional tillage.

Official wheat grain grade was inconsistent from year to year (Table 16). In 2004 at Alfalfa County, official grain grade was higher with no-till than with conventional tillage. However, in 2003 at Garfield County, official grain grade was lower with no-till than with conventional tillage. An overview of the data suggest that factors other than tillage system were influencing grain grade, and that wheat produced using no-till should not necessarily be expected to grade differently.

Averaged over production objectives, tillage system seldom affected wheat grain crude protein content (Table 17). Wheat grain crude protein content was less with no-till than with conventional tillage at Alfalfa County in 2004, but at Garfield County in 2003, crude protein content was greater with no-till than with conventional tillage.

At Alfalfa (2003) and Garfield Counties (2004), crude protein was greater with traditional dual-purpose and grain only than with dual-purpose emphasizing forage. In no situation did wheat produced for grain only have more crude protein than traditional dual-purpose wheat.

Official grain dockage varied from year to year (Table 18). In 2003, tillage system did not affect dockage at any site. At Alfalfa County in 2004, dockage was less with no-till than with conventional tillage.

At Garfield County in 2004, wheat grain dockage in the grain only and traditional dual-purpose production objectives was greater than in dual-purpose emphasizing forage. However, over all sites, there was no situation where dockage was higher in dual-purpose emphasizing forage than in grain only.

Foxtail Millet. Foxtail millet stand was affected by tillage system only in 2004 at Alfalfa County where foxtail millet stands were greater with no-till than with conventional tillage (Table 19). However, when pooled over locations for 2002 (P = 0.13) and 2004 (P = 0.06), there were contrasting tillage system affects. In 2002, stands were less with no-till than with conventional tillage. But in 2004, densities were greater with no-till than conventional tillage. Stand densities were not obtained in 2003. Thus, adequate foxtail millet stands were obtainable in either no-till or conventional tillage and were influenced by factors other than tillage system.

Foxtail millet hay yield was greater with no-till than conventional tillage at least one year at each location (Table 20). In years when there was a tillage system effect, foxtail millet hay was greater with no-till than conventional tillage by 34 to 48 %. The greater yield of no-till foxtail millet in 2004 at Garfield County was attributed to greater stand density in no-till that year.

There were three of nine situations where tillage system affected foxtail millet crude protein content (Table 21). At Garfield County in 2002 crude protein content was slightly greater with no-till than with conventional tillage. However, at Alfalfa (2003) and Garfield Counties (2004) crude protein content was less with no-till than with conventional tillage.

The data suggest that doublecropped foxtail millet performs well when planted no-till in fields where wheat has been removed as hay. Also, the forage produced by the foxtail millet greatly contributed to total forage production available from a given area.

Weed Species and Control. Targeted weed species for summer fallow weed control were volunteer wheat, *Amaranth* species, kochia and horseweed. Both chemical and mechanical control of these weed species were consistently excellent (95% control or greater). Horseweed plants were scattered throughout the experiments and they were controlled with the glyphosate application indicating that glyphosate resistant horseweed plants were not present (Main et al., 2004).

Winter annual grasses present at Alfalfa, Garfield, and Kingfisher Counties were jointed goatgrass, cheat, and rescuegrass, respectively. Each year pooled over production objectives, weed densities were unaffected by tillage system at Alfalfa County (P = 0.3, 0.7 and 0.1), Garfield (P = 0.3, 0.1 and 0.5), and Kingfisher Counties (P = 0.1, 0.5 and 0.3).

Weed densities were unaffected by production objective until the last year of production (Table 22). In the last year, weed densities were greater with traditional dual-purpose than with dual-purpose emphasizing forage and grain only production objectives at all sites. These data indicate that wheat planted in early September emerged before winter annual grasses and obtain a competitive advantage. Wheat seeded in late October was seeded after winter annual grasses emerged, thus they were controlled before the wheat was seeded (Anderson and Soper, 2003). Wheat seeded in late September may have emerged at about the same time as the winter annual grasses and was therefore more heavily infested with weeds.

In 2005 at Alfalfa County, jointed goatgrass densities were unaffected (P = 0.2) by the application of sulfosulfuron (Table 23). Previous studies reported that sulfosulfuron had poor efficacy on jointed goatgrass (Kelley and Peeper, 2003; Olson et al., 2000). At Kingfisher County, there was a production objective by sulfosulfuron application interaction. Within the treated plots, sulfosulfuron was less effective in reducing rescuegrass in wheat seeded in early September than in wheat seeded in late September.

At Alfalfa County averaged over other factors, wheat grain yield was less (P = 0.01) with the untreated (2030 kg ha^{-1}) than with treated (2460 kg ha^{-1}). Grain yield at Kingfisher County was unaffected (P = 0.6) by herbicide application.

Averaged over other factors dockage was unaffected (P = 0.1) by sulforsulfuron application at Alfalfa County. However, at Kingfisher County dockage was reduced (P = <0.01) from 6.0% in the check to 3.0%.

Wheat Disease. Dryland root rot was affected more by location than other factors. Only in 2004 at Kingfisher County was there a tillage system by production objective interaction for dryland root rot incidence (Table 24). In that situation, dryland root rot within the grain only production objective was greater in no-till. Dryland root rot in the grain only production objective was also greater than in the dual-purpose production objectives. Contrary to current recommendations, conventional tillage only reduced wheat disease one year at one site (Kingfisher County 2005) (Anonymous, 2003a).

In the situations where production objective affected dryland root rot the results were mixed. At Garfield County in 2003, dead and discolored spikes were greater with traditional dual-purpose and dual-purpose emphasizing forage than grain only. These findings support the previous reports that earlier planted wheat is more susceptible to disease in some years and not others (Kelley, 2001; Lyon et al., 2001).

CONCLUSION

Cattle were observed to bed down most frequently on the no-till areas seeded by the growers, in preference to the smaller no-till plots. Thus, this source of potential variation was removed from the experiment through the efforts of the farmer cooperators. In conclusion, adoption of no-till wheat should be considered especially where growers want to maximize wheat forage production. Only in one year at one location was fall forage reduced with no-till, and that was following foxtail millet. Planting wheat in early

September often increased forage production each year, which supports previous findings (Krenzer, 2000).

Summed over three years for each location, total wheat forage consumed by cattle was increased with planting wheat in early September compared to traditional dual-purpose planted in late September (Appendix E-G). However, wheat grain yield was unaffected by planting wheat in early September versus late September. Thus, indicating that wheat can be seeded in early September to increase consumable forage and still harvest for grain without reducing grain yields.

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Table 1. Field operations and dates for each production objective by tillage and site.

	Tillage[i]		Production objective[ii]					Site		
Field operation	CT	NT	GO	TDP	DPF	WFH	MF	Alfalfa	Garfield	Kingfisher
Wheat hay harvested	CT	NT				X	X	4/17/02	5/02/02	5/21/02
Glyphosate applied	——	NT				X	X	5/10/02	5/10/02	5/23/02
CT plots chiseled	CT	——				X	X	5/14/02	5/14/02	5/22/02
CT plots tilled	CT	——				X	X	5/14/02	5/14/02	5/22/02
Foxtail millet planted	CT	NT					X	5/14/02	5/14/02	5/22/02
Granular urea broadcasted	CT	NT					X	5/22/02	5/22/02	5/22/02
Wheat grain harvested	CT	NT	X	X	X			6/12/02	6/10/02	6/11/02
Foxtail millet density estimated	CT	NT					X	6/12/02	7/15/02	6/11/02
Foxtail millet replanted	CT	NT					X	——	6/19/02	——
Moldboard plowed	CT	——	X	X	X	X		6/26/02	6/27/02	6/27/02
Glyphosate applied	——	NT	X	X	X	X		6/26/02	——	6/27/02
Light tillage	CT	——				X		6/28/02	——	6/28/02
Foxtail millet hay harvested	CT	NT					X	7/15/02	——	——
2,4-D applied	CT	NT					X	——	——	7/16/02
Light tillage	CT	——	X	X	X	X		8/07/02	8/07/02	8/07/02
Glyphosate and 2,4-D applied	——	NT	X	X	X	X		8/07/02	8/07/02	8/07/02
Foxtail millet hay harvested	CT	NT					X	8/22/02	8/21/02	8/21/02
Light tillage	CT	——					X	8/22/02	8/21/02	8/21/02
Fertilized	CT	NT	X	X	X	X	X	9/04/02	9/04/02	8/29/02
Glyphosate applied[iii]	——	NT			X	X	X	9/04/02	9/06/02	8/29/02
CT plots tilled	CT	——			X	X	X	9/05/02	9/06/02	9/03/02
Wheat planted	CT	NT			X	X	X	9/05/02	9/06/02	9/03/02
Wheat densities estimated	CT	NT			X	X	X	9/20/02	9/24/02	9/23/02

Table 1 (continued.). Field operations and dates for each production objective by tillage and site.

	Tillage		Production objective					Site		
Field operation	CT	NT	GO	TDP	DPF	WFH	MF	Alfalfa	Garfield	Kingfisher
Glyphosate applied	——	NT		X				9/20/02	9/24/02	9/23/02
CT plots tilled	CT	——		X				9/20/02	9/24/02	9/23/02
Wheat planted	CT	NT		X				9/20/02	9/24/02	9/23/02
Wheat density estimated	CT	NT		X				10/15/02	10/11/02	10/16/02
Glyphosate applied	——	NT	X					10/15/02	10/11/02	10/16/02
CT plots tilled	CT	——	X					10/15/02	10/11/02	10/16/02
Wheat planted	CT	NT	X					10/15/02	10/11/02	10/16/02
Wheat stand estimated	CT	NT	X					11/08/02	11/08/02	11/14/02
Fall forage clipped	CT	NT		X	X	X	X	11/15/02	11/18/02	11/14/02
Cattle released on grazed plots	CT	NT		X	X	X	X	11/22/02	12/15/02	12/01/02
Spring forage clipped	CT	NT	X	X	X	X	X	2/13/03	2/13/03	2/13/03
Grazed wheat topdressed	CT	NT		X	X	X	X	2/19/03	2/19/03	2/17/03
Cattle removed	CT	NT		X	X	X	X	3/01/03	3/01/03	3/02/03
Dimethoate applied	CT	NT	X	X	X	X	X	——	4/03/03	4/03/03
Wheat hay harvest	CT	NT				X	X	4/29/03	4/22/03	4/22/03
Glyphosate applied	——	NT				X	X	4/29/03	4/25/03	4/25/03
CT plots chiseled	CT	——				X	X	4/29/03	4/25/03	4/25/03
CT plots tilled	CT	——				X	X	4/29/03	4/25/03	4/25/03
Fertilizer applied	CT	NT					X	4/29/03	4/25/03	4/25/03
Foxtail millet planted	CT	NT					X	4/29/03	4/25/03	4/25/03
2,4-D applied	CT	NT					X	4/29/03	4/25/03	4/25/03
Weed densities estimated	CT	NT	X	X	X			6/13/04	6/13/04	6/10/04
Wheat grain harvested	CT	NT	X	X	X			6/13/03	6/13/03	6/10/03

Table 1 (continued). Field operations and dates for each production objective by tillage and site.

	Tillage		Production objective					Site		
Field operation	CT	NT	GO	TDP	DPF	WFH	MF	Alfalfa	Garfield	Kingfisher
CT plots chiseled	CT	——	X	X	X	X		6/25/03	6/25/03	6/25/03
Glyphosate and 2,4-D applied	——	NT	X	X	X	X		6/26/03	6/26/03	6/26/03
Foxtail millet harvested	CT	NT					X	7/17/03	7/16/03	7/16/03
CT plots chiseled	CT	——	X	X	X	X	X	7/31/03	7/31/03	7/31/03
Glyphosate applied	——	NT	X	X	X	X	X	9/05/03	9/05/03	9/05/03
Granular urea applied	CT	NT	X	X	X	X	X	9/10/03	9/09/03	9/08/03
CT plots tilled[iv]	CT	——		X	X	X	X	9/10/03	9/09/03	9/08/03
Planted wheat	CT	NT			X	X	X	9/10/03	9/09/03	9/08/03
Glyphosate applied	——	NT		X				9/22/03	9/22/03	9/22/03
CT plots tilled (twice at Alfalfa)	CT	——	X	X				9/24/03	9/24/03	9/24/03
Wheat planted	CT	NT		X				9/24/05	9/24/05	9/24/05
Wheat densities estimated	CT	NT		X	X	X	X	10/16/03	10/17/03	10/16/03
Glyphosate applied	——	NT	X					——	10/16/03	10/13/03
CT plots disked	CT	——	X					10/16/03	10/16/03	10/16/03
CT plots tilled	CT	——	X					10/16/03	10/16/03	10/16/03
Wheat planted	CT	NT	X					10/16/03	10/17/03	10/16/03
Wheat densities estimated	CT	NT	X					11/04/03	11/04/03	11/04/03
Fall forage clipped	CT	NT		X	X	X	X	11/12/03	11/12/03	11/12/03
Cattle released on grazed plots	CT	NT		X	X	X	X	11/22/03	11/05/03	11/20/03
Cattle removed from plots	CT	NT		X	X	X	X	2/11/03	2/27/03	3/1/03
Grazed portions topdressed	CT	NT		X	X	X	X	2/19/04	2/18/04	2/16/04
Spring forage clipped	CT	NT	X	X	X	X	X	3/15/04	3/16/04	3/15/04
Insecticide applied	CT	NT	X	X	X	X	X	3/22/04	——	——
Wheat hay harvested	CT	NT				X	X	5/11/04	5/11/04	5/12/04
CT plots chiseled	CT	——				X	X	5/12/04	5/12/04	5/12/04

Table 1 (continued). Field operations and dates for each production objective by tillage and site.

Field operation	Tillage		Production objective					Site		
	CT	NT	GO	TDP	DPF	WFH	MF	Alfalfa	Garfield	Kingfisher
Glyphosate applied	——	NT				X	X	5/19/04	5/19/04	5/19/04
Fertilizer applied	CT	NT					X	5/17/04	5/17/04	5/17/04
CT plots disked	CT	——				X	X	5/19/04	5/19/04	5/19/04
CT plots tilled	CT	——				X		5/19/04	5/19/04	5/19/04
Foxtail milletplanted	CT	NT					X	5/19/04	5/19/04	5/19/04
Weed densities estimated	CT	NT	X	X	X			6/08/04	6/08/04	6/13/04
Dryland root rot visually rated	CT	NT	X	X	X			6/08/04	6/08/04	6/13/04
Wheat grain harvested	CT	NT	X	X	X			6/08/04	6/08/04	6/13/04
Foxtail millet density estimated	CT	NT					X	6/16/04	6/16/04	8/02/04
CT plots Plowed	CT	——	X	X	X			6/16/04	6/16/04	6/25/04
2,4-D applied	CT	NT					X	6/28/04	——	——
CT plots disked	CT	——	X	X	X	X		7/13/04	7/13/04	7/13/04
Glyphosate and 2,4-D applied	——	NT	X	X	X	X		7/14/04	7/14/04	7/14/04
Foxtail millet hay harvested	CT	NT					X	8/02/04	8/02/04	8/02/04
Glyphosate applied	——	NT	X	X	X	X	X	8/10/04	8/10/04	8/10/04
CT plots disked	CT	——	X	X	X	X	X	8/10/04	8/10/04	8/10/04
Glyphosate applied	——	NT			X	X	X	9/6/04	9/1/04	9/2/04
Fertilizer applied	CT	NT	X	X	X	X	X	9/7/04	9/3/04	9/3/04
CT plots disked	CT	——			X	X	X	9/7/04	9/3/04	9/3/04
CT plots tilled	CT	——			X	X	X	9/7/04	9/3/04	9/3/04
Wheat planted	CT	NT			X	X	X	9/7/04	9/3/04	9/3/04
Wheat densities estimated	CT	NT			X	X	X	9/27/04	9/16/04	9/17/04
Glyphosate applied	——	NT		X				9/27/04	9/27/04	9/27/04
CT plots chiseled	CT	——		X				9/28/04	9/29/04	9/29/04
Wheat planted	CT	NT		X				9/28/04	9/29/04	9/29/04
Glyphosate applied	——	NT	X					10/18/04	10/18/04	10/15/04

Table 1 (continued). Field operations and dates for each production objective by tillage and sites.

	Tillage		Production objective					Site		
Field operation	CT	NT	GO	TDP	DPF	WFH	MF	Alfalfa	Garfield	Kingfisher
CT plots tilled	CT	——	X					10/19/04	10/21/04	10/18/04
Wheat planted	CT	NT	X					10/19/04	10/21/04	10/18/04
Wheat density estimated	CT	NT		X				10/19/04	10/21/04	10/18/04
Wheat density estimated	CT	NT	X					11/1/04	10/25/04	10/25/04
Sulfosulfuron applied	CT	NT	X	X	X	X	X	11/1/04	11/9/04	11/8/04
Fall forage clipped	CT	NT		X	X	X	X	11/12/04	11/9/04	11/9/04
Cattle released on grazed portions	CT	NT		X	X	X	X	11/12/04	——	11/15/04
"Grazed" portions of plots mowed	CT	NT		X	X	X	X	——	12/15/04	——
Grazed (mowed) topdressed	CT	NT		X	X	X	X	2/17/05	1/26/05	1/25/05
Cattle removed	CT	NT		X	X	X	X	3/16/05	——	3/7/05
Spring forage clipped	CT	NT		X	X	X	X	3/16/05	3/14/05	3/14/05
Fungicide applied	CT	NT	X	X	X	X	X	——	4/4/05	——
Harvest wheat hay	CT	NT				X	X	5/9/05	5/9/05	5/9/05
Estimated weed densities	CT	NT	X	X	X	X	X	5/30/05	5/30/05	5/30/05
Root rot rated	CT	NT	X	X	X			5/30/05	5/30/05	5/30/05
Wheat grain harvested	CT	NT	X	X	X			6/03/05	6/07/05	6/02/05

[i] CT= conventional tillage, NT= no-till

[ii] GO = grain only, DPT = dual-purpose-traditional, DPF = dual-purpose-forage emphasis, WFH = wheat forage plus wheat hay, MF = maximize forage.

[iii] Chlorpyrifos tank mixed with glyphostate for grasshopper control.

[iv] CT plots tilled twice at Alfalfa and disked at Garfield

Table 2. Tillage system by production objective interaction on wheat plant density at Alfalfa and Kingfisher Counties (2003 and 2005), and effect of production objective pooled over tillage system on wheat plant density at Alfalfa (2004), Garfield (2003 to 2005), and Kingfisher (2004) Counties.

	Alfalfa					Garfield			Kingfisher				
	2003		2004	2005		2003	2004	2005	2003		2004	2005	
	Tillage*												
Production objective†	CT	NT	Mean	CT	NT	Mean	Mean	Mean	CT	NT	Mean	CT	NT
	no. plants m^{-2}												
GO	205	176	192	290	189	188	209	183	232	199	227	272	240
TDP	185	169	268	181	166	205	217	163	199	173	258	249	199
DPF	163	194	256	205	221	208	267	78	161	294	264	74	146
WFH	132	176	240	147	247	199	318	93	135	262	300	23	134
MF	158	203	245	224	286	171	284	86	198	282	294	4	120
LSD (0.05)	41		NS	62		NS	31	39	40		37	45	
CV	16		24	20		14	12	32	12		14	21	

* CT = conventional tillage, NT = no-till, Mean = pooled over tillage.

† GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis, WFH = wheat forage plus wheat hay, MF = maximize forage.

Table 3. Tillage system by year by production objective interaction on dry weight of wheat forage in the fall at Alfalfa, Garfield, and Kingfisher Counties.

Production objective[†]	Alfalfa						Garfield						Kingfisher					
	2003		2004		2005		2003		2004		2005		2003		2004		2005	
	Tillage[*]																	
	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT	CT	NT
	kg ha $^{-1}$																	
TDP	1170	1120	1180	1380	860	790	1290	1320	690	800	200	760	980	810	570	820	660	690
DPF	2710	3810	2360	2830	1450	1470	3100	3280	1590	2510	960	920	1880	2230	2000	1860	1260	1430
WHF	1340	2400	1960	2930	960	1260	2700	3290	1870	2300	700	520	1360	2270	1340	1960	630	1090
MF	710	840	1450	1990	1370	1580	2130	2310	1870	2290	690	190	1530	1440	1970	2230	950	1250
LSD(0.05)	620						500						470					
CV %	53						63						45					

[*] CT = conventional tillage, NT = no-till, Mean = pooled over tillage.

[†] TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis, WFH = wheat forage plus wheat hay, MF = maximize forage.

Table 4. Effect of production objective pooled over tillage system on dry weight of wheat forage consumed by cattle at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa				Garfield			Kingfisher			
Production objective*	2003	2004	2005	Mean	2003	2004	2005	2003	2004	2005	Mean
	kg ha^{-1}										
TDP	500	160	2070	1020	2050	640	470	980	390	430	670
WDP	1090	440	2530	1510	3980	1260	760	1580	570	880	1140
WFH	840	400	2500	1400	3440	1680	760	1090	760	450	600
MF	430	480	2260	1180	2850	1770	530	1070	770	790	980
LSD (0.05)	420	NS	NS	310		660		NS	NS	NS	340
CV %	63	85	27	82		66		56	78	68	72

* TDP = traditional dual-purpose, WDP = dual-purpose forage emphasis, WFH = wheat forage plus wheat hay, MF = maximize forage.

Table 5. Effect of tillage system pooled over production objective on crude protein content of wheat forage at the termination of grazing at Alfalfa and Kingfisher Counties.

	Alfalfa			Kingfisher		
Tillage	2004	2005	Mean	2004	2005	Mean
			%			
Conventional tillage	31.5	25.3	28.4	22.8	25.5	24.2
No-till	30.3	23.4	26.9	22.1	24.8	23.5
LSD (0.05)	NS	1.3	1.0	NS	NS	NS
CV %	9	13	16	12	12	16

Table 6. Effect of production objective pooled over tillage system on crude protein content of wheat forage at the termination of grazing at Alfalfa , Garfield, and Kingfisher Counties.

	Alfalfa			Garfield		Kingfisher		
	Tillage*							
	2004	2005	Mean	2004		2004	2005	Mean
Production objective†	Mean	Mean		CT	NT	Mean	Mean	
	%							
GO	32.7	28.8	30.8	31.1	27.0	20.3	30.6	25.5
TDP	31.6	24.5	28.0	30.3	27.3	25.0	24.5	24.8
WDP	29.8	22.1	25.9	27.2	23.9	21.3	21.2	21.2
WFH	30.1	23.0	26.6	24.0	23.8	21.7	25.4	23.5
MF	30.4	23.3	26.9	23.3	23.6	23.9	24.1	24.1
LSD (0.05)	NS	2.0	1.6	2.4		3.0	3.0	2.1
CV %	9	13	16	12		12	12	17

* Mean = pooled across tillage system, CT = conventional tillage, NT = no-till.

† GO = grain only, TDP = traditional dual-purpose, WDP = dual-purpose emphasize on wheat forage, WFH = wheat forage plus wheat hay, MF = maximize forage.

Table 7. Effect of tillage system pooled over production objective on dry weight of wheat hay at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa				Garfield				Kingfisher		
Tillage*	2003	2004	2005	Mean	2003	2004	2005	Mean	2003	2004	2005
		kg ha^{-1}									
CT	5430	11900	9360	8890	6580	10910	9340	8940	4880	8660	6220
NT	6300	11090	9130	8840	7270	10990	9140	9130	4600	7720	7400
LSD (0.05)	NS	NS	NS	NS	630	NS	NS	NS		1000	
CV %	33	13	13	34	8	17	19	66		26	

* CT = conventional tillage, NT = no-till.

Table 8. Effect of production objective pooled over tillage system on dry weight of wheat hay at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa				Garfield				Kingfisher			
Production objective*	2003	2004	2005	Mean	2003	2004	2005	Mean	2003	2004	2005	Mean
	kg ha^{-1}											
WFH	6250	11650	8810	8900	7240	11380	9360	9330	4890	8370	6750	6670
MF	5480	11350	9680	8837	6610	10520	9120	8750	4590	8000	6870	6490
LSD (0.05)	NS	NS	NS	NS	630	NS	NS	NS	NS	NS	NS	NS
CV %	33	13	13	34	8	17	19	66	19	12	15	26

* WFH = wheat forage plus wheat hay, MF = maximize forage.

Table 9. Effect of production objective pooled over tillage system on wheat grain yields at Alfalfa and Garfield Counties.

Production objective*	Alfalfa				Garfield		
	2003	2004	2005	Mean	2003	2004	2005
	kg ha^{-1}						
GO	3420	3870	2060	3120	2430	2390	2502
TDP	3330	3790	2040	3050	3050	2930	2380
DPF	3030	3730	1990	2920	2780	3330	2450
LSD (0.05)	NS	NS	NS	NS	360		
CV %	11	22	27	32	19		

* GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose-forage emphasis.

Table 10. Effect of tillage system on wheat grain yield pooled over production objective at Alfalfa and Garfield Counties.

	Alfalfa			Garfield			
Tillage	2003	2004	2005	2003	2004	2005	Mean
			kg ha^{-1}				
Conventional tillage	3430	3350	2280	2910	2940	2730	2860
No-till	3100	4240	1750	2600	2830	2150	2530
LSD (0.05)		440		200	NS	350	160
CV %		32		14	19	20	19

Table 11. Tillage system by production objective by year interaction on wheat grain yield at Kingfisher County.

	2003		2004		2005	
	Tillage*					
Production objective†	CT	NT	CT	NT	CT	NT
	kg ha^{-1}					
GO	3030	2400	3660	2580	1180	1460
TDP	3620	2700	3770	3150	1330	1070
DPF	2710	1380	3130	3260	1840	2240
LSD	580					
CV %	39					

* CT = conventional tillage, NT = no-till

† GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose-forage emphasis.

Table 12. Effect of tillage system pooled over production objective on the effect of grazing on grain yield of wheat seeded in dual-purpose production objectives at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa				Garfield				Kingfisher		
Tillage	2003	2004	2005	Mean	2003	2004	2005	Mean	2003	2004	2005
	% of ungrazed										
Conventional tillage	83	77	105	89	106	95	112	104	92	104	170
No-till	88	104	136	109	102	98	102	100	92	103	120
LSD (0.05)	NS	7	NS	16	NS	NS	NS	NS		26	
CV %	12	17	34	30	11	15	19	16		34	

Table 13. Effect of grazing on yield of wheat seeded in dual-purpose production objectives pooled over tillage system at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa				Garfield				Kingfisher		
Production objective*	2003	2004	2005	Mean	2003	2004	2005	Mean	2003	2004	2005
	% of ungrazed										
TDP	87	88	120	98	102	89	102	101	86	95	161
DPF	84	95	120	94	105	103	112	103	98	112	131
LSD (0.05)	NS	7	NS	NS	NS	NS	NS	NS	26		
CV %	12	17	34	30	11	15	19	16	34		

* TDP = traditional dual-purpose, DPF = dual-purpose emphasis wheat forage

Table 14. Effect of tillage system pooled over production objective on official test weight of wheat grain at Alfalfa and Garfield Counties.

Tillage	Alfalfa		Garfield	
	2003	2004	2003	2004
	lb $bu.^{-1}$			
Conventional tillage	59.7	55.7	57.6	56.4
No-till	59.3	58.8	56.8	56.4
LSD (0.05)	NS	1.8	0.5	NS
CV %	2	4	2	2

Table 15. Effect of production objective pooled over tillage system on official wheat test weigh at Alfalfa and Garfield Counties, and tillage system by production objective interaction on official test weight at Kingfisher County.

	Alfalfa		Garfield		Kingfisher			
	2003	2004	2003	2004	2003		2004	
	Tillage*							
Production objective	Mean	Mean	Mean	Mean	CT	NT	CT	NT
	lb bu.$^{-1}$							
Grain only	59.7	57.1	57.1	55.6	58.1	58.5	59.4	61.1
Traditional dual-purpose	59.4	57.8	57.8	56.2	59.2	58.1	60.8	60.9
Dual-purpose forage emphasis	59.6	56.9	56.7	57.4	58.6	56.4	61.2	59.7
LSD (0.05)	NS	NS	0.6	0.8	1.3		1.1	
CV %	2	4	2	2	2		2	

* Mean = pooled over tillage system, CT = conventional tillage, NT = no-till.

Table 16. Tillage system by production objective interaction on mean official wheat grain grade at Alfalfa (2003) and Kingfisher Counties (2003 and 2004), effect of production objective pooled over tillage system on mean official wheat grain grade at Garfield County in 2004, and effect of tillage system pooled over production objective on mean official wheat grain grade at Alfalfa (2004) and Garfield Counties (2003)[*].

	Alfalfa				Garfield			Kingfisher			
	2003		2004		2003		2004	2003		2004	
	Tillage[†]										
Production objective[‡]	CT	NT	CT	NT	CT	NT	Mean	CT	NT	CT	NT
GO	2.0	1.3	—	—	—	—	3.6	2.3	2.0	2	1
TDP	1.5	2.3	—	—	—	—	3.4	1.8	2.5	1	1
DPF	1.3	2.0	—	—	—	—	2.9	2.0	3.3	1	2
Mean	—	—	3.4	2.0	2.5	3.0	—	—	—	—	—
LSD (0.05)	0.9		0.75		0.40		0.5	0.6		0.5	
CV %	40		40		19		17	27		34	

[*] Official U.S. grade is a number based on physical and biological factors, with number one the highest and sample grade the lowest quality (USDA, 2005).

[†] CT = conventional tillage, NT = no-till, Mean =pooled over tillage.

[‡] GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis.

Table 17. Effect of production objective pooled over tillage system on official crude protein content of wheat grain at Alfalfa (2003), Garfield (2003), and Kingfisher (2003 and 2004) Counties, and effect of tillage system pooled over production objective on official crude protein content at Alfalfa (2004) and Garfield (2003).

	Alfalfa			Garfield			Kingfisher	
	2003	2004		2003		2004	2003	2004
	Tillage*							
Production objective†	Mean	CT	NT	CT	NT	Mean	Mean	Mean
	%							
GO	11.7	—	—	—	—	13.0	12.4	12.3
TDP	11.8	—	—	—	—	13.0	12.5	13.0
DPF	11.2	—	—	—	—	12.4	12.3	12.6
Mean	—	13.4	12.1	11.9	12.3	—	—	—
LSD (0.05)	0.4	0.9		0.3		0.3	NS	NS
CV %	4	9		3		4	5	6

* CT = conventional tillage, NT = no-till, Mean =pooled over tillage.

† GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis.

Table 18. Effect of production objective pooled over tillage system on wheat grain dockage at Alfalfa (2003 and 2005), Garfield (2003 and 2004), and Kingfisher (2003 and 2005) Counties, effect of tillage system pooled over production objective on grain dockage at Alfalfa County (2004), and tillage by production interaction on grain dockage at Kingfisher County(2003).

	Alfalfa				Garfield		Kingfisher			
	2003	2004		2005	2003	2004	2003	2004		2005
	Tillage[*]									
Production objective[†]	Mean	CT	NT	Mean	Mean	Mean	Mean	CT	NT	Mean
	%									
GO	1.6	—	—	12.7	2.6	2.9	1.0	0.7	0.7	4.3
TDP	1.4	—	—	9.3	2.1	2.5	0.7	0.5	0.5	7.5
DPF	1.4	—	—	7.1	23	1.9	0.6	0.4	0.8	4.8
Mean	—	2.8	1.5	—	—	—	—	—	—	—
LSD (0.05)	NS	0.64		NS	NS	0.39	0.23	0.2		NS
CV %	29	46		72	23	25	38	28		75

[*] CT = conventional tillage, NT = no-till, Mean = pooled across tillage.

[†] GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose-forage emphasis.

Table 19. Effect of tillage system on foxtail millet plant density at Alfalfa, Garfield, and Kingfisher Counties for 2002 and 2004.

Tillage	Alfalfa		Garfield		Kingfisher		Mean	
	2002	2004	2002	2004	2002	2004	2002	2004
	plants m^{-2}							
Conventional tillage	270	263	384	105	316	42	326	137
No-till	184	410	410	132	258	42	237	195
LSD (0.05)	NS	105	NS	NS	NS	NS	49	25
CV %	41	28	36	40	26	88	36	85

Table 20. Effect of tillage system on dry weight of foxtail millet hay at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa				Garfield				Kingfisher		
Tillage	2002	2003	2004	Mean	2002	2003	2004	Mean	2002	2003	2004
	kg ha^{-1}										
Conventional tillage	3760	6010	4740	4840	9000	4330	3310	5550	2460	2060	4200
No-till	6030	5890	7150	6360	7820	3360	5010	5390	4750	1160	3630
LSD (0.05)	1330	NS	NS	1380	NS	NS	1530	NS		1360	
CV %	29	41	50	34	28	37	29	49		50	

Table 21. Effect of tillage system on foxtail millet hay crude protein at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa				Garfield			Kingfisher		
Tillage*	2002	2003	2004	Mean	2002	2003	2004	2002	2003	2004
	%									
CT	16	8	9	11	14	15	16	13	11	15
NT	15	5	9	10	16	14	11	11	10	14
LSD (0.05)	NS	2	NS	NS	2			3		
CV %	12	26	47	47	16			22		

* CT = conventional tillage, NT = no-till.

Table 22. Effect of production objective pooled over tillage system on jointed goatgrass, cheat, and rescuegrass spike densities at Alfalfa, Garfield, and Kingfisher Counties, respectively, at crop maturity each year, where no herbicide had been applied to control these species.

	Alfalfa			Garfield			Kingfisher		
Production objective*	2003	2004	2005	2003	2004	2005	2003	2004	2005
	spikes m^{-2}								
GO	1	10	4	0	0	11	1	2	1
TDP	1	2	120	4	5	30	3	9	123
DPF	1	15	10	0	0	1	3	15	102
LSD (0.05)	NS	NS	59	NS	NS	20	NS	NS	6
CV %	248	250	86	489	296	115	144	123	89

* GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis.

Table 23. Effect of production objective pooled over tillage system on jointed goatgrass spike density in 2005 at Alfalfa County and production objective by spraying interaction on rescuegrass spike density at Kingfisher County in 2005.

	Alfalfa			Kingfisher	
Production objective*	Sulfosulfuron	Check	Mean	Sulfosulfuron	Check
	no. m^{-2}				
GO	0	3	1	0	1
TDP	33	73	53	3	75
DPF	21	6	13	12	62
LSD (0.05)	— NS —		2	— 4 —	
CV %	118			125	

* GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis.

Table 24. Effect of production objective pooled over tillage system on the density of wheat spikes at harvest that appeared to be killed by dryland root rot as determined by counting number of prematurely dead and discolored spikes just prior to wheat grain harvest.

	Alfalfa		Garfield		Kingfisher		
	2004	2005	2004	2005	2004		2005
	Tillage						
Production objective*	Mean	Mean	Mean	Mean	CT	NT	Mean
	dead spikes m^{-2}						
GO	3	7	0	1	21	58	26
TDP	2	5	4	1	16	19	17
WDP	4	1	5	0	4	5	18
LSD (0.05)	NS	NS	4	NS	20		NS
CV %	166	156	153	270	115		65

* GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis.

Appendix A. Monthly rainfall totals from the nearest mesonet weather station*.

Date	Alfalfa	Garfield	Kingfisher
		cm	
April 2002	5.9	8.2	7.8
May 2002	7.8	6.8	6.3
June 2002	12.9	8.2	11.2
July 2002	13.2	9.4	4.2
August 2002	12.0	7.5	8.0
September 2002	2.9	12.0	18.4
October 2002	32.3	14.9	13.2
November 2002	0.4	0.5	0.8
December 2002	3.0	4.0	5.4
January 2003	0.3	0.4	0.0
February 2003	1.7	2.4	0.0
March 2003	7.1	4.6	6.2
April 2003	9.0	5.6	7.6
May 2003	9.2	6.5	15.2
June 2003	10.6	5.6	10.9
July 2003	1.2	0.8	1.8
August 2003	7.3	6.5	9.0
September 2003	4.0	6.2	5.8
October 2003	2.3	5.6	9.1
November 2003	1.2	1.7	1.1
December 2003	3.1	3.6	3.4
January 2004	6.6	5.6	6.8
February 2004	2.7	3.6	3.2
March 2004	8.7	19.4	18.0
April 2004	9.8	8.2	6.5
May 2004	2.8	1.5	1.3
June 2004	10.1	11.7	19.5
July 2004	8.7	8.3	4.0
August 2004	9.4	10.2	3.8
September 2004	2.2	0.9	2.1
October 2004	5.5	9.9	8.7
November 2004	12.3	9.8	11.7
December 2004	0.3	1.4	1.1
January 2005	10.6	6.5	7.1
February 2005	2.9	2.9	3.3
March 2005	1.4	1.2	0.9
April 2005	1.1	1.0	1.0
May 2005	2.3	7.7	9.2

* Data available through Oklahoma Climatological Survey, University of Oklahoma, 710 Asp Ave., Suite 8, Norman, Oklahoma 73019-0501.

Appendix B. Initial soil test results from composite samples collected in August 2002 from both conventional tillage and no-till plots*.

	Alfalfa		Garfield		Kingfisher	
	Tillage					
Test†	CT	NT	CT	NT	CT	NT
pH	5.4	6.0	6.0	5.5	4.8	4.7
Buffer Index	7.0	7.1	6.9	7.0	6.9	6.9
Nitrogen	71.0	22.0	51.0	103.0	53.0	120.0
Phosphorus	33.0	32.0	71.0	92.0	63.0	72.0
Potassium	547.0	627.0	356.0	409.0	316.0	546.0

* Soil was analyzed by Soil, Water and Forage Analytical Laboratory, Oklahoma State University, Stillwater, OK.

† N = nitrogen in kg ha^{-1}, P =phosphorous from Mehlich, K = potassium from Mehlich.

Appendix C. Soil test analysis from composite soil samples collected in August 2004from each production objective*.

		Alfalfa				Garfield				Kingfisher			
		Test†											
Production objective‡	Tillage system§	pH	N	P	K	pH	N	P	K	pH	N	P	K
GO	CT	5.6	48	40	596	5.7	44	87	372	4.9	47	57	283
	NT	5.6	38	35	666	5.7	35	81	326	4.8	27	105	356
TDP	CT	6.6	62	52	674	6.5	45	612	1820	4.7	47	92	470
	NT	5.4	52	31	512	6.3	27	37	508	5.9	36	62	332
DPF	CT	5.3	83	37	562	6.4	46	122	393	4.7	49	73	409
	NT	5.7	45	38	615	7.2	48	424	1184	5.3	69	104	517
WFH	CT	5.5	54	32	535	6.1	27	68	264	4.6	54	93	384
	NT	—	—	—	—	6.4	28	246	354	4.8	37	70	266
MF	CT	5.5	49	41	457	6.0	21	69	214	4.8	19	111	453
	NT	6.5	32	48	427	6.1	18	76	216	4.8	26	108	407

* Soil was analyzed by Soil, Water and Forage Analytical Laboratory, Oklahoma State University, Stillwater, OK.

† N = nitrogen in kg ha^{-1}, P =phosphorous from Mehlich, K = potassium from Mehlich.

‡ GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis, WFH = wheat forage plus hay, MF = maximizing forage.

§ CT = conventional tillage, NT = no-till

Appendix D. Stocker cattle information for Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa			Garfield			Kingfisher		
	2003*	2004	2005	2003	2004	2005	2003	2004	2005
Release date	22 Nov.	22 Nov.	11 Nov.	15 Dec.	5 Nov.	—	1 Dec	26 Nov.	15 Nov.
Removal date	1 March	1 March	16 March	1 March	27 Feb.	—	2 March	5 March	7 March
Stocking density	—	—	—	39	40	—	44	40	—

* Year is from the year wheat was harvested. For example 2003 is from the 2002 to 2003 growing season.

Appendix E. Three year total dry forage and wheat grain production obtained from each production objective under no-till and conventional tillage management at Alfalfa County.

	Wheat forage consumed			Wheat hay			Wheat grain			Foxtail millet hay		
	Tillage*											
Production objective†	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean
	kg ha^{-1}											
GO	—	—	—	—	—	—	9730	8970	9350	—	—	—
TDP	3760	3060	3410	—	—	—	8810	9510	9160	—	—	—
DPF	5360	4820	5090	—	—	—	8650	8860	8760	—	—	—
WHF	4650	4720	4690	26140	27280	26710	—	—	—	—	—	—
MF	4400	3560	3980	27250	25770	26510	—	—	—	14510	19070	
LSD (0.05)	NS		1050	NS		NS	NS		NS	NS		
Mean	4540	4040	—	26690	26530	—	9060	9120	—	—	—	—
LSD (0.05)	NS			NS			NS					—
CV %	26			26			10			25		

* CT = conventional tillage, NT = no-till.

† GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forge emphasis, WFH = wheat forage plus hay, MF = maximize forage.

Appendix F. Three year total dry forage and wheat grain production obtained from each production objective under no-till and conventional tillage management at Garfield County.

	Wheat forage consumed			Wheat hay			Wheat grain			Foxtail millet hay		
	Tillage[*]											
Production objective[†]	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean
	kg ha^{-1}											
GO	—	—	—	—	—	—	7780	6870	7330	—	—	—
TDP	3010	1940	2480	—	—	—	8910	7820	8360	—	—	—
DPF	5370	3920	4650	—	—	—	9070	8050	8560	—	—	—
WHF	4690	4280	4490	28080	27900	27990	—	—	—	—	—	—
MF	3660	4330	3990	25590	26900	26250	—	—	—	16640	16180	—
LSD (0.05)	NS		1590	NS		NS	NS		590	NS		
Mean	4180	3620	—	26830	27400	—	8590	7580		—	—	—
LSD (0.05)	NS			NS			480					—
CV %	50			8			11			11		

[*] CT = conventional tillage, NT = no-till.

[†] GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis, WFH = wheat forage plus hay, MF = maximize forage.

Appendix G. Three year total dry forage and wheat grain production obtained from each production objective under no-till and conventional tillage management at Kingfisher County.

	Wheat forage consumed			Wheat hay			Wheat grain			Foxtail millet hay		
	Tillage*											
Production objective†	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean
	kg ha^{-1}											
GO	—	—	—	—	—	—	7680	6880	7280	—	—	—
TDP	2740	1760	2250	—	—	—	8720	6920	7280	—	—	—
DPF	3780	3850	3810	—	—	—	7870	6430	7150	—	—	—
WHF	3360	2700	3030	20360	19680	20020	—	—	—	—	—	—
MF	2990	3590	3290	19170	19760	19470	—	—	—	8720	9490	—
LSD (0.05)	NS		1170	NS		NS	NS		NS	NS		
Mean	3220	2980		19760	19720		8090	6740		—	—	—
LSD (0.05)	NS			NS			740					—
CV %	38			8			12			17		

* CT = conventional tillage, NT = no-till.

† GO = grain only, TDP = traditional dual-purpose, DPF = dual-purpose forage emphasis, WFH = wheat forage plus hay, MF = maximize forage.

Appendix H. Effect of grazing on spring forage at Alfalfa, Garfield, and Kingfisher Counties.

	Alfalfa			Garfield			Kingfisher		
				Tillage					
Production objective	CT	NT	Mean	CT	NT	Mean	CT	NT	Mean
				% of ungrazed					
TDP	53	63	58	71	84	77	45	76	60
DPF	42	53	48	59	80	69	43	48	46
MHF	46	51	48	64	89	77	50	64	57
MF	54	52	53	84	79	82	53	50	52
LSD (0.05)		NS	NS		NS	NS		NS	NS
Mean	59	49		70	83		48	59	
LSD (0.50)		NS			11			NS	
CV (%)		52			47			58	

VITA

Deena Leigh Morley

Candidate for the Degree

Master of Science

Thesis: EFFECTS OF TILLAGE SYSTEM, GRAZING, AND SEEDING DATE ON GRAIN YIELD OF HARD RED WINTER WHEAT (*TRITICUM AESTIVUM)* AND EFFECT OF PRODUCTION OBJECTIVE AND TILLAGE SYSTEM ON FORAGE PRODUCTION

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Education: Graduated from Weatherford High School, Weatherford, Oklahoma in May 1997; attended Southwestern Oklahoma State University from August 1997 to May 1999; received Bachelor of Science degree in Plant and Soil Sciences from Oklahoma State University, Stillwater, Oklahoma in May 2002. Completed the requirements for the Master of Science degree with major in Plant and Soil Sciences at Oklahoma State University in May 2006.

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Name: Deena Leigh Morley Date of Degree: May, 2006

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECTS OF TILLAGE SYSTEM, GRAZING, AND SEEDING DATE ON GRAIN YIELD OF HARD RED WINTER WHEAT (*TRITICUM AESTIVUM)* AND EFFECT OF PRODUCTION OBJECTIVE AND TILLAGE SYSTEM ON FORAGE PRODUCTION

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Major Field: Plant and Soil Sciences

Scope and Method of Study: The effect of no-till versus conventional tillage on various wheat production objectives was studied for three years at three sites. Data were statistically analyzed using ANOVA procedures.

Findings and Conclusions: Fall wheat forage yields were affected by wheat seeding date but not by tillage system. Wheat hay forage was seldom affected by tillage system. Wheat grain yield was often less with no-till than with conventional. No-till did not decrease foxtail millet yield.

ADVISER'S APPROVAL: Thomas F. Peeper