ESSAYS ON DUAL-PURPOSE WHEAT PLANTING DATE, WHEAT PRODUCTION AND GRAZING PRACTICES IN OKLAHOMA, AND AGRICULTURAL LEASE AGREEMENTS

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CHAPTER I

PLANTING DATE INFLUENCE ON DUAL-PURPOSE WINTER WHEAT FORAGE YIELD, GRAIN YIELD AND TEST WEIGHT

INTRODUCTION

Wheat is one of the most important crops in the Southern Great Plains. Wheat may be grown for grain or forage only or for both forage and grain (Redmon et al., 1995). A 1996 Oklahoma statewide survey found that two-thirds of the wheat planted in the fall of 1995 was intended for dual-purpose (True et al., 2001). Wheat pasture is a valuable source of high-quality forage; it is high in protein, energy, and minerals, and low in fiber. It is typically available in late fall, winter and early spring, when other forage sources in the region are low in quantity and quality. In terms of crude protein and digestibility, wheat fall-winter forage is comparable to alfalfa (*Medicago sativa*). In a typical growing season in Oklahoma, winter wheat is available for grazing by livestock from late November until development of the first hollow stem, usually in early March. If livestock are removed prior to development of first hollow stem, the wheat will mature and produce a grain crop for harvest in June. Producers differentiate between wheat intended for dual-purpose and wheat intended for grain only (True et al., 2001). They plant dual-purpose wheat earlier than grain-only wheat to increase the likelihood of fall forage production.

Use of winter wheat as a dual-purpose crop is important to the agricultural economies of southwestern Kansas, eastern New Mexico, western Oklahoma, southeastern Colorado, and the Texas Panhandle (Pinchak et al., 1996; Redmon et al., 1995; Shroyer et al., 1993). Wheat grazing is also practiced in Argentina, Australia, Morocco, Pakistan, Syria, and Uruguay (Rodriguez et al., 1990). Krenzer (2000) identified three factors that facilitate dual-purpose winter wheat production in the southern Great Plains. First, biotic and abiotic conditions in the region reduce the risk of severe Hessian fly infestations. This enables early planting, which increases the forage production potential by extending the vegetative growth period. Second, winter grazing is enabled since extended snow cover is not common. Third, typical rains in April and May reduce concern about soil moisture limiting potential grain production.

Dual-purpose wheat production is a complicated process, mainly due to complex interactions of livestock production with wheat grain production and variable weather. Selection of wheat planting date is one of the most important management decisions for dual-purpose production. In general, fall-winter forage production is expected to be greater for earlier planted wheat. Historically, public wheat breeding and development programs conducted in the Southern plains have selected varieties based upon grain yield and grain quality from planting in mid-October (Carver et al., 1991; Winter and Thompson, 1990). However, in most growing seasons, fall-winter forage production from winter wheat seeded in mid-October or later will be insufficient to support fall-winter grazing. Thus, farmers who plan to produce both forage and grain may plant in an environment different from that used in the wheat breeding programs.

For a given planting date, if grazing is properly managed, fall-winter grazing is not expected to adversely affect grain yield of dual-purpose wheat (Christiansen et al., 1989; Winter et al., 1990; Worrell et al., 1992). Recommended management strategies include delaying livestock placement on the wheat until the plant roots are well anchored, ensuring adequate soil fertility, and removing livestock from the pasture no later than development of the first hollow stem stage of wheat development. Under these conditions, for a given planting date and reasonable stocking densities, fall-winter grazing is not expected to be detrimental to grain yield.

Early planting increases the total length of time that the wheat is in the field and exposed to the environment. It is associated with increased incidences of several diseases including wheat streak mosaic, High Plains mosaic, barley yellow dwarf, sharp eyespot, common root rot, and take-all root rot (Bowden, 1997). Thus, early planting increases the probability of unfavorable consequences relative to grain yield. Planting date may also influence the quality of the wheat grain. Epplin et al. (2000) estimated wheat forage and wheat grain yield response to seeding rate and planting date. However, the effect of planting date on winter wheat grain test weight has not been determined.

Wheat breeding programs, production practices, and marketing programs all recognize the importance of wheat grain quality. Test weight is used as an indicator, or proxy, for overall grain quality and soundness by domestic flour millers (Leath, 1995). Export markets also consider and use test weight as one measure of wheat grain quality. Test weight affects the productivity, efficiency, and operating costs of flour milling.

Wheat grain with high test weight will usually contain kernels that reduce milling costs and increase flour yields and flour purity relative to wheat grain with low test weight (Parcell and Stiegert, 1998). As a result, lots with low test weights are discounted.

Farmers receive a lower net price for wheat grain marketed with a low test weight. A 1996 Oklahoma statewide survey found that test weight is one of the top three characteristics farmers consider (along with grain yield and forage yield) when selecting a dual-purpose variety (True et al., 2001). No prior studies have determined the impact of planting date on test weight of dual-purpose winter wheat grain.

The overall objective of the research reported in this paper is to determine the economic optimal planting date for dual-purpose winter wheat production. The specific objectives are to determine wheat fall-winter forage yield, wheat grain yield, and wheat test weight response to planting date for dual-purpose winter wheat production. Economic optimal planting dates are determined for several sets of grain and forage prices, with appropriate grain price adjustments for test weight.

MATERIALS AND METHODS

Data

Data for this study were obtained from planting date field trials conducted over nine winter wheat (*Triticum aestivum* L.) production seasons, from 1991-1992 through 1999-2000, on the North Central Research Station near Lahoma, Oklahoma. The soil type was a Pond Creek silt loam (fine-silty, mixed, superactive, thermic Pachic Argiustolls). Planting date treatments ranged from late August to mid November in a randomized complete block design. Table I-1 includes the planting dates for each of the nine years. Plot size was 8-15 cm rows by 6.7 m. Each treatment was replicated four times.

For the first three years of the study (1991-92, 1992-93, and 1993-94), seeding rate was a treatment variable. However, beginning in 1994-95, the seeding rate was fixed at 134 kg ha^{-1} across all plots. Epplin et al. (2000) used data from the first six years of the study to estimate optimal seeding rates for dual-purpose winter wheat production in the region. They also used data from the first six years of the study to estimate optimal planting dates. However, they did not consider wheat test weight response to planting date. For the current study, only those observations from each of the nine years that had a seeding rate of 134 kg ha^{-1} were used.

To simulate grazing, the plots were mechanically clipped. The clipped forage from each plot was dried and forage yield computed and reported as kg ha^{-1} oven dry forage. The first clipping was conducted in the late fall. The second clipping was conducted prior to first hollow stem in late winter after emergence from dormancy. Hence, the estimate of dry matter forage yield was based upon the sum of the two clippings. The plants were permitted to mature and produce grain. Foliar fungicide (Tilt®) was applied to all plots at the labeled rate at growth stage eight to reduce the confounding of planting date and foliar disease susceptibility. Grain yield was obtained with a small plot combine harvesting the center 5.3 m of each plot. A subsample of the combine harvested grain was cleaned and test weight was determined. All plots were fertilized to ensure that soil fertility would not be the yield-limiting factor.

Response Functions

Response functions for wheat fall-winter forage yield, wheat grain yield, and wheat test weight were estimated. Plots of observed fall-winter forage yield, grain yield, and test weight values for each planting date for each year are charted in Figures I-1, I-2, and I-3 respectively. A squared term was included in the regression equations to allow for a nonlinear relationship between planting date and dependent variable.

The MIXED procedure in SAS that enables inclusion of fixed factors and random factors was used to estimate quadratic response functions (SAS Institute, 1999). Given the mixed model nature of the study, this procedure facilitates computation of efficient estimates of treatment effects and valid standard errors of the estimates. The principles of maximum likelihood and generalized least squares are applied by the MIXED procedure (Littell et al., 1998). Model parameters can be estimated by restricted maximum likelihood (REML), whose major advantage is its applicability to unbalanced data (Piepho, 1999). The data set is unbalanced in that the number of planting dates and the number of plots differed across years. The mixed model is:

(1) $y = X\beta + Zu + e$

Where y is a vector of observations, β is a vector of unknown treatment-effects parameters to be estimated, X is a known design matrix for the treatment effects that includes three columns including a column of ones, a column with planting date entered as a continuous number (for example, January 1 = 1 and December 31 = 365) and a column with planting date squared. The vector u is a vector of unobservable random effects. Z is a known design matrix for the random effects that includes 45 columns, one for each of the nine years and one for each of the four blocks within each of the nine years. The vector e is a vector of residual random errors. Both u and e are assumed normally distributed with mean 0 and variance G and R, respectively. So, y is normally distributed with mean, $E(y) = X\beta$ and variance, $V(y) = V(Zu + e) = ZGZ' + R$. The R matrix is equal to $\sigma^2 I$ (I denotes the identity matrix), under the assumption of homoskedasticity.

For this study, year is modeled as a random effect, because the nine years represent a random sample of years from the potential population of all years. In other words, the level or characteristics of a year (for example 1992, 1994) cannot be replicated exactly. This differs from a treatment variable such as planting date that can be replicated. Since the treatment variable, planting date, can be replicated, it is modeled as a fixed effect.

In the randomized complete block design, within a given year, treatments (planting dates) were randomly assigned within the blocks. These blocks were randomly selected from a population of blocks on which the wheat could have been planted. Therefore, the blocks within each year are also modeled as a random effect. The G matrix has the standard diagonal variance components structure (VC option in the RANDOM statement of PROC MIXED), which assigns a distinct variance component to each random effect (SAS Institute, 1999). Littell et al. (1996) and Piepho (1999) provide a detailed discussion of the statistical methods employed by the MIXED procedure in SAS.

The regression equation to be estimated for the forage yield is:

(2) $$F = \alpha_0 + \alpha_1 PD + \alpha_2 PD^2$$

Where F is forage yield (kg ha^{-1}); α_i are fixed effects coefficients to be estimated; PD is planting date (the day of the year, for example, September 9 = 252). The variance of forage yield is:

(3) $\quad V(F) = \sigma^2_{yr} + \sigma^2_{bl} + \sigma^2_e$

Where σ^2_{yr} and σ^2_{bl} are variance components associated with year and blocks within year, respectively, and σ^2_e is variance for residual random errors.

Based on the Harvey test, the null hypothesis of homoskedasticity (equal variances) was rejected at the five percent level for the forage yield model. Initially the multiplicative or log-linear variance model, described by Harvey, was used to correct for heteroskedasticity (Greene, 1997; Littell et al., 1996). But convergence problems occurred due to demanding computations, which are common in mixed model analysis (Piepho, 1999; Sorensen and Kennedy, 1986). So, a weighted two-stage method, which has a lower computational burden, was used. Heteroskedasticity was corrected with a weighting based on reciprocals of the square root of the estimated error variances (Kennedy, 1992; Piepho, 1999). Error variances were modeled using planting date and squared planting date as the explanatory variables.

The equations for grain yield and test weight response to planting date have the same form and independent variables as the forage yield response:

(4) $\quad G = \beta_0 + \beta_1 PD + \beta_2 PD^2$

(5) $\quad T = \gamma_0 + \gamma_1 PD + \gamma_2 PD^2$

Where G is grain yield (kg ha^{-1}); T is test weight of the wheat (kg cu m^{-1}); β and γ are fixed effects coefficients to be estimated associated with G and T, respectively; and other symbols are as previously defined.

The Harvey test also rejected the null hypothesis of homoskedasticity at the five percent level for both the grain yield and the test weight models. For these two equations, the multiplicative or log-linear variance model, described by Harvey, was used to correct for heteroskedasticity (Greene, 1997; Littell et al., 1996).

Optimal Planting Date

Economic optimal planting date depends on the price of wheat forage, the price of wheat grain, the test weight price adjustment, and cost differences across planting dates. It was assumed that tillage, seeding, and grain harvest costs are constant across planting dates. Some custom harvesters adjust charges based upon grain yield. However, Kletke and Doye (2000) reported that the majority of observations in their custom rate survey reported a flat rate charge per acre for harvesting wheat.

Fertilizer was applied sufficiently to all plots in the field experiment so that nutrient deficiencies were not a yield-limiting factor. However, it is assumed that nitrogen requirements and nitrogen removal depend upon forage and grain yield. For the purpose of economic analysis, it is assumed that one kg of wheat forage will remove 0.03 kg of nitrogen and one kg of wheat grain will remove 0.0333 kg of nitrogen (Krenzer, 1994). The adjustment for nitrogen cost may be accomplished by subtracting the cost of 0.03 kg of nitrogen from the price of a kg of forage, and the cost of 0.0333 kg of nitrogen from the price of a kg of grain.

The wheat grain price was also adjusted to reflect the cost of the quantity of phosphorus removed in grain. Hard red winter wheat contains approximately 0.43% P (National Research Council, 1984). The price of wheat grain was adjusted by subtracting the cost of 0.0043 kg of P from the price of a kg of wheat grain. However, an adjustment was not made to the price of forage for phosphorus. A very small quantity of phosphorus is removed by grazing livestock. The grazing animal would return almost all of the phosphorus consumed to the soil in the urine and feces. The same argument could be made for nitrogen in the forage. However, nitrogen in the urine and feces is much more likely to be lost as a result of volatilization and leaching. A second reason for assessing a charge for the nitrogen used to produce the forage is that producers apply more nitrogen to wheat intended for dual-purpose use than they do for wheat intended for grain only (True et al., 2001). Hence, the price of wheat grain is adjusted to reflect the cost of nitrogen and phosphorus and the price of wheat forage is adjusted to reflect the price of nitrogen. All production costs other than that of nitrogen and phosphorus are assumed constant across planting dates.

The net returns function for the dual-purpose wheat enterprise is:

(6) $$\pi(PD) = P_f F(PD) + [P_g - D(T(PD))]\ G(PD)$$

Where: π = net returns per hectare; P_f = nitrogen cost adjusted price of wheat forage; P_g = nitrogen and phosphorus cost adjusted price of wheat grain and D is the adjustment that depends upon the test weight function, T; F is the forage yield function; and G is the grain yield function. The choice variable is planting date (PD). All three functions, F, G and T, have random error term variables. Therefore, F, G and T are also random variables.

Assuming that the dual-purpose winter wheat producers' objective is to maximize expected net returns, the optimization problem can be stated as

(7) $\max E(\pi(PD)) = \max \{P_f E(F(PD)) + E[(P_g - D(T(PD)))\ G(PD)]\}$

Where $E(\cdot)$ is the expectations operator. The test weight adjustment schedule determined by market forces is assumed to be independent of grain yield. By definition, the expected value of the product of two independent random variables is equal to the product of the two expected values of those variables. Equation (7) becomes

(8) $\max E(\pi(PD)) = \max \{P_f E(F(PD)) + P_g E(G(PD)) - E[D(T(PD))] E(G(PD))\}$

Assuming that the random error terms of the functions are normally distributed with mean zero, the expected values of *F, G* and *T* were approximated by the estimated *F, G* and *T* functions, respectively. Approximation of the expected value of *D* requires special attention. By definition,

(9) $$E[D(T(PD))] = \sum_{i=1}^{n} D_i \text{Prob}\left(T_i \leq T(PD) < T_{i+1}\right)$$

Where Prob(·) is the probability operator, D_i is the discount associated with the relevant test weight range, T_i is the lower limit of that test weight range and T_{i+1} is the lower limit of the next range. Using the assumption that $T \sim N(E(T), \sigma^2_T)$, the normal cumulative distribution function available in EXCEL was used to approximate the expected value of *D*.

RESULTS AND DISCUSSION

As shown in Figure I-1, fall-winter forage production is negligible for wheat seeded in the region after the first week of October. Therefore, only observations from plots planted before October 8 were used to estimate the forage yield response function.

The estimated regression equations for the forage yield, grain yield, and test weight response functions are reported in Table I-2. All estimated parameters are significantly different from zero at the five percent level. Charts of the estimated forage yield, grain yield, and test weight response to planting date functions are included in Figure I-4. The charts show the magnitude of forage yield, grain yield, and test weight response to planting date. A 20-day change in planting date from September 10 to 30, results in an 18% increase in expected grain yield and a 68% decrease in expected forage yield, but only a 0.5% increase in expected test weight.

Producers whose sole objective is to maximize forage production would be expected to plant early. The earliest planting date used in the trials was August 24. The expected fall-winter forage yield from an August 24 planting date is 3,277 kg ha^{-1}. Based upon the estimated wheat grain yield response function, the maximum wheat grain yield of 3,196 kg ha^{-1} is expected to result from planting on October 8. However, if planting is delayed until October 8, the expected forage yield declines to 246 kg ha^{-1}. The expected grain yield from an August 24 planting date is only 1,879 kg ha^{-1}. Producers who wait until October 8 give up an expected 3,031 kg ha^{-1} of fall-winter forage but gain an expected 1,317 kg ha^{-1} of wheat grain.

For the economic analysis, base price estimates for standing wheat forage, wheat grain, nitrogen, and phosphorus were required as well as test weight wheat grain price adjustment factors. The average wheat grain price in Oklahoma over the 1991-2000 period was \$0.12 kg^{-1} (National Agricultural Statistics Service, 2001a). The lowest was \$0.08 in 1999 and the highest was \$0.17 in 1996. The economic analysis was conducted for six levels of wheat grain prices, \$0.095, \$0.110, \$0.128, \$0.147, \$0.165, and \$0.184

kg^{-1}. An estimate of the variance of test weight, T, was needed to approximate the expected value of the test weight discount, D. The procedure used to estimate the test weight regression equation parameters also provided the following estimate of the variance of T,

(10) $\sigma^2_T = 86.8 + (714.8 \times e^{(-0.1512 \times PD)})$

Where e is the base of the natural logarithm (approximately 2.718). Wheat grain test weight adjustment schedules were obtained from two companies that purchase wheat grain from farmers in the region (Dunn, 1998; Peavey Company, 2000).

Prices for standing fall-winter wheat forage are not routinely reported. However, some wheat producers lease their pasture to livestock owners and, in informal surveys over the time period of the field trials, farmers reported a range on lease rates of \$0.55 to \$0.88 kg^{-1} of beef gain for winter wheat pasture (Doye et al., 2001). In these lease arrangements, payments from livestock owners to wheat producers are based upon net live weight gain attributable to the wheat pasture. These lease arrangements are made based upon cattle price expectations and are typically not changed if the price of cattle increases or decreases beyond the expected levels.

The quantity of winter wheat forage required per kg of beef gain has not been precisely determined. Based upon the National Research Council (1984) net energy equations used to estimate livestock requirements and based upon nutrient analysis of wheat forage, an average of seven kg of forage would be required per kg of gain for a 200 kg steer gaining 0.9 kg per day for 115 days. Seven kg would be the minimum possible allowance, assuming 100% harvest efficiency, and no allowance for nonconsumptive loss (Krenzer et al., 1996). Allowing for nonconsumptive loss, it is assumed that a kg of beef gain is expected to require 10 kg (dry matter) of standing wheat forage. By this measure, over the time period of the study, the value of standing fall-winter forage was approximately \$0.055 to \$0.088 kg^{-1} dry matter. For the present study, given the lack of precision relative to forage prices, the economic analysis was conducted for five levels of forage prices, \$0.055, \$0.061, \$0.066, \$0.073, and \$0.077 kg^{-1} dry matter.

For the analysis, two nitrogen prices were used. A price of \$0.31 kg^{-1} N was used to represent a low price situation and a price of \$0.61 kg^{-1} N was used to represent a high price situation. For all situations analyzed, the price of phosphorus was held constant at \$0.56 kg^{-1} P_2O_5 (National Agricultural Statistics Service, 2001b). The SOLVER option in EXCEL was used to solve the optimization problem to determine the optimal planting date.

Table I-3 includes the estimated planting dates that result in maximum net returns for 30 different combinations of wheat forage and wheat grain prices with a nitrogen price of \$0.31 kg^{-1}. When the price of wheat forage is high (\$0.077 kg^{-1}) and the price of wheat grain is low (\$0.095 kg^{-1}) the optimal planting date is late August. Alternatively, when the price of wheat forage is low (\$0.055 kg^{-1}) relative to the price of wheat grain (\$0.184 kg^{-1}) the optimal planting date is September 27. Based upon the estimated functions, fertilizer prices, and test weight discount schedules, when the price of forage is \$0.066 kg^{-1} and the price of wheat grain \$0.128 kg^{-1}, the optimal planting date is September 6.

Table I-4 includes the estimated optimal planting dates for a nitrogen price of \$0.61 kg^{-1} rather than \$0.31 kg^{-1}. The results in Table I-4 may be compared with those reported in Table I-3 to determine the consequences of a change in the nitrogen price on the optimal planting date for the alternative wheat forage and wheat grain prices. In all cases, the optimal planting date is later with the higher nitrogen price. In general, the magnitude of the difference depends upon the price of grain. For example, if the price of wheat grain is \$0.128 kg^{-1}, the optimal planting date is delayed approximately five days if the price of nitrogen increases from \$0.31 to \$0.61 kg^{-1}. However, if the price of wheat grain is \$0.184 kg^{-1}, the optimal planting date is delayed by approximately two days for the same change in nitrogen price.

As reported in Table I-2, planting date has a statistically significant effect on wheat grain test weight. However, as shown in Figure I-4, the magnitude of the expected change in test weight across planting dates is relatively small. To determine if inclusion of test weight adjustments in the optimization procedure matters, optimal planting dates were determined under the assumption that the test weight adjustment schedules would not be considered. This was accomplished by optimizing the net returns function (equation 8) without the test weight discount schedule (*E[D(T(PD))]*).

Table I-5 includes the optimal planting dates for the same combinations of wheat grain, wheat forage, nitrogen, and phosphorus prices as used to determine the dates reported in Table I-3, but under the assumption that none of the wheat grain prices were adjusted for differences in test weight. For a wheat grain price of \$0.095 kg^{-1}, and a wheat forage price of \$0.055 kg^{-1}, the optimal planting date is August 24 if the test weight adjustment is included, but August 28 when the test weight adjustment is ignored. Based upon the estimated response function, the early-planted wheat has a lower expected test weight. Inclusion of the test weight adjustment decreases the price of wheat grain relative to the price of wheat forage. Forage becomes relatively more valuable and planting four days earlier is expected to increase production of the relatively more valuable forage. However, as the price of wheat grain increases, for example to \$0.184 kg^{-1}, the optimal planting date occurs in late September, and inclusion of the test weight adjustment in the optimization model does not change the optimal date. As shown in Tables 3 and 5, the optimal planting dates are the same across all forage prices when the wheat grain price is \$0.184 kg^{-1}. It can be concluded that the optimal planting date is relatively insensitive to the test weight discount schedules when grain prices are relatively high.

Table I-6 includes estimates of the expected cost to the producer of planting on a nonoptimal date for the two nitrogen prices with a wheat grain price of \$0.128 kg^{-1}, wheat forage price of \$0.066 kg^{-1}, and a P_20_5 price of \$0.56 kg^{-1}. For these prices and a nitrogen price of \$0.31 kg^{-1}, the optimal planting date is estimated to be September 6. Planting one week earlier or one week later than the optimal date is expected to decrease expected net returns by less than \$2.00 ha^{-1}. However, if planting is delayed by three weeks to September 27, the expected net returns are decreased by \$13.44 ha^{-1}. Similarly, if the price of nitrogen is \$0.61 kg^{-1}, the optimal planting date is estimated to be September 11. The decline in net returns from planting one week earlier or one week later is relatively small. However, if planting is delayed by three weeks the expected net returns are decreased by \$13.64 ha^{-1}.

SUMMARY AND CONCLUSIONS

Dual-purpose (forage plus grain) winter wheat is an important crop for producers in the southern Great Plains and many other parts of the world. Planting date is an important decision variable for dual-purpose winter wheat. Hence, this study was undertaken to determine the economic optimal planting date for dual-purpose winter wheat production. The specific objectives were to determine wheat fall-winter forage yield, wheat grain yield, and wheat test weight response to planting date for dual-purpose winter wheat production. Economic optimal planting dates were determined for several sets of grain and forage prices, with appropriate grain price adjustments for test weight. Optimal planting dates were also determined under the assumption of no test weight adjustments to the wheat grain price. Finally, the economic consequences of planting on a nonoptimal date were determined.

Based on the estimated response functions, a 20-day delay in planting date from September 10 to 30, results in an 18% increase in expected grain yield and a 68% decrease in expected forage yield, but only a 0.5% increase in expected test weight. Producers whose sole objective is to maximize forage production would be expected to plant early. The expected fall-winter forage yield from the earliest planting date used in the field trials, August 24, is 3,277 kg ha^{-1}. However, the expected grain yield from an August 24 planting date is only 1,879 kg ha^{-1}. Based upon the estimated wheat grain yield response function, the maximum wheat grain yield of 3,196 kg ha^{-1} is expected to result from planting on October 8. However, if planting is delayed until October 8, the expected forage yield declines to 246 kg ha^{-1}. As the planting date changes from August 24 to October 8, the expected fall-winter forage yield declines by 3,031 kg ha^{-1}, but the expected wheat grain yield increases by 1,317 kg ha^{-1}.

The estimated economic optimal planting date for dual-purpose winter wheat ranged from August 24 to September 29 depending upon the relative prices of wheat forage and wheat grain. When the price of fall-winter wheat forage is high relative to the price of wheat grain, it is optimal to plant early. Alternatively, when the price of wheat grain is high relative to the value of standing wheat forage, it is economically optimal to plant later. However, planting one week earlier or one week later than the optimal date is expected to decrease expected net returns by less than \$2.00 ha^{-1}. Finally, it was also determined that the optimal planting date is relatively insensitive to wheat price test weight adjustments when wheat grain prices are relatively high.

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Table I-1. Wheat planting dates and number of observations per year.

Variable	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Planting date 1	28 Aug	4 Sep	27 Aug	24 Aug	11 Sep	30 Aug	28 Aug	15 Sep	10 Sep
Planting date 2	9 Sep	18 Sep	10 Sep	7 Sep	29 Sep	13 Sep	11 Sep	29 Sep	23 Sep
Planting date 3	27 Sep	1 Oct	24 Sep	21 Sep	13 Oct	2 Oct	29 Sep	13 Oct	7 Oct
Planting date 4	7 Oct	15 Oct	7 Oct	5 Oct	27 Oct	11 Oct	10 Oct	27 Oct	21 Oct
Planting date 5						31 Oct	22 Oct	16 Nov	4 Nov
Number of Observations	16	16	16	96	64	160	120	240	120

Table I-2 Estimates of winter wheat forage yield (kg ha^{-1}), wheat grain yield (kg ha^{-1}), and wheat grain test weight (kg cu m^{-1}) response to planting date.

Variable	Forage Yield	Grain Yield	Test Weight
Intercept	63,774** (8,308)	-47,802** (2,327)	213.37* (95.70)
Planting Date (PD)	-413.20** (64.15)	361.21** (16.33)	3.7259** (0.6793)
Planting Date Squared (PD^2)	0.6664** (0.1235)	-0.6396** (0.0289)	-0.0067** (0.0012)
Log likelihood function	-3,598	-2,879	-1,579
Observations	484	848	848

** Significant at the 0.01 probability level.
* Significant at the 0.05 probability level.
Numbers in parentheses are standard errors. Planting date is modeled as a day of the year continuous number (for example, January 1=1 and December 31 = 365).

Table I-3 Optimal planting dates for dual-purpose (forage and grain) winter wheat for different wheat forage and grain prices and nitrogen price of \$0.31 kg^{-1} and P_2O_5 price of \$0.56 kg^{-1}.

Forage Price (\$ kg^{-1})	**Grain Price (\$ kg^{-1})**					
	0.095	**0.110**	**0.128**	**0.147**	**0.165**	**0.184**
0.055	24 Aug	9 Sep	17 Sep	22 Sep	25 Sep	27 Sep
0.061	†	31 Aug	12 Sep	18 Sep	22 Sep	25 Sep
0.066	†	†	6 Sep	15 Sep	19 Sep	23 Sep
0.073	†	†	27 Aug	9 Sep	16 Sep	20 Sep
0.077	†	†	†	4 Sep	13 Sep	17 Sep

† Predicted planting date is earlier than the earliest date of 24 Aug used in the field trials.

Table I-4 Optimal planting dates for dual-purpose (forage and grain) winter wheat for different wheat forage and grain prices and a nitrogen price of \$0.61 kg^{-1} and P_2O_5 price of \$0.56 kg^{-1}.

Forage Price (\$ kg^{-1})	**Grain Price (\$ kg^{-1})**					
	0.095	**0.110**	**0.128**	**0.147**	**0.165**	**0.184**
0.055	2 Sep	14 Sep	21 Sep	25 Sep	27 Sep	29 Sep
0.061	†	6 Sep	17 Sep	22 Sep	25 Sep	27 Sep
0.066	†	26 Aug	11 Sep	18 Sep	22 Sep	25 Sep
0.073	†	†	2 Sep	13 Sep	19 Sep	22 Sep
0.077	†	†	25 Aug	9 Sep	16 Sep	20 Sep

† Predicted planting date is earlier than the earliest date of 24 Aug used in the field trials.

Table I-5 Optimal planting dates without the test weight discount schedule for dual-purpose (forage and grain) winter wheat for different wheat forage and grain prices and nitrogen price of \$0.31 kg-1 and P_2O_5 price of \$0.56 kg-1.

Forage Price ($ kg^{-1})	Grain Price ($ kg^{-1})					
	0.095	**0.110**	**0.128**	**0.147**	**0.165**	**0.184**
0.055	28 Aug	10 Sep	18 Sep	22 Sep	25 Sep	27 Sep
0.061	†	2 Sep	13 Sep	19 Sep	22 Sep	25 Sep
0.066	†	†	7 Sep	15 Sep	20 Sep	23 Sep
0.073	†	†	30 Aug	10 Sep	16 Sep	20 Sep
0.077	†	†	†	5 Sep	13 Sep	18 Sep

† Predicted planting date is earlier than the earliest date of 24 Aug used in the field trials.

Table I-6 Expected cost of nonoptimal planting dates, for two nitrogen prices with wheat grain price of $0.128 kg^{-1}, wheat forage price of $0.066 kg^{-1}, and P_2O_5 price of $0.56 kg^{-1}.

Planting date	**Expected cost of nonoptimal date ($ ha^-1)**	**Planting date**	**Expected cost of nonoptimal date ($ ha^-1)**
Nitrogen price of $0.31 kg^-1		**Nitrogen price of $0.61 kg^-1**	
23 Aug	6.77†	28 Aug	6.70
30 Aug	1.88	4 Sep	1.83
6 Sep	-	11 Sep	-
13 Sep	1.26	18 Sep	1.33
20 Sep	5.73	25 Sep	5.86
27 Sep	13.44	2 Oct	13.64

† The optimal planting date given the expected prices is September 6. The expected net returns from planting at the nonoptimal date of August 23 is $6.77 ha^-1 less than the expected net returns from planting on the optimal date.

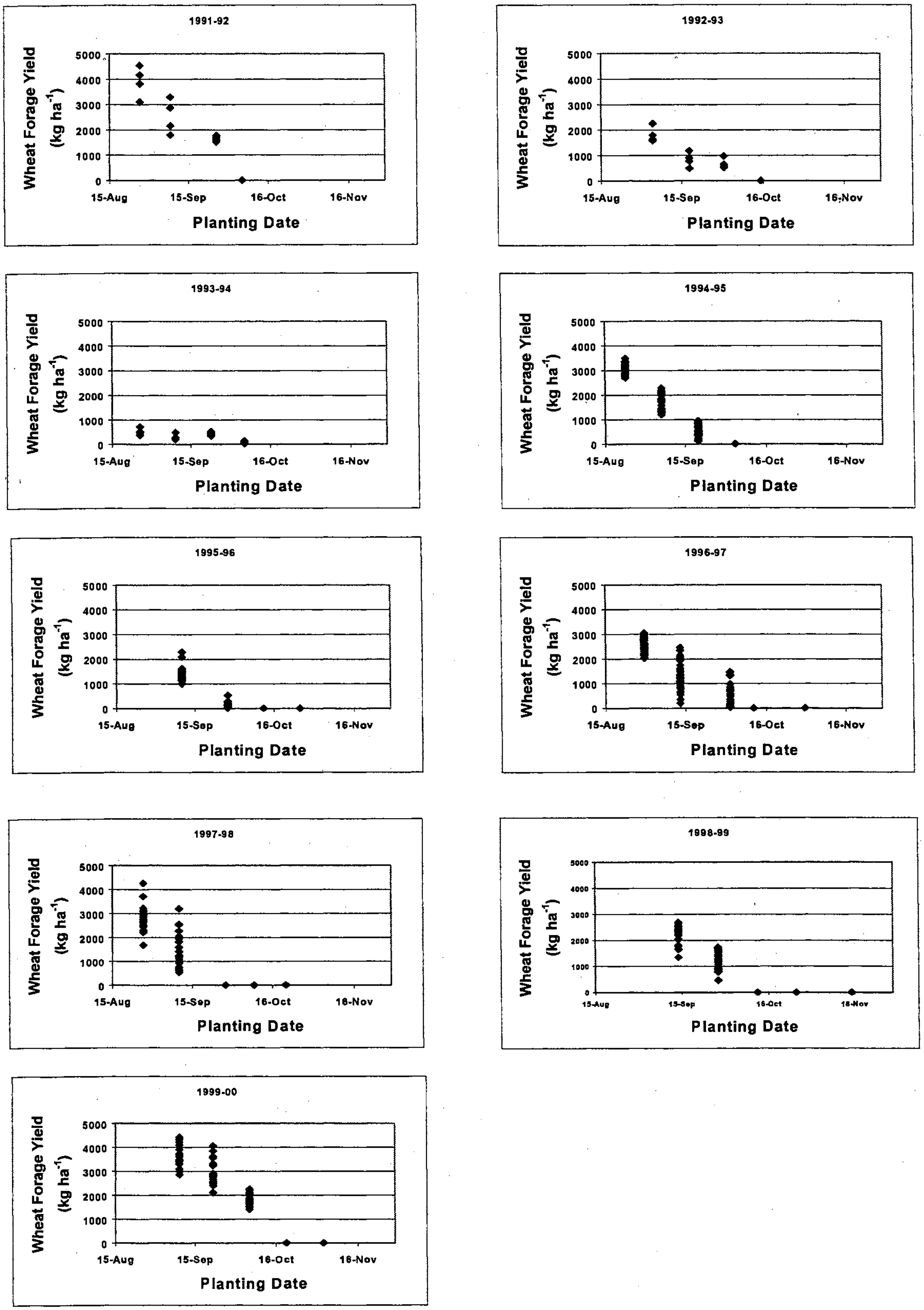

Figure I-1 Observed winter wheat forage yield response to alternative planting dates, Lahoma, Oklahoma from 1991-92 through 1999-2000.

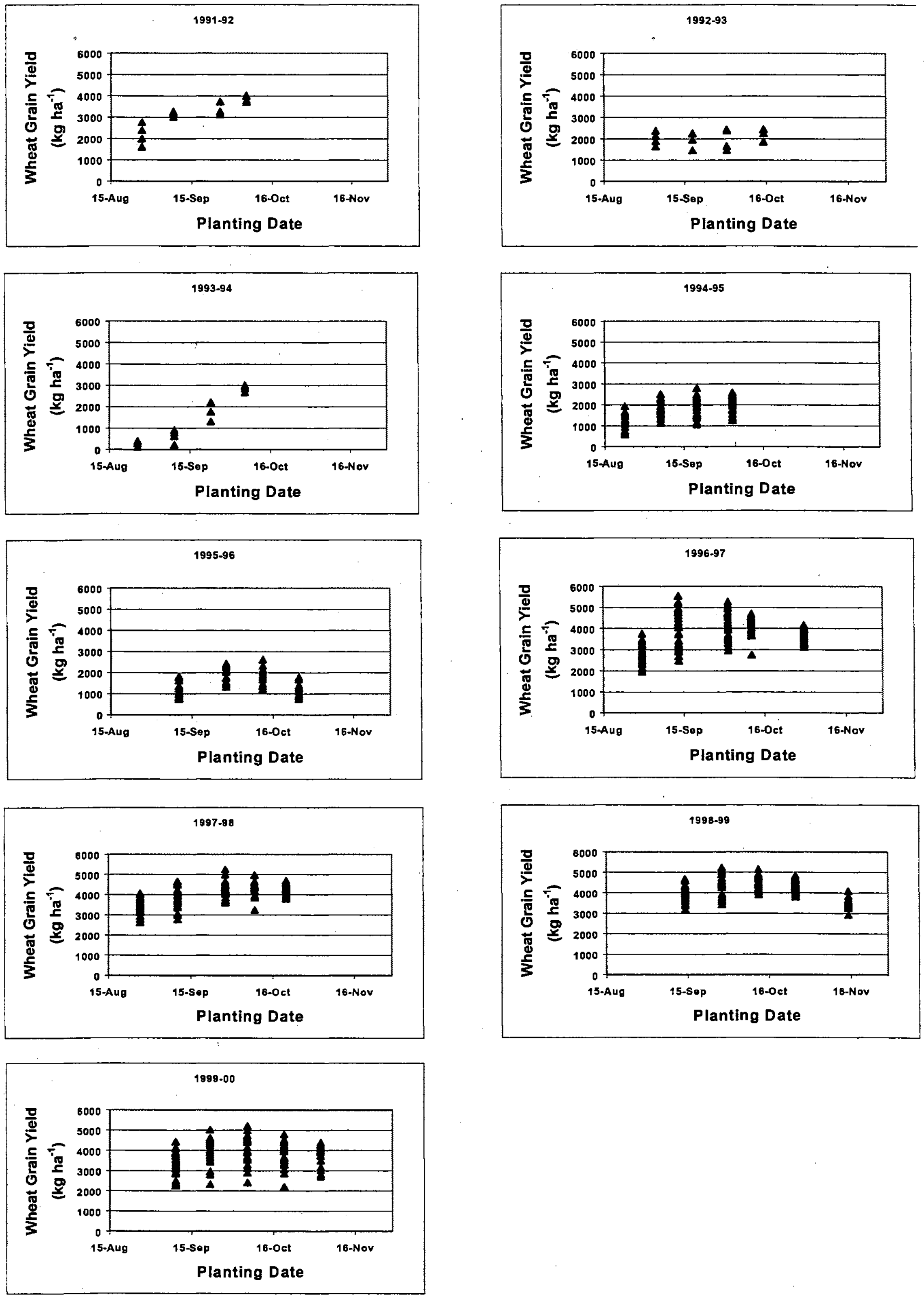

Figure I-2 Observed winter wheat grain yield response to alternative planting dates, Lahoma, Oklahoma from 1991-92 through 1999-2000.

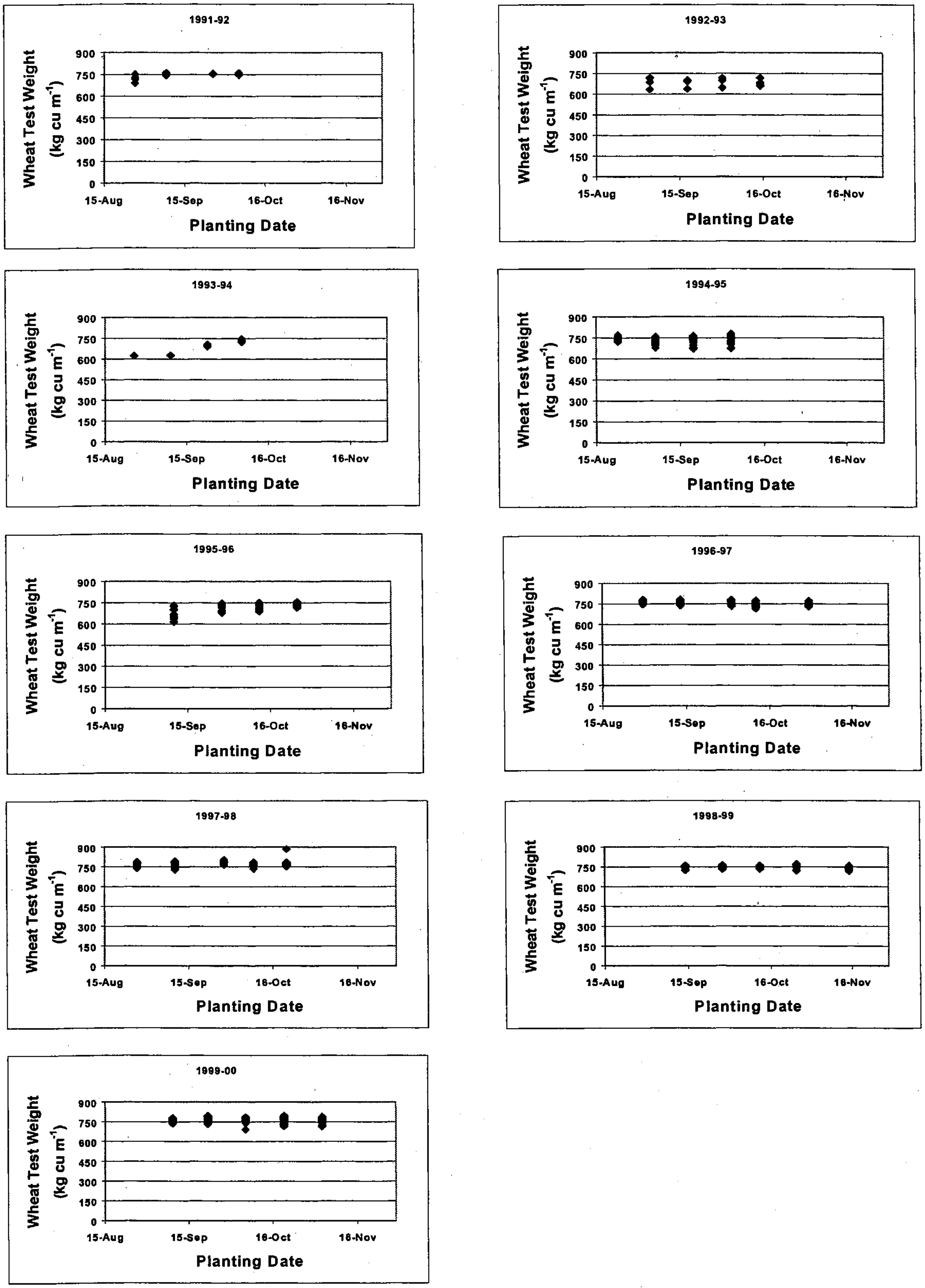

Figure I-3 Observed winter wheat grain test weight response to alternative planting dates, Lahoma, Oklahoma from 1991-92 to 1999-2000.

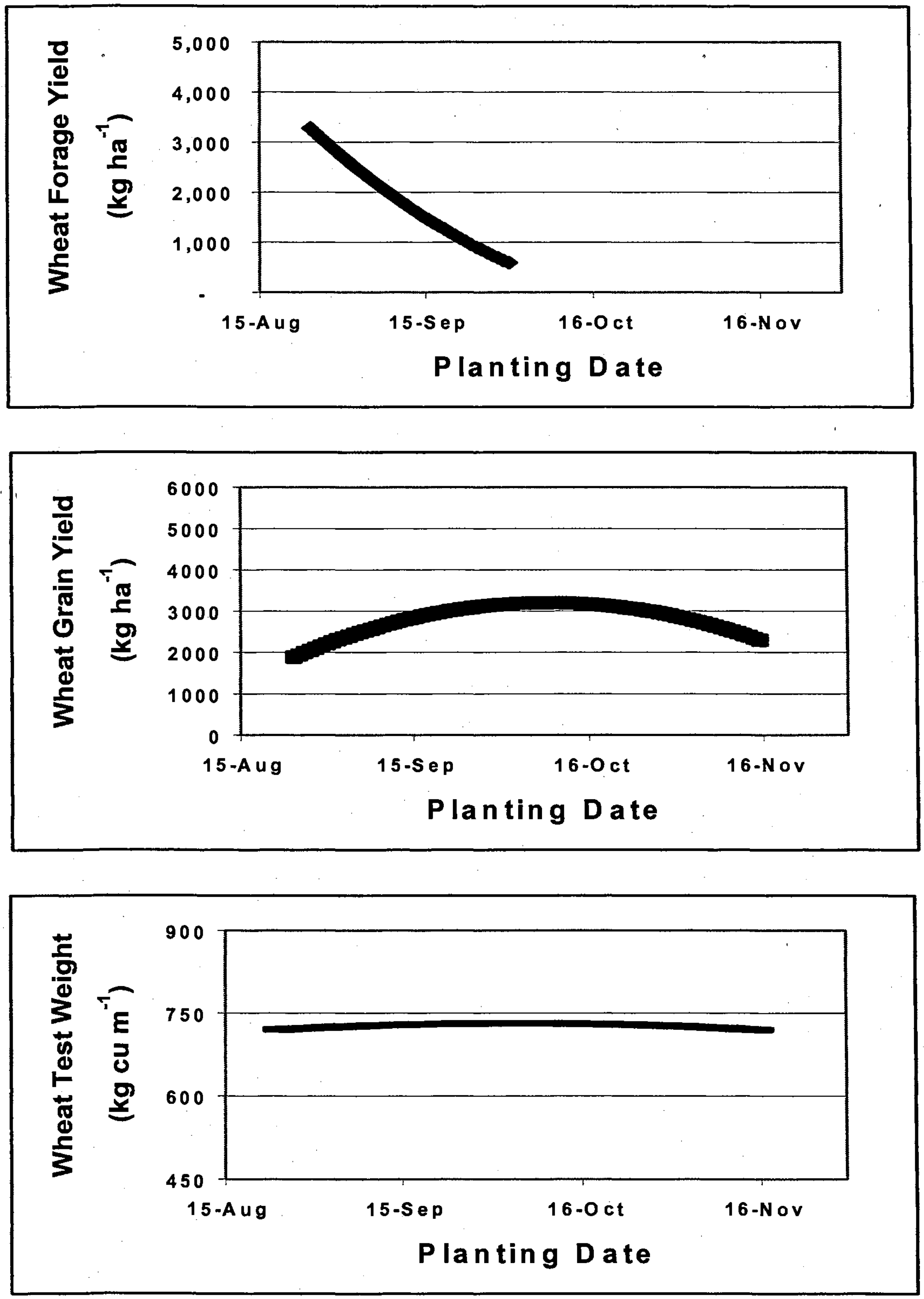

Figure I-4 Predicted dual-purpose winter wheat forage yield, grain yield, and test weight generated from data of field trials conducted at Lahoma, Oklahoma from 1991-92 through 1999-2000.

CHAPTER II

WHEAT PRODUCTION AND GRAZING IN OKLAHOMA: A SURVEY OF PRODUCTION PRACTICES, LIVESTOCK MANAGEMENT, AND LEASE ARRANGEMENTS

INTRODUCTION

Wheat can be grown in almost all areas of Oklahoma. According to the 1997 census of agriculture, approximately 56% of the harvested cropland in Oklahoma was for wheat. All wheat grown in Oklahoma is winter wheat. Oklahoma is ranked second in winter wheat production in the U.S (Oklahoma Agricultural Statistics Service, 2001a). The Southern Great Plains region has a unique niche enabling the production of winter wheat for three purposes, grain or forage-only or for a dual-purpose forage and grain crop (Krenzer, 1994).

In a dual-purpose system, the wheat is available for grazing by livestock from late November until development of the first hollow stem, usually in early March. If the livestock are removed no later than the development of first hollow stem, the wheat will mature and produce a grain crop for harvest in June. Krenzer (2000a) identified some reasons enabling the dual use of wheat in Oklahoma and other surrounding states in the Southern Great Plains. They are: 1) biotic and abiotic conditions reduce the risk of severe Hessian fly infestations. This gives the producers the option to plant much earlier, which increases the forage production by extending the vegetative growth period. 2) Having little snow makes it possible for livestock to graze during the winter. 3) Adequate rainfall in April and May reduces concern about soil moisture limiting potential grain production. It is estimated that approximately 30 to 80% of the wheat acres in the Southern Great Plains are used for grazing and 10 to 20% are used for forage-only and grazed out (Pinchak et al., 1996). When the price of the wheat grain is relatively low, forage-only and dual-purpose options may even constitute more areas of total wheat acreage. Precise estimates of the areas allocated to these two options are not available.

Wheat pasture is a valuable source of high-quality forage; it is high in protein, energy, and minerals, and low in fiber. It is typically available in late fall, winter and early spring, when other forage sources are low in quantity and quality. In many cases, forage production and length of grazing period may become crucial to many producers to remain solvent.

Oklahoma is one of the top five states in the U.S. in terms of number of cattle and calves, and number of cattle operations (Oklahoma Agricultural Statistics Service, 2001a). Many lightweight calves are brought in from the Southeast, Midwest, and West to graze on wheat pasture in the Southern Plains (Brorsen et al., 1994). After wintering on wheat pasture, these calves are fed to slaughter weight in Southern Plains feedlots. Hence, the use of winter wheat as a forage-only and dual-purpose crop is important in the agricultural economies of southwestern Kansas, eastern New Mexico, western Oklahoma, southeastern Colorado, and the Texas Panhandle (Epplin et al., 2000; Pinchak et al., 1996; Redmon et al., 1995; Shroyer et al., 1993).

The practice of wheat grazing is also common in Argentina, Australia, Morocco, Pakistan, Syria, and Uruguay (Rodriguez et al., 1990). However, the United States Department of Agriculture (USDA) does not make the differentiation in wheat use in collecting and reporting of data. They provide the annual estimates of the wheat acres planted and harvested for grain (National Agricultural Statistics Service, 2003). There are no data available from the USDA on the proportion of wheat acres used for each of the three purposes. Estimates of the number and class of animals stocked on wheat pasture in Oklahoma are also not provided by the USDA.

Some of the important production practices and management decisions regarding wheat production vary depending on the intended use. For example, the recommended planting date for wheat that is intended for forage production is two to six weeks before the recommended planting date for grain-only production. The recommended seeding rate is also greater for forage-only wheat (Krenzer, 2000b). Variety selection, fertility program, weeds and disease control systems are also important economic factors that differ across intended use of wheat. However, little information on actual production practices is available.

Dual-purpose wheat production is a complicated process, mainly due to complex interactions of livestock production with wheat grain production and weather variability. Comprehensive evaluation of the economics of alternative production and management strategies and full exploitation of this unique option require information on effects and interactions between planting dates, wheat varieties, soil fertility, stocking densities, grazing termination dates, types and levels of supplementation, and climatic variables (Redmon et al., 1995).

Several research projects have been carried out to address specific segments of the overall management and production system. For example, Christiansen et al. (1989) concluded that when, (1) grazing is not too heavy, (2) trampling losses are avoided, (3) abundance of fall growth might lead to impeded re-growth in spring, and (4) weather conditions do not put extra stress on crops, grazing of winter wheat can be advantageous without loss of grain yield. Historically, public wheat breeding programs in the Southern plains have selected varieties based upon grain yields and grain quality and have not developed varieties for dual-purpose use (Carver et al., 1991; Winter and Thomson, 1990). Other studies have focused on grazing initiation and termination (Krenzer, 1994; Winter and Thomson, 1990). Winter wheat stocker cattle research has concentrated on issues such as bloat, supplementation, and stocking density (True et al., 2001). Little effort has been extended to develop comprehensive strategies to maximize returns to the dual-purpose wheat enterprise.

Surveys were conducted by Harwell et al. (1976) and Walker et al. (1988) on selected groups of dual-purpose wheat producers. These farmers provided information on wheat grazing practices. However, neither of these surveys was random. They were not drawn from a representative sample of wheat producers. Hence, the data could not be used to conduct hypothesis tests regarding differences in production practices across intended use. A 1995-96 survey of Oklahoma wheat producers was also conducted by True et al. (2001). They recommended an additional survey to cross check and confirm the results of that study.

OBJECTIVES

The overall objective of this study is to provide information about the production and management practices, with special emphasis on pasturing of wheat, on Oklahoma wheat farms. The specific objectives are:

1. Determine the proportion of wheat grown for each of the three purposes, grain-only, forage-only and dual-purpose, and determine whether the production practices differ across the intended use.
2. Identify the producers' actual livestock management practices on wheat pasture.
3. Identify the lease arrangements for wheat pasture grazing.
4. Determine whether there are any changes in major practices in comparison to the similar 1996 survey of Oklahoma wheat producers (True et al., 2001).

The information obtained in this survey will aid the public in monitoring the actual wheat management and production practices used in Oklahoma. It will also help research and extension workers to provide adequate research regarding the pasturing of wheat and focus their efforts on the important practices that deviate substantially from recommendations.

ANALYTICAL FRAMEWORK

The primary tool of this study was a survey of Oklahoma wheat producers conducted in the year 2000.

Choice of Survey Method

The self-administered questionnaires method was used to carry out the survey. A four-page questionnaire was mailed to each of the selected producers. The length of the questionnaire and the budget played the major role in determining the use of this method over the alternative methods such as the personal interview and telephone interview methods.

The questionnaire required detailed information about wheat and livestock production practices. This required time and effort from the respondents. The location of the respondents throughout the state would have made it very expensive to conduct personal interviews. Personal interviews also may require that some remuneration be paid to the interviewers. Telephone interviews also would have been associated with high expenses of long distance charges. Use of a mail questionnaire was deemed the least expensive method to obtain the desired information. Mail questionnaires also have the advantage of least interviewer bias, as there is no direct contact between the interviewer and the respondents.

However, there are some disadvantages with the selected method. Mail surveys tend to be prone to greater non-response rates than interviews. They are also somewhat affected by bias due to poor wording and miscommunication of the questions, since there is no researcher present to explain the questions. Sometimes, difficulty in reading the respondent's answers to the questions creates errors in coding. However, after weighing the trade-off between advantages and disadvantages, the method of self-administered questions was selected.

Questionnaire Design

A panel of experts and faculty members from the Oklahoma State University Departments of Animal Science, Plant and Soil Sciences, and Agricultural Economics designed the survey questions. Agricultural statisticians of the Oklahoma Agricultural

Statistics Service (OASS) cooperated in making the final edit of the questionnaire form (Appendices). The questions were designed to determine wheat production practices and livestock management practices on wheat pasture. Some questions (e.g. income related) developed in the first stage, were eliminated from the final form as it was agreed that many respondents would not be willing to answer those.

The beginning questions were used among other things to identify whether the respondent was a valid member of the survey population. For example, question number five was used to determine if the respondent was a wheat producer for the growing season of 1999-2000. Question number one was used to identify the respondent's region. Special attention was given to place simple questions early and more detailed and complicated questions later in the questionnaire. The question types used in the questionnaire were: open-ended, ranking, multiple choice, and combination of those. To minimize item non-response, few open-ended questions were used.

Due to budget constraints and limited time, pre-testing was limited to administering the questionnaire to three agricultural economics graduate students at Oklahoma State University, who were from Oklahoma and had similar farming experience. This helped to determine whether the real respondents would be able to perceive and answer the questions correctly. Minor adjustments were made to the final questionnaire based on their responses and the previous experience with the same kind of surveys. It is possible that this pre-testing might have been somewhat biased, because of the difference in the level of education and familiarity of the terminologies and theories used in the questionnaire between the students and the actual producers.

The Frame

Oklahoma Agricultural Statistics Service (OASS) maintains a database that includes all the wheat farms of Oklahoma. As a frame, the current survey used the latest database that is mainly based on the 1997 census of agriculture. OASS also periodically updates the database using information gathered from other wheat related surveys conducted by them after the 1997 census. However, it was not expected that the database had been perfect in including all relevant wheat farms of Oklahoma. A frame should have every element of the survey population exactly once. Nevertheless, almost every frame faces some problems in fulfilling those requirements. Warde (1990) mentioned four major common problems encountered in the use of a frame. They were: missing elements, foreign elements, duplicates, and clusters. Each of these problems and their corrective measures are discussed in the context of this study.

Missing elements

These are the elements, which are part of the survey population, but do not appear in the frame. It is possible that some of the wheat farms did not participate in the 1997 agricultural census and other wheat surveys. Hence, they would be missing in the OASS database. However, it is expected that the missing elements from this category were not significant, as the census participation rate is usually very high. Therefore, no corrective measure was taken in this case.

Another possible group of missing elements could come from the fact that some farms might have started wheat farming after the 1997 census, which were also not included in subsequent surveys. No action was taken to account for these potential elements. If it was possible to collect these elements with the help of the local extension workers or by some other means, the database could have been updated and eradicated of this frame problem.

Foreign elements

The elements that are not part of the survey population, but included in the frame, are called the foreign elements. The frame was mainly based on the 1997 census and the study was done in 2000. Because of this time difference, it was expected to have some foreign elements in the frame. If it was possible to identify those elements before sending out the surveys, then the frame could have been updated by eliminating the identified elements. However, it was difficult to do so in this study until after the questionnaires were administered. Question five of the survey instrument was used as a screening tool to determine whether the element was part of the survey population or not. An answer of zero to question five meant that the element did not produce wheat in the 1999-2000 season. Some of the questionnaires were returned from respondents with a note that they were not producing wheat at the time. All those elements were discarded from the analysis. The possibility that some of the producers in the frame might have been deceased was taken into account in choosing the sample size.

Duplicates

Duplicates are those elements, which are included more than once in the frame. It was expected that there would be very few duplicate elements. Address change, mistakes in spelling the names of the producers might have resulted in having them listed more than once. However, due to the expectation of having very small numbers of duplicates compared with the size of the frame, this problem was ignored. When identified, they should be included in the frame exactly once to avoid double counting.

Clusters

The problem of clusters occur when more than one element is grouped together under one appearance in the frame. Due to the nature of the frame, it was expected to be cluster free.

Sampling Method

A stratified sampling plan was used for the survey. The state was divided into six regions (Figure II-1) to account for the variability of practices due to weather and soil in different parts of Oklahoma. It was expected that the variability would be minimum within each region. Five of these regions corresponded with the five Oklahoma crop reporting districts – Panhandle, West Central, Southwest, North Central, and Central. The sixth region included the four remaining crop-reporting districts – South Central, Northeast, East Central, and Southeast. The OASS database was divided into six strata corresponding to the six regions as specified.

The equal allocation method was used. From OASS experience, it was decided to attempt to obtain at least 100 responses from each of the stratum to carry out meaningful analysis. Keeping that in mind, previous OASS experience with response rate and the budget constraint allowed us to select approximately 800 farms from each of the stratum. Systematic random sampling within each stratum was used for the selection of those elements. Altogether, OASS selected a representative sample of 4,815 Oklahoma wheat producers from the database.

Mailing

Consistent with federal policy, access to the OASS database was restricted to OASS statisticians. Hence, OASS selected the sample of wheat producers, and addressed and mailed the survey questionnaires. The questionnaire was mailed on March 9, 2000. OSU provided pre-addressed metered business reply envelopes, which were enclosed with the questionnaires. OSU agricultural economics department's address was used on the reply envelopes. The business reply envelopes were used to save time and money.

An introductory statement was included at the top of each questionnaire, explaining the purpose of the study and assuring the respondents of the confidentiality of the provided information. The OSU agricultural economist in-charge and the OASS statistician signed the statement. The questionnaire was printed on the OSU Department of Agricultural Economics letterhead. OASS mailed reminder postcards on March 15, 2000 as a follow-up mechanism. A copy of the reminder postcards is included in the Appendix.

Response Rate Analysis

A total of 1,204 survey questionnaires of the 4,815 mailed were returned by the end of September 2000. Thus, the response rate was 25%. However, 114 responses were discarded due to various reasons. Data from the remaining 1,090 were analyzed. More than half of the 114 were discarded because of blank county names. Privacy laws prevented personal identification on the returned questionnaires, so it was not possible to contact these respondents to determine their location within the state. Some of the discarded surveys did not provide consistent and reliable information. Others were identified as foreign elements (not producing wheat in 1999-2000). More than 160 usable responses were received from each of the six regions (Table II-4). The 1,090 respondents reported that they had planted 460,997 acres of wheat in the fall of 1999. This was approximately 8% of the total Oklahoma acres of 6.1 million planted for all wheat purposes in the 1999-2000 crop year.

The response data were entered into an ACCESS database. The responses were then summarized into tables. Multiple mean comparison procedures were used to conduct hypothesis tests regarding relevant production practice differences across intended use within each region. Some results were compared with those obtained from the 1996 survey of Oklahoma wheat producers (True et al., 2001).

WEATHER

Weather plays an important role in wheat production. Adequate soil moisture is needed for soil preparation and planting. However, heavy rainfall is also not helpful as fields become too wet to plant. Good growing conditions are essential for success in the dual-purpose wheat production enterprise. Among the factors that may minimize effects of grazing winter wheat during fall, winter, and spring on grain yield are adequate soil moisture at planting and subsequent precipitation during the growing season (Redmon et al., 1995). Precipitation in August, September, and October largely determines the germination and fall growth of wheat (Christiansen et al., 1989). On the other hand, severe winter weather can prove harmful for both forage and grain production.

Rainfall varies from region to region in Oklahoma. Average precipitation decreases as one moves from Southeast to Northwest in Oklahoma (Tables II-1 and II-2). Historically, average precipitation in South Central & East is about double that of the Panhandle region.

The state average annual precipitation was 37.88 inches in 1999, 1.33 inches greater than the mean of 1971-2000 (Table II-1). Though the first half of the year was wetter than normal, the second half was drier. The statewide average annual temperature was 61.4 degrees Fahrenheit, 1.3 degrees above the mean of 1971-2000 (Table II-3). The second half of the year was also warmer than normal.

Table II-1 also includes the 1999 average precipitation by region by month (July-December) in Oklahoma. Every region, especially the Southwest, Central, Northeast, East Central and Southeast regions, had significantly lower than normal precipitation in July and August of 1999. As a result of rainfall during the second week of September, the situation improved statewide except in the West Central, Southwest and Southeast regions, thus helping wheat planting. In October, the dry weather was again widespread except in the Panhandle and Southwest regions. Exceptionally dry and warm weather was present throughout the state in November. It was followed by mild weather in December, when on average almost all regions had higher than normal precipitation. However, lack of precipitation in the later parts of December resulted in dwindling soil moisture supplies.

The statewide average annual temperature was 60.4 degrees in 2000, close to the normal (Table II-3). Though the statewide average annual precipitation was above normal in 2000, the year began rather dry (Table II-2). Overall, mild temperatures and good spring rainfall helped wheat growth and development. The year included one of the wettest months of March on record (Oklahoma Climatological Survey, 2001). Excellent growing weather in March and April helped to improve wheat conditions all over the state. Almost the entire wheat crop had jointed by the end of April. Despite the abnormally wet conditions in June, wheat grain harvest was completed earlier than normal (Oklahoma Agricultural Statistics Service, 2001b).

RESULTS AND DISCUSSION

Introductory Findings

Farming operation

The survey found that statewide respondents owned half (50%) and leased the other half of the total acreage included in their farming operations (Table II-5). Based upon the question, farming operation was defined to include cropland, pastureland, woodland, CRP, and other land. The largest farms were in the Panhandle region and smallest ones were in the South Central & East region. On average, producers owned 651 acres and leased 835 acres. Though total acres reported in the survey were divided equally into owned and leased, there were fewer number of respondents who had leased compared with those who had owned acres in their farming operation. Therefore, the average size leased was greater than the average size owned.

Membership in organizations

Respondents were asked if they had membership in the Oklahoma Wheat Growers Association (OWGA), the Oklahoma Grain and Stocker Producers (OGSP), and/or the Oklahoma Cattlemen's Association (OCA). Most of the respondents (66%) in the state indicated that they were not member of any of the three associations (Table II-6). Statewide, the membership percentages were 11% in OWGA only, 0% in OGSP only, 14% in OCA only, 0% in both OWGA and OGSP, 7% in both OWGA and OCA, 0% in both OGSP and OCA only, and 1% in all three. The proportion of the members' wheat acreage with respect to the total planted wheat acres were also calculated and included in Table II-6. For example, members of OCA only planted 17% of the total planted wheat acreage, whereas members of the OWGA only planted 11% of the total wheat acreage.

In a related table, the respondents were divided into three categories: grain-only, forage-only, and forage and grain (Table II-7). The grain-only category included producers who planted wheat intended only for grain, forage-only included producers who planted wheat intended only for grazing, and the forage and grain category included producers who intended to use their wheat to produce both fall-winter forage and grain. As expected, in the grain-only category, more producers (18%) were members of OWGA-only and few (6%) were OCA-only members. In the same manner, 17% of the producers in the forage-only category were members of OCA-only, and only 3% were members of OWGA-only. In the forage and grain category, 12% were OWGA-only members, 16% were OCA-only members, and 9% were members of both OWGA and OCA.

Other crops with wheat

Producers sometimes plant other species, such as rye or ryegrass, with wheat. This may be done in an attempt to produce more forage or to increase the length of the grazing season. When mixed with wheat, rye can improve early fall grazing and annual ryegrass can extend the spring graze-out period. However, both rye and ryegrass can become serious weed problems for future wheat crops in the same field. Producers who follow this practice are encouraged to destroy the rye and ryegrass after grazing to eliminate seed production.

When asked whether they had planted any other species with the wheat, 13% of the respondents in the state answered in the positive (Table II-8). This ranged from 3% in Panhandle to 31% in South Central & East region. About 4% of the state's planted wheat acreage included a species in addition to wheat. The combination percentage was greatest in South Central & East region (16%) and least in North Central region (1%).

Soil test

Good nutrient management is essential for maintaining fertile and productive soils, and minimizing pollution of ground and surface water with nutrients. Soil testing is recommended to identify nutrient deficiencies and is the most reliable guide to develop an efficient fertilization strategy (Krenzer, 1994). It is also good for the environment, as it helps to minimize the residual fertilizer. Nitrogen, phosphorus, and potassium are the nutrients of concern for most of the wheat producers in Oklahoma. The availability of these nutrients is greatly affected by soil pH. It is recommended to analyze soil at least every three years to check the levels of pH, phosphorus, and potassium (Johnson et al., 2000). Of the respondents in the state as a whole, 60% reported that they test soil at least once every three years (Table II-9). However, 37% responded that they seldom or never have their soil tested. The percentage of respondents in the Panhandle region who seldom or never have their soil tested was about 48%. The percentages in other regions were similar to the state percentages.

Definition of "first hollow stem"

The first hollow stem growth stage or the earliest stage of jointing is very important in dual-purpose wheat production. This is the stage when the stems begin to elongate or hollow stem is forming just above the roots (Krenzer, 1994). Research has shown that grazing wheat beyond the first hollow stem growth stage substantially decreases grain yield, but grazing before that stage would have little or no effect on subsequent grain yield (Harwell et al., 1976; Redmon et al., 1995; Winter and Thompson, 1987).

A question was asked to determine how familiar the producers were with the term "first hollow stem" in reference to wheat growth stages. The choices were: joint or node above the soil surface; developing head is at or above the soil surface; hollow stem can first be identified above the roots; and not familiar. The respondents were categorized into three groups: grain-only, forage-only, and dual-purpose. Under the grain-only category, those producers who intended to use all of their acreage for the purpose of grain-only were included. They did not intend to plant for any other purposes. Similarly, producers who reported no use other than forage were included in the forage-only category. Producers who had at least some proportion of their acreage for dual-purpose were included in the dual-purpose category. Producers in the dual-purpose category were most important with respect to this question. They are most likely to benefit from the ability to identify the "first hollow stem" growth stage, so that they may terminate wheat grazing at the appropriate time.

According to the survey responses, only 36% of the statewide respondents in the dual-purpose category identified the correct answer that "first hollow stem is the growth stage when hollow stem can first be identified above the roots" (Table II-10). However, even fewer producers, 24% in the grain-only and 21% in the forage-only categories identified the correct answer. In the dual-purpose category, the most correct responses (44%) were received from the North Central region and least (27%) were received from the Panhandle region.

Wheat variety selection

The selection of wheat varieties to plant is an important management decision. There are no perfect varieties. Each variety has its strengths and weaknesses. Yield potential, disease and insect resistance, grain quality, grazing potential, acid tolerance, and maturity vary across available varieties. Producers need to prioritize their needs based upon their individual production goals, environmental conditions, location of the farms, and expected field problems, and select varieties accordingly. Some possible characteristics in choosing wheat varieties were listed in the survey. Respondents were asked to rank the top three characteristics in order of importance that they used when determining the varieties they planted.

Grain yield and forage yield were by far the two most important characteristics producers in every region looked for in selecting varieties (Table II-11). Statewide, grain yield received 44% of the number one (most important) counts, 22% of the number two counts, and 8% of the number three counts. The percentages for the forage yield were 38%, 19%, and 8%, respectively. In the Central and South Central & East regions, forage yield was more important than grain yield. Grain yield and forage yield were also cited by the producers as the principal factors in the 1996 survey (True et al., 2001) and in the 1988 survey (Walker et al., 1988) of Oklahoma wheat pasture use systems.

Krenzer et al. (1996) showed that varieties used in the Southern Great Plains for dual-purpose wheat production should be evaluated based upon both forage and grain yields. They expressed forage and grain production in terms of dollars of income to choose the economically efficient varieties. Other important characteristics identified by the producers in this survey were past success, test weight and drought tolerance. Winter hardiness was also noted as an important characteristic in both the Panhandle and South Central & East regions.

In a related question, producers were asked to rank the sources of information as to their importance when selecting which variety of wheat to plant. Producers rely on various sources for their information, since it is impossible for them to individually test all varieties on their farm. As in the previous 1996 survey (True et al., 2001), past performance on their farm was also identified in this survey as the most popular source in all the regions (Table II-12). Statewide, 51% of the producers checked that as the number one source. Extension test plot results (18% checked as #1) and results of neighboring fields (11% as #1) were also popular sources of information. Among the others, seed availability was considered important, especially in the Central and South Central & East regions.

Wheat Acreage for Different Purposes

As stated before, wheat is used in the Southern Great Plains for three purposes: grain-only, forage-only, and dual-purpose (forage and grain). Grain-only wheat is grown only to produce wheat grain. Forage-only wheat is grown only to produce forage and is not harvested for grain. Dual-purpose wheat is grown to produce both fall-winter forage and wheat grain. Typically, dual-purpose wheat may be grazed from the time the plants become well anchored in the soil in the fall until first hollow stem in late winter. At or prior to first hollow stem, grazing is terminated and the plants are permitted to mature and produce grain for harvest in June. A study by Epplin et al., (2001) showed that for the twenty wheat production seasons from 1980 to 1999, grain-only wheat generated more net returns to land, labor, and machinery fixed costs, overhead, risk, and management in four seasons and dual-purpose wheat generated more net returns in 16 seasons.

Intended use

Statewide, the response to the question, "How many of your 1999-2000 wheat acres were planted for each purpose", was 31% for grain-only, 20% for forage-only, and 49% for dual-purpose (Table II-13). The North Central (46%) and Panhandle (45%) regions had the greatest percentages intended for grain-only. The West Central (16%) and Central (16%) regions had the least percentages intended for grain-only. The greatest percentage (49%) of acreage intended for forage-only was in the South Central and East region, typically the region with greatest rainfall. The region with the least amount of rainfall, Panhandle, had one of the least percentages (10%) of acreage intended for forage-only. In the West Central region, 61% of the acreage was intended for dual-purpose use.

In the 1996 survey, only 9% of the wheat acreage was intended for forage-only compared with 20% in this survey (Table II-15). This major change was very likely a response to changes included in the 1996 Federal Agriculture Improvement and Reform (FAIR) Act. At the time of the 1996 survey, farmers were operating under a federal policy that often required wheat grain harvest on a large proportion of the acres planted to maintain wheat program base acres. Since federal payments were tied to wheat program base acres, producers were very reluctant to engage in practices that may have jeopardized wheat program base acres. However, under the 1996 act, producers were given greater flexibility. They were permitted to use wheat base acres to produce forage and still collect federal payments based upon their historical wheat base acres and wheat base grain yield. In addition, use of the land to produce forage did not jeopardize their wheat base acres. Another contributing factor to the relative decrease in acres intended for wheat grain in the 1999-2000 survey was that the 1999 average market year price of $2.24 per bushel of wheat was the lowest in decades (National Agricultural Statistics Service, 2003).

Actual use

The responses of a related question, "How many acres of your 1999-2000 wheat crop will actually be used for each purpose", were summarized in Table II-14. Actual usage may differ from intended use for various reasons, especially due to weather circumstances. Since both grain yield and forage yield are affected by planting dates (Epplin et al., 2000), wheat should be planted at the appropriate time for the desirable intention. When the weather is not favorable for planting during the intended planting date window, producers may be forced to change planting date and actual use of wheat may differ from original intended use. Sometimes unfavorable weather, such as drought, severe cold or rain, after the planting or during the production season may force the producers to abandon their original intention.

Statewide, 39% was used for grain-only, 22% for forage-only, and 39% for dual-purpose. The percentage (22%) of wheat acreage actually used for forage-only changed very little from the original intention (20%). The main differences were in grain-only and dual-purpose. Producers reported that they had intended to use 31% for grain-only and 49% for dual-purpose, but ended up actually using 39% for grain-only and 39% for dual-purpose. The major differences between the intention and actual usage were in the West Central, Panhandle, and Southwest regions. One of the reasons might be that the September precipitation levels in the western regions were worse than other regions in the state. This probably delayed many of the wheat plantings intended for dual-purpose, and some of the producers ended up using those acreages for grain-only.

Diversification

Diversification is one of the strategies producers may use to manage production risks and reduce income variability. Wheat producers can diversify by getting involved in a combination of activities on their wheat acreage. The majority (61%) of the respondents reported that they intended to grow wheat for more than one purpose (Table II-16). However, 39% of the producers intended to use all of their wheat acreage for just one purpose, 19% for grain-only and 20% for forage-only. Dual-purpose is considered to be a multiple activity and 27% indicated dual-purpose only. Other potential combinations were forage-only and dual-purpose (12%); grain-only and dual-purpose (8%); grain-only, forage-only, and dual-purpose (7%), and grain-only and forage-only (6%). The West Central region had the greatest percentage (76%) and South Central & East region had the least percentage (26%) of producers who intended to grow wheat for more than one purpose.

Production Practices across Intended Use of Wheat Acreage

After producers have determined the intended use of their wheat acreage, important decisions on seeding rate, planting date, and fertilization are made. To manage wheat production successfully, producers must make wise choices regarding those decisions. Intended use of the wheat is one of the main factors that influences the choices made (Epplin et al., 2000; Krenzer, 2000b; Shroyer et al., 1993). An attempt was made to determine how wheat producers vary their production practices according to the intended use.

Multiple pairwise comparisons of the means associated with each of the three purposes within each region were conducted using the Tukey method, also known as the Honestly Significant Difference. This method provides the best protection against decision errors, and gives strong inference about the direction and magnitude of the difference (Kuehl, 2000; SAS Institute, 1999a). The state averages of selected responses in this survey were also compared with state averages obtained in the 1996 survey (True et al., 2001) to the same or a very similar question to determine if the respective averages were statistically different from each other. For example, in the case of seeding rate, the grain-only averages of the two surveys were compared, the forage-only averages of the two surveys were compared, and the dual-purpose averages of the two surveys were compared. Assuming that the surveys were independent of each other, the data were normally distributed in each group, and the variances of the respective two groups were equal, it is appropriate to use the *t* test to compare the two surveys (SAS Institute, 1999b; Wackerly et al., 1996). All mean comparison tests were done at the 5% level of significance using SAS.

Seeding rate

Statewide, the respondents reported the greatest seeding rate of 94 lb/acre for wheat intended for forage-only (Table II-17). The seeding rate for wheat intended for grain-only was 77 lb/acre and the seeding rate for wheat intended for dual-purpose was 84 lb/acre. These rates are consistent with the recommendations in the sense that a greater seeding rate is recommended for wheat that is intended for grazing relative to wheat intended for grain-only. However, the reported forage-only and dual-purpose rates were lower than rates recommended by state extension specialists (Krenzer, 2000c; Shroyer et al., 1993).

The Tukey test revealed that the forage-only average seeding rate was significantly greater than the seeding rates of both grain-only and dual-purpose. And, the seeding rate for dual-purpose production was significantly greater than that for grain-only. When comparing between the state averages in the two surveys (Table II-21), the *t* test showed that the grain-only seeding rate average of 72 lb/acre in 1996 survey was significantly different than the grain-only average of 77 lb/acre in this survey. Similarly, the forage-only average of 90 lb/acre in 1996 survey was significantly different than the 94 lb/acre reported in this survey, and the dual-purpose average of 79 lb/acre in 1996 survey was also significantly different than the 84 lb/acre reported in this survey. Based upon these findings the average seeding rate increased by 4-5 pounds per acre from the fall of 1995 to the fall of 1999 across all three intended uses.

Table II-17 also includes the reported average seeding rates across intended use by region. The least averages occurred in the Panhandle region, and the greatest averages occurred in the South Central & East region. This was similar to the situation found in the 1996 survey. Producers in the greater rainfall areas were using greater seeding rates probably with the expectation of getting more benefits that would result from the potential increasing yields because of greater moisture level. Forage-only seeding rate averages were always the greatest among the three averages within each region. Grain-only averages were significantly lower than the respective forage-only averages in all the regions. Grain-only averages were also significantly lower than the respective dual-purpose averages in all regions except the Central region. However, the difference between the forage-only and dual-purpose averages was significant only in the Panhandle and Central regions.

Planting date

Late planted wheat limits the fall grazing potential. A study by Epplin et al. (2000) found relatively large differences in expected fall-winter forage yield and expected grain yield across planting date. It was found that as planting date is delayed more and more in September, expected wheat forage yield decreases and expected grain yield increases. Producers should optimally plant two to six weeks earlier than the ideal planting date for grain-only wheat if the intended use is forage-only. When asked to report the target and actual fall 1999 wheat planting dates, the respondents often recorded a range of dates for each category. In those cases, the middle date of the range was used for the analysis. The reported average target planting dates showed that producers consistently planted forage-only wheat earliest, then dual-purpose wheat, followed by grain-only wheat (Table II-18).

The state average wheat target planting dates were significantly different across intended use (Table II-18). The average target planting date of October 2 for grain-only was significantly later than both forage-only and dual-purpose averages. The average dual-purpose target planting date of September 20 was significantly later than the average forage-only target planting date of September 13. These averages were found to be significantly different than the respective 1995-96 grain-only average of September 27, forage-only average of September 10 and dual-purpose average of September 17 (Table II-21). Average grain-only target planting date was significantly later than forage-only and dual-purpose averages in all regions. The difference between forage-only and dual-purpose averages was significant only in the West Central, North Central and Central regions.

The average responses to the question of actual planting date (Table II-19) were later than the average target planting dates. Lack of favorable weather is probably one of the main reasons producers often fail to plant during their preferred target planting date window. Various cropping practice considerations may be another reason (Witt, 1996). Respondents on average planted in the second week of October for the wheat intended for grain-only, in the fourth week of September for the wheat intended for forage-only, and in late September or early October for dual-purpose wheat. Statewide, average grain-only actual planting was significantly later than both forage-only and dual-purpose averages, and average dual-purpose actual planting date was significantly later than the forage-only average. The 1996 actual planting date state averages were October 7 for grain-only, September 23 for forage-only and October 1 for dual-purpose. The *t* test showed that only the grain-only average was significantly different from the grain-only average in this survey (Table II-21). Within each region, in comparison to those of target planting dates there are fewer significant differences between the average actual planting dates. The latest average actual planting date (October 16) was for grain-only wheat in the Southwest region, and the earliest one (September 21) was for forage-only wheat in the South Central & East region.

Nitrogen rate

The fertility of the soil plays a major role in wheat production. The most limiting nutrient associated with wheat forage production is usually nitrogen (Shroyer et al., 1993). Available nitrogen changes in the soil mainly as a result of the amount of nitrogen removed in forage and/or grain harvest relative to the amount added. Nitrogen requirements can be calculated based on expected yields. Let us assume that expected grain yield is 35 bushels per acre in the grain-only enterprise, expected forage yield is 5,000 pounds of dry forage per acre in the forage-only enterprise, and 2,000 pounds of forage and 30 bushels of grain per acre in the dual-purpose enterprise. Assuming that 1,000 pounds of dry forage requires 30 pounds of nitrogen and each bushel of grain requires two pounds of nitrogen (Krenzer, 1994), the recommended nitrogen applications per acre will be approximately 70 pounds, 150 pounds, and 120 pounds for grain-only, forage-only, and dual-purpose, wheat enterprises, respectively. These quantities are based upon the assumption that no nitrogen becomes available from other sources such as breakdown of organic matter, and that none of the nitrogen consumed by the livestock that is returned to the soil in the form of urine and feces is available for use by the plant.

Table II-20 includes a summary of the actual nitrogen used across the regions. All the reported forage-only and dual-purpose nitrogen uses were lower than the recommendations by a large margin. This suggests that either (i) farmers are under applying nitrogen to grazed fields or (ii) the recommendation relative to nitrogen requirements for livestock production on grazing wheat is incorrect. It could be that the quantity of nitrogen returned to the field in the form of urine and feces is substantial and that may be available for use by the plant. Current nitrogen recommendations relative to forage production and use by livestock were derived from wheat plots that were clipped rather than grazed. Perhaps additional research is needed to determine forage and livestock response to nitrogen on plots that are actually grazed.

In the state as a whole, though the grain-only average of 63 lb/acre was significantly lower than both forage-only and dual-purpose averages of 69 lb/acre, the differences were not large. The averages in 1996 were 66 for grain-only, 78 for forage-only and 70 for dual-purpose (Table II-21). The *t* test showed that only for forage-only was the actual average nitrogen applied significantly different from that reported in the 1996 survey. In the regional analysis, the reported averages were not significantly different from each other except in the Panhandle region. In the Panhandle, the grain-only average was significantly lower than the dual-purpose average, but other averages were not significantly different from each other. The greatest reported average actual nitrogen use was for the wheat intended for dual-purpose in the South Central & East region, and the least was for the wheat intended for grain-only in the Panhandle region.

Fall and Winter Grazing Operation

Wheat pasture is high quality forage. Cost of gain from wheat grazing usually compares favorably with other backgrounding or growing programs (Shroyer et al., 1993). Another advantage is that wheat pasture is available in a time when other quality forage sources are scarce and when perennial grasses are dormant.

Grazed livestock species

Approximately 90% of the respondents in every region, who checked at least one livestock type for Question 14, grazed either stocker cattle or cows-and/or replacement heifers on 1999-2000 wheat pasture (Table II-22). This response was similar to that reported in the 1996 survey. Other than the combination of stocker cattle and cows-replacement heifers, almost all other responses were checked as only one species. The responses for the state as a whole were 42% for stocker cattle, 22% for cows-replacement heifers, 28% for both stocker cattle and cows-replacement heifers, 1% for sheep, 2% for dairy cattle, 3% for horses and 1% for others. Stocker cattle had the greatest percentages in all regions except in the West Central region, where most respondents (38%) checked both stocker cattle and cows-replacement heifers. This combination was also high (34%) in the Southwest region.

Wheat grazing has an important place in the Oklahoma agricultural economy. Nevertheless, there are no formal estimates provided by USDA on the species and number of livestock grazed on Oklahoma wheat pasture. Tweeten (1982) hypothesized that approximately 1.5 million stocker cattle graze on Oklahoma's winter wheat pasture in years with favorable weather. The survey results and Oklahoma Agricultural Statistics Service reports were used to approximate the number of stocker steers and stocker heifers producers grazed on 1999-2000 wheat pasture (Tables II-23 and II-24). The calculation for the estimates requires special mention. Column one of each table contains the estimate of wheat acres in the regions provided by the Oklahoma Agricultural Statistics Service (2001c). Column two contains the percentages of wheat acres used for either forage-only or dual purpose from the Table II-14. Column three is the multiplication of the first two columns and provides an estimate of the total wheat acres used for forage by region. Column four of Table II-23 is derived from the survey results.

Respondents, who checked stocker steers in question 15, were divided into two groups. One group of respondents had only stocker steers in their 1999-2000 fall-winter operation. The other group had steers in combination with other species of livestock. It was assumed that the first group used all of their forage-only and dual-purpose acreage to graze steers and the second group used half of their forage-only and dual-purpose acreage to graze steers. Those two groups of acreage were added and divided by the sum of all forage-only and dual-purpose acreage in each region. The result was the percentages of column four. Column four of Table II-24 was calculated in a similar manner. Multiplication of columns three and four resulted in column five. Column six comes from Table II-25. The last column was derived by dividing column five by column six.

By this measure, there were an estimated 886,351 stocker steers (Table II-23) and 466,136 stocker heifers (Table II-24) on 1999-2000 Oklahoma wheat pasture. The Panhandle and the South Central & East were regions with least number of steers and heifers. The numbers in other regions were approximately twice as much as numbers of those two regions. The Panhandle, the region with the least numbers (60,134 for steers and 36,814 for heifers), had the least number of wheat acreage used for forage and least stocking rates for steers and heifers. On the other hand, the North Central, the region with greatest number of steers (212,051) and heifers (111,390), had the greatest number of wheat acreage used for forage and one of the greatest percentages of forage acreage used by steers and heifers.

Grazing practices

Table II-25 includes average beginning weight, rate of gain, and stocking rates for steers and heifers, and stocking rates for cows on 1999-2000 wheat pasture in Oklahoma. State average for beginning weight was 460 lb for stocker steers and 447 lb for stocker heifers. The North Central region had the greatest averages, 479 lb for steers and 466 lb for heifers. The West Central region had the least average beginning weight of 430 lb for heifers. The averages for heifers in other regions were close to the state average. The least average beginning weight for steers was 436 lb in the South Central & East region.

On average, the reported rate of gain for steers was greater than the rate of gain for heifers in all regions. The range of average daily gains of stockers on wheat pasture has been estimated to be between 1.5 to 2.0 pounds (Shroyer et al., 1993). The reported state averages in this survey were 2.3 lb/day for steers and 2.1 lb/day for heifers, which were greater than those usually reported. Almost all regions reported gains over 2.0 lb/day.

Stocking rates vary from year to year and region-to-region depending upon climatic and management factors that influence wheat forage production. Stocking rates on wheat pasture range from 1.6-2.5 acres/stocker, under favorable weather conditions (Rodriguez et al., 1990). The weight of the animal is also important in determining the rate. In this survey, the state stocking rate averages were 2.1 acres/steer and 2.0 acres/heifer. Other statewide stocking rate averages were 3.5 acres/head for cows with fall calves, 3.3 acres/head for cows with spring calves, and 2.9 acres/head for cows only. The reported stocking rates across regions varied from each other. One of the main reasons might have been the difference in precipitation levels across regions. The regions with greater soil moisture levels usually have greater wheat forage yields. In Oklahoma, the South Central & East and Central regions receive considerably more rain than other regions. They also almost always report greatest stocking rates. The Panhandle, the region with least rainfall, almost always reported the least stocking rates. The North Central region had one of the least stocking rates for stockers in Oklahoma, possibly one of the reasons being that it had the greatest average beginning weights for steers and heifers.

Purchase of stockers

Many respondents, who purchased stocker cattle for fall-winter grazing, purchased animals in more than one month (Table II-26). For example, statewide 6% of the respondents checked October, November, and December as the months they purchased stocker cattle. Some combination of months (July to December), other than the ones reported in the Table II-26, were used by 27% of the respondents. October (15%) and November (14%) were the most popular months among the producers who checked only one month. Seven percent of the respondents purchased stocker cattle in months other than July to December. In the state, 42% of the stocker cattle producers reported that they usually mass medicated stockers with an antibiotic after purchase and before placement on wheat (Table II-27). The response percentages were similar across the regions. Almost half (49%) of the respondents reported that they mass medicated in the Southwest, whereas 38% of those in the South Central & East region did.

In response to the question, "How many days do you typically have purchased stockers on the farm before placing them on wheat", the state average was 26 days (Table

II-28). The greatest average (31 days) was reported in Panhandle region and the least average (23 days) was in Central region.

Receiving programs

The receiving period is one of the most stressful times during an animal's life as it gets acclimated to the new environment (Lalman and Gill, 1997). Hence, many producers use a receiving diet for the purchased stocker cattle or buy them pre-conditioned before placing them on wheat pasture. In the state as a whole, among the respondents who checked at least one of the four choices in question 18, 21% used their own receiving diet, 23% used a commercial diet, 8% purchased cattle pre-conditioned, and 48% did not use any receiving diet (Table II-29). A receiving diet, own or commercial, was most common (55%) in the North Central region. However, 57% of the respondents in the South Central & East region did not use any receiving diet. Purchasing pre-conditioned cattle was most common (16%) in the Southwest region.

Table II-30 includes a summary of days and cost of the receiving diets. The statewide averages were 23 days at $12/head for producers who used their own receiving program, and 20 days at $15/head for a commercial program. Some of the regional averages might be unreliable because of fewer observations.

Grass hay was the most widely used feed during the receiving by the producers who used their own receiving program (Table II-31). The three most commonly used programs in the state included grass hay. They were grass hay plus a high-protein supplement (27%), grass hay plus a high-energy supplement (22%), and grass hay alone (16%). Those three programs were mostly used (79%) in the South Central & East region and least used (49%) in the Panhandle region. A complete mixed ration (hand-fed daily) was also popular (19%) in the Panhandle.

Grazing initiation and termination

Krenzer (1994) recommended that grazing should not begin until wheat has developed a coronal root system. The coronal root system, also called secondary root system, anchors the plant, which makes it difficult for grazing animals to uproot it. Furthermore, future growth is not critically affected by the leaf removal at this growth stage. In response to the question, "How did you determine when to begin grazing your wheat pasture", statewide 51% of the respondents checked visual assessment of top growth (Table II-32). This ranged from 32% in the Panhandle to 68% in the South Central & East region. Statewide, 39% reported that they initiated grazing after the root system was anchored. The choice of root system was greatest (60%) in the Panhandle and least (23%) in the South Central & East. Other choices (calendar date, climate conditions, recommendation of others) were not very popular.

Timing of fall-winter grazing termination is critical to successful dual-purpose wheat production. Removing livestock from wheat grazing by the first hollow stem growth stage is important to minimize reductions in grain yield (Croy, 1984; Redmon et al., 1996). Studies have shown that net return per acre to a dual-purpose enterprise declines significantly if grazing continues beyond the presence of first hollow stem (Krenzer, 2000c). The stem will not elongate in heavily grazed wheat, hence the first hollow stem stage of growth must be determined in un-grazed wheat of the same variety and planting date as the wheat being grazed (Krenzer, 1994).

Table II-33 includes a summary of the responses to the question about the most important factor producers used to determine when to terminate fall-winter grazing. Only 17% of the respondents in the state said that they used first hollow stem stage of un-grazed wheat to terminate grazing, while 14% identified first hollow stem stage of grazed wheat. Though calendar date of the first hollow stem stage can vary considerably from year to year (Christiansen et al., 1989), the majority (58%) of respondents identified calendar date to be the important factor in determining grazing termination. Very few respondents (2%) relied upon the recommendation of someone else. The responses across regions were similar to the state percentages.

Statewide, producers on average removed the livestock from wheat that they had planned to harvest for grain on March 3 (Table II-34). Krenzer (1994) found that stem elongation usually occurs in Central Oklahoma between March 1 and March 20. In the survey, the average date for removal of livestock from grazing in the Central and the North Central regions was February 29. The Panhandle region had the latest average date of March 9.

Supplements

Horn and Paisley (1999 and 2000) and Horn et al. (2002) recently reviewed several management and supplementation strategies for wheat pasture stocker cattle. A question was included in this survey about the types of supplement fed to cows and stocker cattle on wheat pasture. Responses are summarized in Tables II-35 through II-38. Since most producers fed more than one supplement, all rows in the tables add up to more than 100%. Among the cow producers who responded to this question, 78% used hay and 53% used mineral as supplements (Table II-35). Other statewide popular supplements were protein (25%) and wheat straw (22%). Hay (74%), mineral (57%), wheat straw (23%), and protein (17%) were also the most commonly fed supplements statewide to stockers (Table II-36). They were the four most widely used supplements fed to both cows and stockers in every region. Only 2% of the cow producers and 4% of the stocker producers in the state did not use any supplement. None of the other choices (Liquid, High-starch energy, High-fiber energy) was noteworthy in the state as a whole.

Wheat pasture poisoning is a non-infectious metabolic disorder of cows grazed on wheat pasture. It occurs most frequently in mature cows that are in the latter stages of pregnancy or are nursing calves, and that have been grazing wheat pasture for 60 days or more. Cows with wheat pasture poisoning have low blood concentrations of both calcium and magnesium. While a similar, tetany-like condition may occur in stocker cattle, its incidence is extremely low. Considerable variation occurs in the mineral composition of wheat forage. Until more complete data are available, the data in the following table have been selected to indicate the calcium, phosphorus, magnesium, and potassium content of wheat forage in relation to the requirements for the same minerals of a 400 lb steer calf gaining 2 lb per day (Horn, 2003).

Mineral composition of wheat forage and mineral requirements of steers.

Item	Calcium	Phosphorus	Magnesium	Potassium
Composition, % of DM	.35	.25 - .40	.15	3-5
Requirement[a]	.56	.26	.10	0.7

[a]400 lb growing steer gaining 2 lb/day and consuming 11 pounds DM/day.
Source: Horn, 2003.

The values indicate that wheat forage contains marginal to sufficient phosphorus and magnesium, excess potassium (which is characteristic of small grains forages in general) and inadequate amounts of calcium for growing cattle. Therefore, calcium is the macromineral of primary concern in many wheat pasture grazing situations. In these situations, wheat pasture stockers should be supplemented with an additional 10 grams of calcium per day. While this may seem to be a very small amount of calcium (and therefore perhaps not of practical importance), for perspective the total calcium requirement of a 400 lb steer calf gaining 2 lb/day is 28 grams. The additional calcium could be included as calcium carbonate in other supplements or a mineral mixture. No mineral mixture will be efficacious if desired amounts are not consumed. Intake of mineral mixtures must be monitored.

The lower values for phosphorus content of wheat forage in the above table are from Bushland, Texas (Stewart et al., 1981). In this area, and perhaps the Panhandle of Oklahoma and Southwestern Kansas, wheat pasture stocker cattle should also receive supplemental phosphorus depending on soil type and actual mineral analysis of wheat forage. A case of phosphorus deficiency in a group of growing steers grazing wheat pasture was detected near Loyal, Oklahoma (i.e., North-Central Oklahoma) (Horn, 2003). The field had been in alfalfa for about six years prior to wheat. The application of phosphorus fertilizer for the wheat crop was less than recommended from soil test results. Phosphorus, calcium, magnesium and potassium contents of wheat forage samples collected on January 14 were, respectively, 0.16, 0.26, 0.16 and 1.72 % of DM. The Angus steers appeared healthy and were fairly fleshy, but seemed to crave bones, which were present in a native grass area adjacent to the wheat pasture, from carcasses of cows that had died in previous years. Depraved appetite or pica (abnormal chewing and eating behavior) is a classical sign of phosphorus deficiency in beef cattle. The mineral mixture that was being fed was changed from a low-phosphorus mineral (4.0 %) to a mineral mixture that contained 12% calcium, 12% phosphorus and 12% salt. According to the owner, this resolved the bone-chewing problem (Horn, 2003).

The question relative to the effect of feeding mineral mixtures (often high-magnesium mineral mixtures) to wheat pasture stockers on the incidence of bloat is commonly raised. There is no evidence to support the suggestion that supplemental magnesium will decrease the incidence and (or) severity of bloat of stocker cattle on wheat pasture (Horn, 2003). There may be a relationship between ruminal motility (and the ability of stocker cattle to eructate ruminal gases) and the calcium status of the cattle. Ruminal and gut motility is greatly compromised by subclinical deficiencies of calcium. Therefore, the concern of providing additional calcium to growing cattle on wheat pasture is two-fold: (i) to meet requirements for growth and (ii) to perhaps decrease the bloat problem by an effect on ruminal motility (Horn, 2003). A potential research objective may be to determine if the so-called "dry bloat" problems that are sometimes observed in wheat pasture stocker cattle are related to a subclinical deficiency of calcium.

The survey found that more than half of the cow and stocker producers fed mineral supplements. Among the statewide cow producers who used mineral supplements, 79% checked magnesium as their primary mineral concern, 40% checked calcium, and 32% checked phosphorus (Table II-37). The percentages for the stocker producers were 74% for magnesium, 40% for calcium, and 42% for phosphorus (Table II-38).

Table II-39 includes a summary of the primary reasons producers fed a supplement to stocker cattle on wheat pasture. Statewide, 34% of the producers reported that providing supplemental nutrients such as minerals was the number one (most important) reason to feed a supplement; 27% reported providing additional roughage, 16% reported maintaining an ideal average daily gain, and 12% reported increasing stocking density during the fall-winter grazing season as the number one reason. Providing additional energy was not an important reason to most of the producers. The responses were similar across the regions.

Stocker health problems and additives fed

Regarding the primary health problem of stockers after placement on wheat pasture, nearly all in the state reported either respiratory disease (53%) or bloat (41%) (Table II-40). Bloat is a common problem associated with wheat pasture because of its high crude protein and low fiber contents (Horn et al., 1977). The Southwest region had the greatest percentages (57%) for bloat, while the North Central region had the greatest (60%) incidence of respiratory disease. Foot rot (13%) was a significant health problem only in the Central region.

In the state, on average, the respondents reported 1.44% typical total death loss and 0.60% typical death loss from bloat for the wheat pasture stockers on their farms (Table II-41). About half of the total death loss was from bloat, which underscores the significance of bloat as a herd health problem. The West Central region had the greatest averages for both average total death loss (1.72%) and death loss from bloat (0.71%), while the South Central & East region had the least averages (1.09% and 0.41%, respectively).

Bloat can be a big problem especially during the three to four week periods of rapid wheat growth in the fall and late winter. Feeding Bloat Guard (poloxalene) is one of the most effective practices for the prevention of bloat (Shroyer et al., 1993). Two ionophores, Rumensin (monensin) and Bovatec (lasalocid), are also available for wheat pasture stocker cattle. Both of them, if delivered in the proper dosage, increase weight gain of growing cattle on wheat pasture by 0.18 to 0.24 lb/day over that of the carrier supplement (Horn et al., 1981; Andersen and Horn, 1987), and improve the economics of supplementation programs. In addition, research by Branine and Galyean (1990) showed that Rumensin decreased the incidence and severity of bloat from wheat pasture. More recently, Paisley and Horn (1998) reported that Rumensin is more efficacious than Bovatec in decreasing both the incidence and severity of bloat of cattle grazing wheat pasture.

The survey results showed that 59% of the stocker cattle producers in the state fed at least one of the three additives to cattle on wheat pasture (Table II-42). Ten percent used Rumensin only, 12% used Bovatec only, 20% used Bloat Guard only, and 17% used a combination of those three. Bloat Guard was the statewide top choice with 36%, followed by Bovatec with 24%, and Rumensin with 18%. The Southwest region had the greatest percentages (72%) of stocker producers, who used at least one of the three additives. It was also the region where most producers (57%) identified bloat as the primary health problem.

The majority (61%) of the respondents, who fed Bloat Guard to stocker cattle, said that they had used it during the high bloat risk periods (Table II-43). The majority of stocker producers in every region except the North Central region (50%) also said the same thing. Statewide, 39% of the producers fed Bloat Guard during the entire wheat pasture season. Among the statewide stocker cattle producers who used Rumensin, 26% used it only to increase gain, 32% used it only to decrease bloat, and 42% used it for both reasons. The percentages for Bovatec were 36%, 22%, and 42%, respectively. Most of the producers in the state reported that Rumensin (81%) and Bovatec (78%) were self-fed, while a few reported hand feeding.

Graze-out Operation

<u>Graze-out practices</u>

Averages for beginning weights, rates of gain, and stocking rates were considerably greater during the graze-out period (Table II-44) compared with those of the fall-winter grazing period. The average beginning weights varied widely from region to region. In fact, the range of average weights was approximately three times greater than that of the fall-winter period. The state average beginning weights were 556 lb for steers and 526 lb for heifers. Consistent with the fall-winter grazing period, the greatest averages for beginning weights occurred in the North Central region. The South Central & East region had the least averages for both steers and heifers.

The average daily gains were 2.4 lb for steers and 2.2 lb for heifers in the state as a whole. The rates of gain were always greater for steers compared with heifers in all regions except in the Panhandle. The greatest average gains were reported in the Southwest region, 2.6 lb/day for steers and 2.5 lb/day for heifers. The least gains were in the South Central & East region, 2.1 lb/day for steers and 1.9 lb/day for heifers.

Stocking rates may be increased with the progression of the season. Stocking rates in spring are usually 1.5-2.0 times greater than the fall-winter rates. In this survey, all the reported average stocking rates were greater in the graze-out period compared with the fall-winter grazing period. The average stocking rates in the state were 1.2 acres/head for steers and heifers, 2.3 acres/head for cows with fall calves, 2.2 acres/head for cows with spring calves, and 1.7 acres/head for cows only. The stocking rates for steers across regions were similar except in the South Central & East region, where the respondents reported a relatively low rate. All regions also had very similar stocking rates for heifers except the Panhandle and the South Central & East regions. As noted in the Table II-44, some of the reported regional stocking rates were calculated with very few available responses.

Decision to graze-out wheat acreage

The decision of whether or not wheat will be grazed out can be delayed until shortly before or at the first hollow stem stage. This permits flexibility in response to changes in relative prices of wheat and cattle, weather, and federal farm programs. However, among those in the state who responded to the question of their timing of the decision to graze-out, 39% reported that the percentage of their total wheat acres that would be grazed out was determined prior to planting, while 35% reported that it was determined during the fall-winter grazing season (Table II-45). Only 13% checked the choice, "when livestock were removed from fall-winter pasture", and 9% checked "at planting". The response summary across regions is included in Table II-45.

In a related question, producers were asked to rank the top three factors that influence their decision on how many, if any, acres they would graze-out each year.

Statewide, 38% identified wheat prices and 29% identified cattle prices as the number one (most important) factor, while they were checked 33% and 30% of the times, respectively, as the number two factor (Table II-46). They were the top two choices for the most important factor in all the regions. Cattle price, not wheat price, was the top choice for the number one factor only in the Central and the South Central & East regions. In the state as a whole, 9% said that cheat was the most important factor. Cheat refers to several of the annual winter grasses, also known as bromegrasses. Graze-out wheat provides a very effective way for controlling cool season weeds, such as cheat, which is difficult to control with herbicides (Krenzer, 1994). Cheat was particularly identified as a big problem in the North Central region. Among the other prominent factors statewide were lack of moisture and crop rotation. Lack of moisture was more important in the Panhandle, South Central & East, and Southwest regions.

Wheat Pasture Grazing Lease Arrangements

The USDA (1992) reported that 43% of the farmland in the U.S. was operated under lease agreements in 1992 compared with 35% in 1950. Analysis of agricultural land lease arrangements has been a strong focus of economists since the early writings of Smith and Mill (Dasgupta et al., 1999). An attempt was made in this survey to identify some of the common lease arrangements used for wheat pasture grazing in Oklahoma. Wheat pasture leasing may be a good option to many wheat producers, since they can reduce financial risk by not owning the livestock. The tenant's expected earnings, the landowner's costs, competition in the lease market, quality of pasture, amenities of the pasture land, relevant government programs, tax laws, and other related economic activities influence the structure of the lease agreements and rates (Doye et al., 2001).

The majority (58%) of the statewide respondents, who indicated that they were involved in renting or leasing fall-winter wheat pasture, were wheat producers (Table II-47). These individuals produced the wheat and leased the wheat pasture to someone else. However, 29% were livestock owners, who rented the wheat pasture from a wheat producer and stocked their cattle on the pasture. In addition, 13% of the respondents checked both livestock owner and wheat producer.

Legal experts recommend that producers have a written wheat pasture lease agreement, preferably drafted by an attorney (Tilley, 1988). However, the survey results showed that about 90% of the lease contracts statewide were oral and only 10% were written. This was consistent with the previous survey (True et al., 2001), when 82% of the leases were oral. In every region, more than 80% of the leases were oral.

On average, the size of the lease agreements was 303 acres. The range of the average size was from 212 acres in Central Oklahoma to 432 acres in the Panhandle region. The majority (63%) reported that the land had been leased for multiple years, while 38% reported a single year lease. In the South Central & East region, multiple year leases accounted for 79% of the agreements. However, in the North Central region multiple year leases accounted for 48%. On average, the multiple year leased acres had been leased for more than seven years. The greatest for this average was reported in the Panhandle region (over nine years) and the least was in the Central region (over five years).

Rental price

Some respondents used a combination of several methods to determine the rental price. This suggests that some producers may have more than one lease arrangement.

The methods of rate per hundredweight per month ($/cwt/month) and rate per pound of gain ($/lb of gain) were overwhelmingly popular for renting fall-winter grazing in all the regions (Table II-48). None of the respondents used rate per acre per month ($/acre/month). Very few respondents identified rate per acre per year ($/acre/year) and rate per head per month ($/head/month) as the methods used. The state average fall-winter grazing rental rates were $2.74 for the $/cwt/month method and $0.32 for the $/lb of gain method. The regional averages for $/cwt/month method ranged from $2.44 in the Southwest to $2.91 in the North Central region. The averages for $/lb of gain were similar across all regions.

The most widely used rental method for graze-out acreage was $/lb of gain, followed by $/acre/year and $/cwt/month (Table II-49). Other methods were not common. The state averages were $74 for $/acre/year, $2.84 for $/cwt/month, and $0.32 for $/lb of gain. There were no noteworthy differences between the average rental prices of fall-winter grazing and graze-out for the $/cwt/month and $/lb of gain methods.

Responsible parties for services

Lease agreements and negotiations involve assignments of responsibilities to supply relevant inputs and services to the contracting parties. One of the main goals of an optimal contract is to recognize that the assignments should be done to curtail moral hazard by either of the parties. Some empirical studies indicated that landlords expect tenant moral hazard in the use of landlord-supplied inputs (Dasgupta et al., 1999). It is also possible for the tenant to under-invest in resources that have productive benefits beyond the lease term. Alternatively, landlords may under-invest when the benefits of the investment accrue solely during the lease term and mainly benefit the tenant. Hence, assignments of input responsibilities play an important role in determining the efficiency of resource use.

Respondents were asked to identify, under the fall-winter grazing rental price they gave, the responsible parties for a few selected services. Assuming that the livestock owners and wheat producers will be mostly tenants and landlords, respectively, lease agreements should have a tendency to assign the services that would primarily benefit cattle to the livestock owners and the services that would enhance the land beyond the lease period to the wheat producers. This hypothesis was supported by the survey responses (Table II-50). The majority of the respondents reported that livestock owners were responsible for checking livestock, salt and minerals, supplemental feeding, and supplemental pasture. The items for which the wheat producers were most frequently responsible for were fencing materials, fencing labor, fertilizer cost, and water. These findings were also consistent with some previous survey results (Doye et al., 2001; Doye et al., 1999; True et al., 2001).

Respondents' comments

This study has found that wheat producers will require continued research support to succeed in the new market and legislative (Government programs) environment. Some provided written comments in the margins. Lower wheat grain price was an important issue to many, one of them wrote, "Bread is $2 a loaf and wheat is $2 a bushel, something wrong here". Some want price supports and better marketing opportunities for their wheat grain. Respondents were interested in dual-purpose varieties and forage-only varieties for longer grazing periods. They were also interested in drought, insect and disease tolerant varieties. The respondents in general expressed their appreciation about the extension plots and interactions with the researchers. However, they also suggested some other research needs, specifically direct seeding and soil pH management options.

SUMMARY AND CONCLUSIONS

Wheat is by far the number one crop in Oklahoma. Because of the soil and climate Oklahoma and other surrounding states in the Southern Great Plains have a unique option to produce wheat for three purposes: grain-only, forage-only, and dual-purpose (forage plus grain). Wheat forage is high in protein, energy, and minerals, and low in fiber. Wheat grazing is common in the regions of Southern Great Plains. Wheat forage and grain production is very important to the Oklahoma agricultural economy. Oklahoma is one of the top five states in the number of cattle and calves in the U.S. The United States Department of Agriculture does not report data on the proportion of wheat acres used for each of the three purposes, and the number and class of animals stocked on wheat pasture in Oklahoma. There is also little information available on some important actual wheat production practices, such as seeding rate, planting date, fertilizer application, that vary according to the intended use of wheat.

The complex nature of dual-purpose wheat production requires comprehensive information on interactions between various production and management inputs to succeed in this venture. While research information is available on specific segments of the overall dual-purpose system, comprehensive evaluation of the economics of alternative production and management strategies are not well documented. The objectives of this study were to determine the proportion of wheat grown for each of the three purposes in Oklahoma, to analyze the production practices across the intended use of wheat, to identify the livestock management practices on wheat pasture and lease arrangements for wheat pasture grazing in Oklahoma, and to compare some of the practices to those identified in a similar study conducted during the 1995-96 wheat production season.

A self-administered mail survey of Oklahoma wheat farms was the primary source of data for the study. The survey questionnaire was designed and edited by the experts in the Division of Agricultural Sciences and Natural Resources of Oklahoma State University, and the agricultural statistician of the Oklahoma Agricultural Statistics Service (OASS). To account for the variability of practices due to weather and soil, in different parts of Oklahoma, the state was divided into six regions. The stratified random sampling technique was used by OASS to select a representative sample of 4,815 Oklahoma wheat farms from the OASS database, approximately 800 samples from each of the six regions. The questionnaires and follow-up reminder postcards were mailed in March 2000. A total of 1,204 surveys (25% response rate) were returned. After discarding 114 surveys due to various reasons, 1,090 responses, which included more than 160 from each of the six regions, made up the base of the study. All the responses were summarized into tables and relevant hypothesis tests were conducted.

Typically, mail questionnaires have the lowest response rate out of all the data collection methods (Warde, 1990). However, the detailed nature and length of the questionnaire, and the budget constraints were the main reasons in preferring the mailed self-administered questionnaire method rather than the interview methods. Even then, the response rate of 25% can be considered poor. The length of the questionnaire probably discouraged many respondents. Generally, a bulkier questionnaire has a lower response rate (Warde, 1990). A more encouraging cover letter with some kind of incentives might have improved the response rate. Another reminder postcard, one month after the first mailings, could have helped also. Some of the returned survey questionnaires were discarded due to the fact that the respondents left question number one (county name) blank. Without identifying the respondent's region, the questionnaire could not be analyzed. Therefore, a special note should have been attached with question number one, such as saying that the question is a required one. If there is a need to do a similar kind of survey again, the recommendation will be to carry out a shorter survey with the critical questions only, and to use the direct interview method.

Weather is important for wheat production. Regional differences in precipitation in Oklahoma affect the production and management practices of the wheat and livestock producers. Usually, greater rainfall regions use more acreage for wheat forage production. Among other things, seeding rates, planting dates, nitrogen use, stocking rates, demand of certain kind of wheat varieties, varied from region to region. This study found that the majority (66%) of the respondents were not a member of any of the three given organizations, Oklahoma Wheat Growers Association, Oklahoma Grain and Stocker Producers, and Oklahoma Cattlemen's Association. Most producers based variety selection on grain yield and forage yield. Past performance was overwhelmingly the most popular source of information used for selecting varieties to plant.

Statewide, the respondents intended to use 31% of the wheat acreage for grain-only, 20% for forage-only and 49% for dual-purpose, but actually ended up using 39%, 22% and 39%, respectively. Weather constraints were probably the main reason for the difference between the intended and the actual percentages. Based upon the surveys, in comparison to the 1995-96, the respondents intended and actually used more acreage for forage-only in 1999-2000. The difference may be related to changes in the relative prices of wheat and cattle and to changes resulting from the 1996 Federal Agricultural Improvement and Reform (FAIR) act.

To manage risks and income variability, many wheat producers diversify by using their wheat acreage for more than one purpose. The survey showed that 61% of the respondents intended to grow wheat for more than one purpose. One important point to note here is that approximately 81% of the wheat producers indicated their intention of using some portion of their wheat acreage for the purpose of grazing (Table II-16). Again from Table II-14, we can see that producers actually grazed 61% of their wheat acreage to some degree. All these highlight the importance of the use of wheat for forage.

Agronomists recommend different levels of seeding rate, planting date, and fertilizer across the three intended uses of wheat acreage. The reported seeding rates were 77 lb/acre for grain-only, 94 lb/acre for forage-only and 84 lb/acre for dual-purpose. The survey results showed that producers recognize the influence of planting date on wheat forage and grain yields. The state average target planting dates were October 2 for grain-only, September 13 for forage-only and September 20 for dual-purpose. However, unfavorable weather was probably one of the main reasons the reported actual planting dates were delayed from the preferred target planting dates.

Availability of nitrogen in the soil is important in wheat production. Respondents on average used 63 lb/acre, 69 lb/acre and 69 lb/acre for grain-only, forage-only, and dual-purpose, respectively. A *t*-test confirmed that only the difference between average forage-only nitrogen uses reported in this survey and 1996 survey was statistically significant, however the difference was not much.

Stocker cattle and cows-replacement heifers were by far the most common livestock species that grazed on 1999-2000 wheat pasture. Having both of them as a combination was also popular. It was estimated from the survey results that approximately 0.9 million stocker steers and 0.5 million stocker heifers grazed on Oklahoma wheat pasture. On average, the beginning weights for steers and heifers on wheat pasture were 460 lb and 447 lb, respectively. Almost all regions reported daily gains of over 2 lb for stockers. The average stocking rates were 2.1 acres/steer and 2.0 acres/heifer in the state.

Many respondents purchased stocker cattle to graze on fall-winter wheat pasture in more than one month. October and November were the most popular months for purchase. These purchases may have enabled producers to observe forage production before making the purchase. Though livestock specialists recommend the use of a receiving diet for stocker cattle, approximately 48% of the respondents did not use a receiving diet. Producers who did use a receiving diet most frequently reported feeding grass hay.

The majority of the respondents did not identify the recommended stage of developed coronal root system as the factor used to determine when to initiate grazing; 51% of the respondents used visual assessment of top growth to determine when to begin grazing.

Grain-yield and net return per acre declines if dual-purpose wheat is grazed after the first hollow stem growth stage. Since the stem will not elongate in heavily grazed wheat, it is recommended that producers use the first hollow stem stage of un-grazed wheat of the same variety and planting date to determine when to terminate fall-winter grazing. The survey results showed that only 17% of the producers used that correct factor to terminate grazing. The majority (64%) of the dual-purpose producers did not reveal a correct understanding of the term "first hollow stem". On average, the respondents removed livestock on March 3 from wheat intended for grain harvest.

Nearly all cow producers (98%) and stocker producers (96%) fed some type of supplement. Hay and mineral supplements were the most common. Magnesium was the main concern to most producers who used mineral supplement. Providing supplemental nutrients such as minerals and providing additional roughage were the top choices as the most important reason to feed a supplement to stocker cattle on wheat pasture.

The respondents reported respiratory disease (53%) and bloat (41%) as the primary health problem of stockers after placement on wheat pasture. More than half of the stocker producers fed at least one of three additives to stocker cattle. Bloat Guard, which is one of the most effective means to prevent bloat, was the most popular choice. Two other additives, Rumensin and Bovatec, were fed to decrease bloat and to increase gain.

The option to use wheat as forage allows the producers to use their acreage more efficiently in many cases. Sometimes it may be more profitable to graze out wheat than to harvest it for grain. The survey results showed that wheat prices and cattle prices were the main factors that influence the percentage of graze-out acreage in all regions in Oklahoma. This highlights the importance of these prices in determining the duration and intensity of grazing. One advantage producers have is that they can delay the decision whether or not wheat will be grazed full season from the time of planting, which permits them flexibility to respond to market circumstances. However, almost half of the producers reported that the percentage of their total wheat acres that would be grazed out was determined prior to planting or at planting. The averages for livestock's beginning weights, rates of gain, and stocking rates were considerably greater in the graze-out operation than those in the fall-winter grazing operation.

Leasing wheat pasture is attractive to many. Approximately 90% of the statewide lease contracts were reported to be oral rather than written. This suggests that a substantial amount of trust prevails between landlords and tenants perhaps a result of long-term acquaintances. In most cases (63%), the acres had been leased for more than one year. The rental method of rate per pound of gain ($/lb of gain) was a popular arrangement for renting both fall-winter grazing and graze-out acreage. The average rate for both of them was $0.32/lb of gain. Some respondents used more than one method to establish rental charges.

Responsibilities to supply relevant inputs and services under the lease agreements should be assigned to the contracting parties in such a way so that potential moral hazard in the use of inputs by either of the parties can be reduced. It seemed from the survey results that one of the things the contracting parties took into account was the moral hazard issue on assigning responsibilities. Livestock owners were more frequently responsible for checking livestock, salt and minerals, supplemental feeding, and supplemental pasture, and wheat producers for fencing materials, fencing labor, fertilizer cost, and water.

The study findings enhance understanding of the actual practices of wheat and livestock producers in Oklahoma. This information will be useful in identifying the issues that need to be addressed in extension and research programs. It was determined in this and in the 1996 survey that producers do differentiate seeding rates, planting dates, and nitrogen uses according to the intended use of wheat. However, in most cases, the differences were not as mush as recommended by the research and extension specialists. The reported seeding and nitrogen rates were less than recommended for forage-only and dual-purpose operations by a large margin.

Based upon the responses, the majority of producers also need help in using the correct indicators to decide on initiation and termination of grazing in the dual-purpose system. All these factors might have contributed to lower than optimal yields and net incomes, especially in the dual-purpose wheat enterprises. Other areas where practices deviate from recommendations include frequency of soil testing, receiving programs for purchased stockers, and livestock diseases. Bloat was cited as a concern by many respondents.

Emphasis on wheat forage as a vital income source will warrant more studies on risk analysis, comparative economic returns and efficient combinations of the potential three uses of wheat production. Wheat variety development research should continue the effort to select dual-purpose varieties for maximization of net income from the production of both forage and grain. Research on the moral hazard issue in the division of input responsibilities in agricultural lease agreements and its consequences from the economic efficiency point of view need to be addressed. As evident from the literature and discussions, successful dual-purpose wheat production requires unique management skills. Investment in research and extension programs is critical to improve the profitability and reduce financial risks associated with dual-purpose wheat production.

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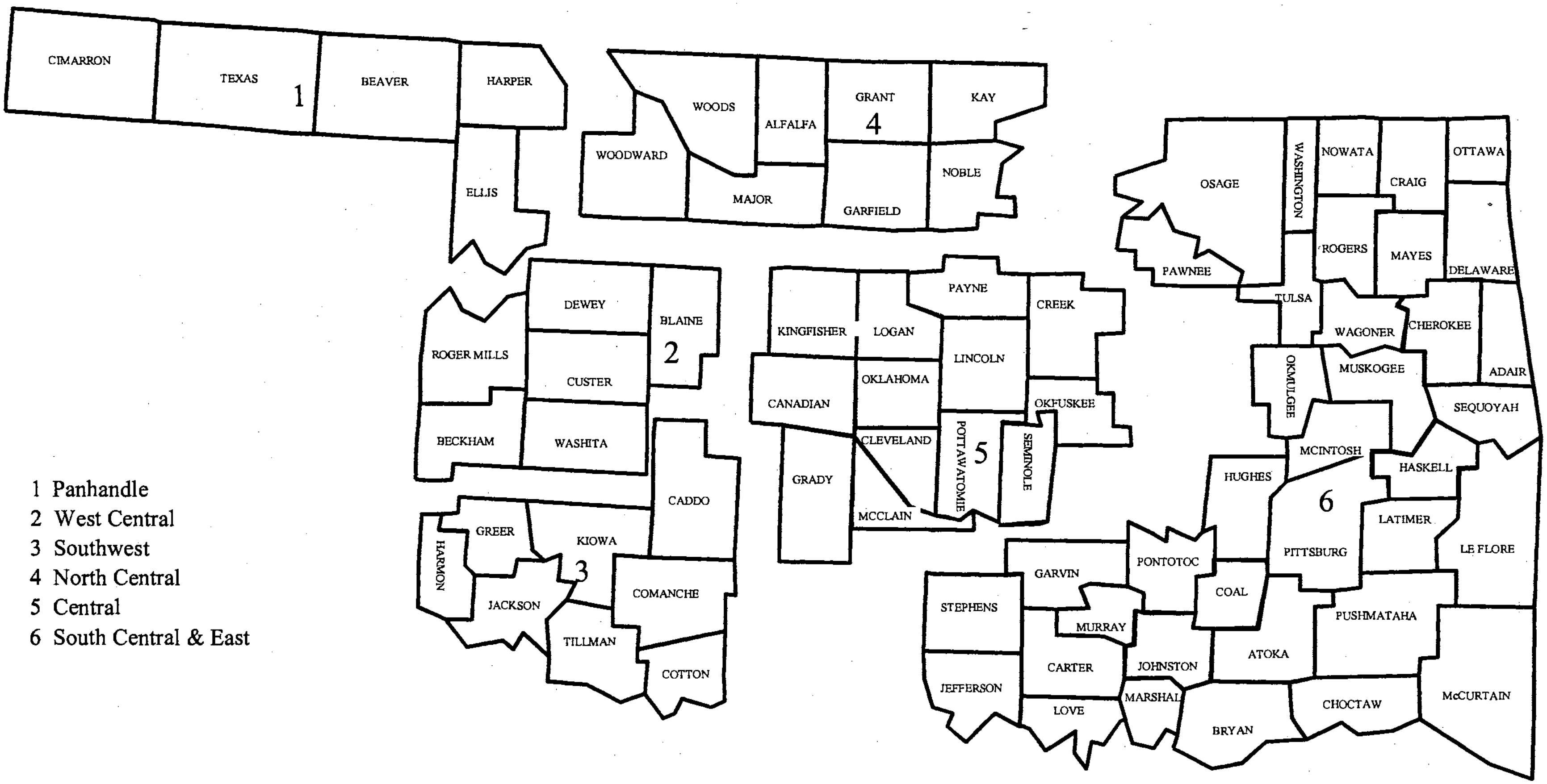

Figure 1. Oklahoma Wheat Producing Regions

Source: Regions 1 through 5 correspond with agricultural statistics districts as defined by the Oklahoma Agricultural Statistics Service. Region 6 includes four districts: South Central, Northeast, East Central, and Southeast.

Table II-1. **Average July-December, 1999 Precipitation (inches) in Oklahoma by Region. Deviations of precipitation from historical (1971- 2000) averages are shown in parentheses.**

REGION	July	August	September	October	November	December	Annual
Panhandle	1.47 (-1.08)	2.27 (-0.22)	1.95 (+0.06)	1.63 (+0.10)	0.00 (-1.01)	0.80 (+0.12)	24.04 (+3.00)
West Central	1.01 (-1.15)	1.98 (-0.74)	1.91 (-1.16)	1.42 (-1.17)	0.83 (-0.98)	2.65 (+1.48)	28.19 (-0.98)
Southwest	1.52 (-0.64)	0.31 (-2.36)	1.80 (-1.59)	2.36 (-0.66)	0.20 (-1.52)	3.02 (+1.60)	29.33 (-1.39)
North Central	2.61 (-0.39)	2.27 (-0.82)	4.62 (+1.50)	1.37 (-1.31)	0.46 (-1.65)	3.24 (+1.91)	42.46 (+10.54)
Central	1.44 (-1.15)	1.03 (-1.58)	4.49 (+0.46)	2.14 (-1.45)	0.58 (-2.13)	3.84 (+1.83)	39.29 (+1.98)
South Central	0.87 (-1.57)	1.68 (-0.84)	4.47 (+0.24)	2.68 (-1.45)	0.92 (-1.97)	2.33 (-0.11)	36.15 (-3.47)
Northeast	1.19 (-1.95)	1.48 (-1.65)	6.46 (+1.57)	1.62 (-2.11)	1.72 (-2.06)	4.19 (+1.71)	50.82 (+7.99)
East Central	1.39 (-1.56)	0.95 (-1.93)	5.28 (+0.34)	1.48 (-2.82)	1.87 (-2.49)	3.65 (+0.57)	45.57 (-0.59)
Southeast	0.97 (-2.63)	0.80 (-1.91)	3.17 (-1.33)	2.32 (-2.73)	1.76 (-3.17)	4.66 (+0.60)	42.08 (-8.75)
STATE	**1.40 (-1.33)**	**1.43 (-1.33)**	**3.92 (+0.12)**	**1.90 (-1.49)**	**0.90 (-1.89)**	**3.15 (+1.10)**	**37.88 (+1.33)**

Source: Oklahoma Agricultural Statistics Service, 2001a.

Table II-2. **Average January-June, 2000 Precipitation (inches) in Oklahoma by Region. Deviation of precipitation from historical (1971- 2000) averages are shown in parentheses.**

REGION	January	February	March	April	May	June	Annual
Panhandle	0.63 (+0.11)	0.38 (-0.15)	5.13 (+3.53)	1.37 (-0.48)	1.87 (-1.49)	3.78 (+0.85)	22.64 (+1.60)
West Central	0.42 (-0.46)	1.64 (+0.49)	6.11 (+3.74)	2.93 (+0.36)	1.97 (-2.84)	7.02 (+3.15)	31.46 (+2.29)
Southwest	0.45 (-0.65)	1.29 (-0.10)	4.36 (+2.11)	2.98 (+0.34)	2.33 (-2.52)	7.17 (+3.06)	33.79 (+3.07)
North Central	0.72 (-0.23)	1.64 (+0.39)	6.33 (+3.61)	1.68 (-1.27)	4.88 (+0.15)	6.08 (+2.09)	33.71 (+1.79)
Central	1.16 (-0.23)	1.55 (-0.28)	3.63 (+0.51)	2.61 (-0.84)	4.78 (-0.71)	7.34 (+2.85)	39.77 (+2.46)
South Central	2.06 (+0.22)	1.41 (-0.78)	3.22 (-0.19)	3.15 (-0.45)	2.02 (-3.44)	6.49 (+2.02)	39.62 (0.00)
Northeast	1.25 (-0.47)	2.02 (-0.05)	4.31 (+0.56)	1.99 (-2.05)	8.97 (+3.57)	8.36 (+3.66)	41.95 (-0.88)
East Central	2.69 (+0.47)	1.85 (-0.64)	2.73 (-1.32)	3.10 (-1.18)	6.45 (+0.66)	11.64 (+6.82)	47.10 (+0.94)
Southeast	1.49 (-1.32)	1.98 (-1.16)	3.33 (-1.12)	3.71 (-0.77)	5.40 (-0.98)	8.62 (+3.90)	48.14 (-2.69)
STATE	**1.22 (-0.26)**	**1.52 (-0.26)**	**4.32 (+1.24)**	**2.56 (-0.76)**	**4.38 (-0.75)**	**7.32 (+3.08)**	**37.58 (+1.03)**

Source: Oklahoma Agricultural Statistics Service, 2001b.

Table II-3. Average annual temperatures in 1999 and 2000, and historical (1971-2000) averages in Oklahoma by region (Degrees Fahrenheit).

REGION	1999	2000	1971-2000
Panhandle	58.0	58.2	56.6
West Central	60.5	59.4	59.5
Southwest	62.6	61.6	61.5
North Central	59.7	58.8	58.9
Central	61.9	60.6	60.6
South Central	63.6	62.4	62.3
Northeast	61.3	59.9	59.4
East Central	62.6	61.1	60.8
Southeast	63.0	61.9	61.6
STATE	**61.4**	**60.4**	**60.1**

Source: Oklahoma Agricultural Statistics Service, 2001a.

Table II-4. Number of usable responses, number of wheat acres included in the survey and size of survey relative to total planted Oklahoma wheat acreage in 1999-2000.

REGION	Usable Responses	Total Wheat Acres of Respondents	Total Oklahoma Wheat Acres*	Percent of Total Acres Included in Survey
Panhandle	161	73,564	680,000	11
West Central	192	86,349	900,000	10
Southwest	193	100,504	1,350,000	7
North Central	201	114,213	1,850,000	6
Central	181	60,521	850,000	7
South Central & East	162	25,846	470,000	5
STATE	**1090**	**460,997**	**6,100,000**	**8**

*Source: Oklahoma Agricultural Statistics Service, 2001c.

Table II-5. Total acres in farming operation.

REGION	Total acres	Percent of total owned	Average size owned*	Percent of total leased	Average size leased*
Panhandle	321,972	47	1,017	53	1,342
West Central	229,051	53	681	47	731
Southwest	220,171	49	600	51	816
North Central	231,174	50	632	50	826
Central	173,567	51	528	49	724
South Central & East	126,503	59	487	41	526
STATE	1,302,438	50	651	50	835

Note:* Total number of acres were divided equally into owned and leased, but there were fewer numbers of respondents who had leased compared with those who had owned acres. Therefore, the average size leased was greater than the average size owned.

Table II-6. Survey respondents who indicated membership in OWGA, OGSP, and OCA (%).

REGION	OWGA only	OGSP only	OCA only	Both OWGA & OGSP	Both OWGA & OCA	Both OGSP & OCA	All three	None of the three
Panhandle	9	1	15	1	5	1	0	68
Wheat Acres Planted*	7	1	17	0	6	3	0	66
West Central	10	0	13	1	8	1	0	68
Wheat Acres Planted	9	0	15	2	11	2	0	62
Southwest	18	0	14	1	5	0	1	62
Wheat Acres Planted	18	0	16	0	7	0	0	58
North Central	14	1	12	0	9	0	2	61
Wheat Acres Planted	13	1	12	0	11	0	4	58
Central	8	0	17	0	11	0	1	62
Wheat Acres Planted	6	0	25	0	21	0	1	46
South Central & East	5	0	14	0	2	1	1	77
Wheat Acres Planted	8	0	21	0	4	1	0	65
STATE	**11**	**0**	**14**	**0**	**7**	**0**	**1**	**66**
Wheat Acres Planted	**11**	**0**	**17**	**0**	**10**	**1**	**1**	**59**

Note: OWGA = Oklahoma Wheat Growers Association ; OGSP = Oklahoma Grain and Stocker Producers; OCA = Oklahoma Cattlemen's Association.
*Proportion of the members' reported wheat acreage with respect to the reported total planted wheat acres in the survey.

Table II-7. Survey respondents, classified by intended use of wheat, who indicated membership in OWGA, OGSP, and OCA (%).

REGION	OWGA only	OGSP only	OCA only	Both OWGA & OGSP	Both OWGA & OCA	Both OGSP & OCA	All three	None of the three
GRAIN-ONLY								
Panhandle	18	4	4	0	5	0	0	69
West Central	19	0	6	0	0	0	0	75
Southwest	38	0	4	0	0	0	0	58
North Central	20	0	7	0	7	0	2	64
Central	6	0	11	0	6	0	0	78
South Central & East	6	0	6	0	0	0	0	87
STATE	**18**	**1**	**6**	**0**	**4**	**0**	**1**	**71**
FORAGE-ONLY								
Panhandle	13	0	25	0	0	0	0	63
West Central	0	0	7	4	7	0	0	82
Southwest	0	0	23	0	0	0	0	77
North Central	0	0	17	0	0	0	0	83
Central	4	0	21	0	4	0	2	69
South Central & East	2	0	14	0	2	1	1	80
STATE	**3**	**0**	**17**	**0**	**3**	**0**	**1**	**76**

Table II-7 (continued). Survey respondents, classified by intended use of wheat, who indicated membership in OWGA, OGSP, and OCA (%).

REGION	OWGA only	OGSP only	OCA only	Both OWGA & OGSP	Both OWGA & OCA	Both OGSP & OCA	All three	None of the three
FORAGE AND GRAIN								
Panhandle	5	0	21	1	5	1	0	68
West Central	11	0	14	1	9	1	0	64
Southwest	18	0	15	0	7	0	1	58
North Central	13	1	14	1	9	0	2	60
Central	11	0	17	0	15	0	1	56
South Central & East	10	0	20	0	5	0	0	66
STATE	**12**	**0**	**16**	**0**	**9**	**0**	**1**	**61**

Note: OWGA = Oklahoma Wheat Growers Association ;
OGSP = Oklahoma Grain and Stocker Producers;
OCA = Oklahoma Cattlemen's Association.
Grain-only - Producers who planted wheat intended only for grain;
Forage-only - Producers who planted wheat intended only for grazing;
Forage and Grain - Producers who intended to use their wheat to produce both fall-winter forage and grain.

Table II-8. **Percentage of respondents who indicated that a crop such as rye or ryegrass was planted with the wheat and the percentage of total wheat acres that included a combination.**

REGION	Respondents who planted a crop with wheat, such as rye or ryegrass	Wheat acreage that included a combination
Panhandle	3.1	1.6
West Central	9.4	2.9
Southwest	11.4	3.8
North Central	6.0	0.7
Central	19.3	9.8
South Central & East	30.9	16.2
STATE	**13.0**	**4.0**

Table II-9. **Frequency of soil test as reported by the respondents (%).**

REGION	Every Year	Every 2 Years	Every 3 Years	Seldom or Never	Other
Panhandle	15	15	21	48	1
West Central	10	25	30	30	4
Southwest	11	15	37	37	1
North Central	16	15	31	36	2
Central	9	13	35	39	4
South Central & East	5	19	36	35	5
STATE	**11**	**17**	**32**	**37**	**2**

Table II-10. Percentage of each definition of "first hollow stem" responses across intended use by region.

REGION	Joint or node above soil	Developing head is above soil	Hollow stem above roots	Not familiar
GRAIN-ONLY				
Panhandle	18	8	21	53
West Central	7	27	20	46
Southwest	26	13	17	43
North Central	28	13	29	30
Central	25	6	31	38
South Central & East	10	3	23	64
STATE	**20**	**11**	**24**	**45**
FORAGE-ONLY				
Panhandle	12	6	38	44
West Central	16	4	32	48
Southwest	9	8	22	61
North Central	33	0	0	67
Central	9	4	22	65
South Central & East	13	10	15	62
STATE	**13**	**7**	**21**	**59**
DUAL-PURPOSE				
Panhandle	26	15	27	32
West Central	20	12	35	33
Southwest	23	13	30	34
North Central	11	20	44	25
Central	20	10	39	31
South Central & East	6	9	41	44
STATE	**19**	**14**	**36**	**31**

Note: Grain-only - Producers who intended to use all of their acreage for the purpose of grain-only.
Forage-only - Producers who intended to use all of their acreage for the purpose of forage-only.
Dual-purpose - Producers who had at least some proportion of their acreage for dual-purpose.

Table II-11. Characteristics of wheat used to determine which variety to plant (%).

	Forage Yield			Grain Yield			Aluminum or Ph tolerance			Test Weight			Coleoptile Length			Winter Hardiness			Drought Tolerance			Late Frost Tolerance			Insect Resistance		
REGION	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**# 1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**
Panhandle	20*	14*	11*	48	22	6	0	0	0	3	15	10	1	1	6	6	7	7	6	14	14	0	2	5	0	2	5
West Central	44	25	7	43	30	8	2	3	9	2	12	19	1	2	4	2	4	7	2	7	11	0	2	4	1	0	2
Southwest	37	21	9	46	22	10	0	2	4	2	12	16	1	2	1	0	4	6	3	10	11	0	2	1	0	2	5
North Central	23	19	9	59	21	7	3	5	9	6	19	16	1	3	5	1	4	3	1	3	5	0	1	3	0	2	3
Central	49	18	7	38	18	7	1	2	7	3	13	13	0	3	3	1	9	10	3	9	8	0	2	2	1	5	4
South Central & East	53	18	5	27	15	8	1	2	0	1	11	8	0	0	1	6	12	8	4	13	10	1	3	3	1	5	7
STATE	**38**	**19**	**8**	**44**	**22**	**8**	**1**	**3**	**5**	**3**	**14**	**14**	**1**	**2**	**3**	**2**	**7**	**7**	**3**	**9**	**9**	**0**	**2**	**3**	**0**	**3**	**4**

* Example: Forage yield received 20% of all number one counts (most important), 14% of all number two counts and 11% of all number three counts in the Panhandle region.

Table II-11 (Continued). Characteristics of wheat used to determine which variety to plant (%).

	Height of Plant			Past Success			Disease Resistance			Maturity			Pedigree			Shattering Reputation			Lodging			Milling & Baking Quality			Other		
REGION	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
Panhandle	0	3	3	12	8	8	1	2	8	0	1	2	0	1	0	1	3	6	1	1	1	0	2	5	1	0	1
West Central	1	3	2	1	5	11	0	2	9	0	2	3	1	0	1	0	0	2	0	0	1	0	1	1	1	0	0
Southwest	0	3	5	6	9	13	2	2	7	1	4	5	0	1	1	1	2	4	0	1	2	0	1	1	1	0	0
North Central	1	3	4	3	7	12	1	6	12	0	3	3	0	0	2	1	1	2	0	2	2	0	1	2	1	0	1
Central	1	6	4	4	6	18	0	2	10	1	4	2	0	0	0	0	0	1	0	0	3	0	1	1	0	0	0
South Central & East	1	4	6	3	4	21	1	8	14	0	3	4	0	0	1	0	1	1	0	1	3	0	0	0	1	0	1
STATE	**1**	**4**	**4**	**5**	**7**	**13**	**1**	**4**	**10**	**0**	**3**	**3**	**0**	**0**	**1**	**0**	**1**	**3**	**0**	**1**	**2**	**0**	**1**	**2**	**1**	**0**	**0**

Table II-12. Sources of information used to select which variety of wheat to plant (%).

REGION	Test Plot			Neighboring Fields			Seed Availability			Past Performance			Research Publications			Extension Service			Seed Company Info.			Other		
	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
Panhandle	15*	16*	12*	8	34	19	5	13	28	59	22	9	7	9	16	2	4	7	3	2	7	1	0	1
West Central	18	18	18	12	32	20	4	13	24	54	19	13	8	12	14	2	3	5	2	2	5	0	0	1
Southwest	18	19	20	16	31	18	6	11	22	54	22	11	3	11	17	1	3	7	3	3	5	0	0	0
North Central	24	22	12	12	25	18	6	11	18	44	26	14	7	8	23	4	3	7	2	5	5	1	0	2
Central	19	11	13	9	29	21	11	15	28	51	22	10	6	13	15	0	4	6	4	4	8	1	1	0
South Central & East	16	9	6	8	25	23	20	24	25	43	23	15	3	8	12	6	1	10	4	10	6	0	1	2
STATE	**18**	**16**	**14**	**11**	**30**	**20**	**8**	**14**	**24**	**51**	**22**	**12**	**6**	**10**	**16**	**2**	**3**	**7**	**3**	**4**	**6**	**1**	**0**	**1**

* Example: Test plot received 15% of all number one counts (most important), 16% of all number two counts and 12% of all number three counts in the Panhandle region.

Table II-13. **Percent of wheat acres planted for intended use of grain-only, forage-only, and dual-purpose by region in Oklahoma, 1999-2000.**

REGION	Grain-only	Forage-only	Dual-Purpose
Panhandle	45	10	45
West Central	16	23	61
Southwest	27	25	48
North Central	46	9	45
Central	16	30	54
South Central & East	30	49	21
STATE	**31**	**20**	**49**

Table II-14. **Percent of wheat acres actually used for grain-only, forage-only, and dual-purpose by region in Oklahoma, 1999-2000.**

REGION	Grain-only	Forage-only	Dual-Purpose
Panhandle	53	15	32
West Central	29	25	46
Southwest	36	25	39
North Central	51	11	38
Central	22	30	48
South Central & East	30	49	21
STATE	**39**	**22**	**39**

Table II-15 Statewide percent of wheat acres for grain-only, forage-only, and dual-purpose in Oklahoma, 1995-96 and 1999-2000.

	1995-96	1999-2000
INTENDED USE		
Grain-Only	25	31
Forage-Only	9	20
Dual-Purpose	66	49
ACTUAL USE		
Grain-Only	50	39
Forage-Only	9	22
Dual-Purpose	41	39

Table II-16. Wheat producers who indicated their intention to grow wheat for one or for more than one purpose (%).

REGION	Grain-only	Forage-only	Dual-Purpose Only	Grain-only & Forage-only	Grain-only & Dual-Purpose	Forage-only & Dual-Purpose	Grain-only Forage-only & Dual-Purpose
Panhandle	35	10	30	6	9	7	3
West Central	9	15	41	8	5	19	3
Southwest	13	14	28	5	9	18	12
North Central	28	3	28	6	12	11	12
Central	10	29	25	7	7	12	9
South Central & East	19	55	10	6	3	4	3
STATE	**19**	**20**	**27**	**6**	**8**	**12**	**7**

Table II-17. Average seeding rate across intended use by region (lb/acre).

REGION	Grain-only	Forage-only	Dual-Purpose
Panhandle	52[a] (81, 16)	73[b] (33, 21)	61[c] (69, 19)
West Central	80[a] (71, 16)	89[b] (78, 18)	86[b] (123, 16)
Southwest	81[a] (93, 17)	90[b] (88, 21)	89[b] (114, 19)
North Central	77[a] (118, 14)	85[b] (59, 16)	81[b] (108, 14)
Central	87[a] (66, 16)	99[b] (94, 22)	90[a] (89, 17)
South Central & East	96[a] (52, 18)	109[b] (90, 22)	108[b] (35, 25)
STATE	**77[a] (481, 20)**	**94[b] (442, 23)**	**84[c] (538, 21)**

Note: Means with common lettered superscript within each row (region) are not statistically different from each other at $\alpha = 0.05$. Numbers in parentheses are sample size and standard deviation, respectively.

Table II-18. Target planting date across intended use by region.

REGION	Grain-only	Forage-only	Dual-Purpose
Panhandle	9/23 [a] (83, 12)	9/9 [b] (38, 17)	9/16 [b] (66, 16)
West Central	9/30 [a] (70, 16)	9/12 [b] (74, 11)	9/20 [c] (110, 13)
Southwest	10/5 [a] (81, 17)	9/16 [b] (81, 16)	9/22 [b] (104, 14)
North Central	10/4 [a] (108, 13)	9/15 [b] (59, 13)	9/22 [c] (99, 10)
Central	10/4 [a] (60, 15)	9/12 [b] (93, 14)	9/20 [c] (88, 12)
South Central & East	10/5 [a] (47, 21)	9/13 [b] (84, 13)	9/15 [b] (31, 13)
STATE	**10/2 [a] (449, 16)**	**9/13 [b] (423, 14)**	**9/20 [c] (498, 13)**

Note: Means with common lettered superscript within each row (region) are not statistically different from each other at $\alpha = 0.05$. Numbers in parentheses are sample size and standard deviation, respectively.

Table II-19. Actual 1999 planting date across intended use by region.

REGION	Grain-only	Forage-only	Dual-Purpose
Panhandle	10/6 ^{a} (59, 19)	9/27 ^{a} (23, 29)	9/28 ^{a} (49, 21)
West Central	10/11 ^{a} (38, 20)	9/25 ^{b} (55, 16)	10/3 ^{a} (81, 20)
Southwest	10/16 ^{a} (61, 18)	9/28 ^{b} (51, 20)	10/2 ^{b} (73, 18)
North Central	10/9 ^{a} (74, 11)	9/24 ^{b} (39, 13)	9/29 ^{c} (73, 9)
Central	10/12 ^{a} (48, 16)	9/22 ^{b} (69, 18)	9/26 ^{b} (67, 13)
South Central & East	10/8 ^{a} (37, 20)	9/21 ^{b} (57, 17)	9/24 ^{b} (25, 18)
STATE	**10/10** ^{a} (317, 17)	**9/24** ^{b} (294, 18)	**9/30** ^{c} (368, 17)

Note: Means with common lettered superscript within each row (region) are not statistically different from each other at $\alpha = 0.05$. Numbers in parentheses are sample size and standard deviation, respectively.

Table II-20. Actual average nitrogen applied across intended use by region (lb/acre).

REGION	Grain-only	Forage-only	Dual-Purpose
Panhandle	42^{a}(61, 28)	50^{ab}(30, 24)	56^{b}(47, 30)
West Central	66^{a}(58, 38)	63^{a}(62, 31)	64^{a}(94, 33)
Southwest	67^{a}(76, 30)	72^{a}(72, 33)	74^{a}(93, 34)
North Central	63^{a}(98, 27)	66^{a}(51, 30)	69^{a}(93, 33)
Central	67^{a}(59, 34)	74^{a}(80, 37)	74^{a}(71, 31)
South Central & East	75^{a}(46, 33)	78^{a}(63, 41)	88^{a}(24, 45)
STATE	**63** ^{a}(398, 32)	**69** ^{b}(358, 35)	**69** ^{b}(434, 34)

Note: Means with common lettered superscript within each row (region) are not statistically different from each other at $\alpha = 0.05$. Numbers in parentheses are sample size and standard deviation, respectively.

Table II-21 Comparison of the state averages of seeding rate (lb/acre), planting date and nitrogen rate (lb/acre) across intended use, 1995-96 and 1999-2000.

	1995-96	1999-2000
SEEDING RATE		
Grain-Only	72^{a} (404, 21)	77^{b}(481, 20)
Forage-Only	90^{a}(226, 24)	94^{b}(442, 23)
Dual-Purpose	79^{a}(535, 20)	84^{b}(538, 21)
TARGET PLANTING DATE		
Grain-Only	9/27 ^{a}(397, 14)	10/2 ^{b}(449, 16)
Forage-Only	9/10 ^{a}(214, 14)	9/13 ^{b}(423, 14)
Dual-Purpose	9/17 ^{a}(513, 11)	9/20 ^{b}(498, 13)
ACTUAL PLANTING DATE		
Grain-Only	10/7 ^{a}(322, 15)	10/10 ^{b}(317, 17)
Forage-Only	9/23 ^{a}(178, 18)	9/24 ^{a}(294, 18)
Dual-Purpose	10/1 ^{a}(431, 15)	9/30 ^{a}(368, 17)
NITROGEN RATE		
Grain-Only	66^{a}(275, 37)	63^{a}(398, 32)
Forage-Only	78^{a}(145, 41)	69^{b}(358, 35)
Dual-Purpose	70^{a}(364, 32)	69^{a}(424, 34)

Note: Means with common lettered superscript within each row (intended use) are not statistically different from each other at $\alpha = 0.05$. Numbers in parentheses are sample size and standard deviation, respectively.

Table II-22. Fall-winter wheat pasture use by livestock type, 1999-2000 (%).

REGION	Stocker Cattle	Cows and/or Replacement Heifers	Both Stocker Cattle and Cows/Replacement Heifers	Sheep	Dairy Cattle	Horses	Other
Panhandle	56	24	18	0	1	0	1
West Central	35	19	38	2	1	5	0
Southwest	37	24	34	1	1	2	1
North Central	52	18	24	1	0	2	3
Central	40	21	28	2	4	4	1
South Central & East	41	28	21	1	4	4	1
STATE	**42**	**22**	**28**	**1**	**2**	**3**	**1**

Table II-23. **Estimated number of wheat acres used for forage in Oklahoma and estimated number of stocker steers on 1999-2000 Oklahoma wheat pasture.**

REGION	Total Oklahoma Wheat Acres* (A)	Percent used for Forage** (B)	Total Wheat Acres used for Forage (C=A*B)	Percent used by Stocker Steers† (D)	Total Wheat Acres Stocked with Stocker Steers (E=C*D)	Stocking Rate Acres/Steer†† (F)	Estimated Number of Steers (G=(E / F))
Panhandle	680,000	47	316,954	45	142,629	2.4	60,134
West Central	900,000	71	640,713	45	288,321	2.0	144,922
Southwest	1,350,000	64	868,378	49	425,505	2.3	185,592
North Central	1,850,000	49	897,483	56	502,591	2.4	212,051
Central	850,000	78	663,146	55	364,730	1.8	202,939
South Central & East	470,000	70	327,698	39	127,802	1.5	82,668
STATE	**6,100,000**	**61**	**3,729,091**	**49**	**1,827,254**	**2.1**	**886,351**

Source: * Oklahoma Agricultural Statistics Service, 2001c.
** Table II-14.
† Derived from survey results.
†† Table II-25

Table II-24. Estimated number of wheat acres used for forage in Oklahoma and estimated number of stocker heifers on 1999-2000 Oklahoma wheat pasture.

REGION	Total Oklahoma Wheat Acres* (A)	Percent used for Forage** (B)	Total Wheat Acres used for Forage (C=A∗B)	Percent used by Stocker Heifers† (D)	Total Wheat Acres Stocked with Stocker Heifers (E=C∗D)	Stocking Rate Acres/Heifer†† (F)	Estimated Number of Heifers (G=(E / F))
Panhandle	680,000	47	316,954	29	91,917	2.5	36,814
West Central	900,000	71	640,713	26	166,585	2.1	80,908
Southwest	1,350,000	64	868,378	20	173,676	2.0	87,505
North Central	1,850,000	49	897,483	28	251,295	2.3	111,390
Central	850,000	78	663,146	27	179,049	1.7	107,740
South Central & East	470,000	70	327,698	19	62,263	1.6	39,793
STATE	**6,100,000**	**61**	**3,729,091**	**25**	**932,273**	**2.0**	**466,136**

Source: * Oklahoma Agricultural Statistics Service, 2001c.
** Table II-14.
† Derived from survey results.
†† Table II-25

Table II-25. Average fall-winter grazing cattle beginning weights, rates of gain, and stocking rates.

REGION	Beginning Weight Steers (lb)	Beginning Weight Heifers (lb)	Rate of Gain Steers (lb/day)	Rate of Gain Heifers (lb/day)	Stocking Rate Steers (acres/hd)	Stocking Rate Heifers (acres/hd)	Stocking Rate Cows with Fall Calves (acres/hd)	Stocking Rate Cows with Spring calves (acres/hd)	Stocking Rate Cows only (acres/hd)
Panhandle	464	449	2.3	2.1	2.4	2.5	6.9**	6.1*	3.0**
West Central	449	430	2.2	2.1	2.0	2.1	3.7	2.6	3.2**
Southwest	454	446	2.3	2.2	2.3	2.0	3.8	3.5	3.0*
North Central	479	466	2.4	2.1	2.4	2.3	4.3	3.8	3.3**
Central	476	449	2.4	2.3	1.8	1.7	2.6	2.6	2.7*
South Central & East	436	440	2.1	2.0	1.5	1.6	2.9	2.4	1.6**
STATE	**460**	**447**	**2.3**	**2.1**	**2.1**	**2.0**	**3.5**	**3.3**	**2.9**

Note: * Less than 25 observations used to calculate.
** Less than 15 observations used to calculate.

Table II-26. The months when stocker cattle for fall-winter grazing were purchased by the respondents (%).

REGION	July Only	August Only	September Only	October Only	November Only	December Only	Other single Months	October November	November December	October November December	Other Combination of months
Panhandle	6*	13	13	13	6	3	10	3	3	6	23
West Central	8	8	11	17	17	2	5	2	3	8	23
Southwest	2	13	3	13	17	7	7	2	0	2	35
North Central	0	2	5	24	16	5	8	8	5	8	19
Central	6	8	6	9	8	8	5	5	5	8	34
South Central & East	0	4	11	15	22	7	11	0	7	4	19
STATE	**4**	**8**	**7**	**15**	**14**	**5**	**7**	**4**	**4**	**6**	**27**

* Example: 6% of the respondents purchased stocker cattle only in July.

Table II-27. Percentage of stocker producers who mass medicated stockers with an antibiotic after purchase and before placement on wheat.

REGION	Mass Medicated
Panhandle	41
West Central	40
Southwest	49
North Central	40
Central	41
South Central & East	38
STATE	**42**

Table II-28. Average number of days producers typically had purchased stockers on the farm before placing them on wheat.

REGION	Purchase Days
Panhandle	31
West Central	28
Southwest	27
North Central	26
Central	23
South Central & East	24
STATE	**26**

Table II-29. Reported receiving diets for purchased stocker cattle (%).

REGION	Own Diet	Commercial Diet	Pre-Conditioned	No Diet
Panhandle	23	26	11	40
West Central	26	16	8	50
Southwest	18	24	16	42
North Central	28	27	4	41
Central	16	24	4	56
South Central & East	17	20	6	57
STATE	**21**	**23**	**8**	**48**

Table II-30. Average days and cost of stocker receiving diets.

REGION	Producer's Own Diet		Commercial Diet	
	Days	Cost ($/Head*)	Days	Cost ($/Head*)
Panhandle	25.73**	9.15**	22.50**	18.20**
West Central	22.79	11.87	16.88**	17.36**
Southwest	22.55**	10.26**	19.57	15.07
North Central	20.55	9.71**	22.53	12.75**
Central	22.20**	19.19**	20.57	12.87
South Central & East	27.88**	11.20**	19.64**	17.19**
STATE	**23.04**	**11.52**	**20.33**	**15.06**

Note: * Dollars per head for the entire receiving period.
** Less than 15 observations used to calculate.

Table II-31. Stocker cattle feeding program during receiving (%).

REGION	Grass hay alone	Silage	Alfalfa hay alone	Silage plus supplement	Grass hay plus high-protein supplement	Self-fed mixed ration	Grass hay plus high-energy supplement	Daily hand-fed mixed ration	Alfalfa hay plus high-energy supplement	Other
Panhandle	7	0	7	2	21	5	21	19	0	17
West Central	18	1	4	1	24	7	21	5	11	8
Southwest	16	0	6	1	24	8	18	8	10	10
North Central	10	0	4	0	31	1	33	4	7	7
Central	19	0	5	1	32	3	13	8	8	11
South Central & East	23	0	4	2	30	2	26	5	5	4
STATE	**16**	**0**	**5**	1	**27**	**4**	**22**	**8**	**8**	9

Table II-32. Factors that producers used to determine when to begin grazing wheat (%).

REGION	Calendar Date	Assessment Of Top Growth	Climate Conditions	Anchored Root System	Recommendations	Other
Panhandle	0	32	8	60	0	0
West central	3	41	6	48	0	2
Southwest	2	59	4	34	0	1
North Central	5	41	6	45	1	2
Central	3	58	6	31	0	2
South Central & East	1	68	5	23	1	2
STATE	**2**	**51**	**6**	**39**	**0**	**2**

Table II-33. **Factors that producers used to determine when to terminate fall-winter grazing (%).**

REGION	Calendar Date	First hollow stem stage of ungrazed wheat	First hollow stem stage of grazed wheat	Recommendations of others	Other
Panhandle	47	25	13	0	14
West central	60	18	14	1	7
Southwest	68	11	13	3	5
North Central	57	22	12	2	7
Central	57	14	15	3	11
South Central & East	50	13	13	2	22
STATE	**58**	**17**	14	**2**	**10**

Table II-34. Average grazing termination date used by producers who planned to harvest wheat for grain.

REGION	DATE
Panhandle	March 9
West central	March 6
Southwest	March 1
North Central	February 29
Central	February 29
South Central & East	March 1
STATE	**March 3**

Table II-35. Types of supplement fed to cows on wheat pasture (%).

REGION	None	Hay	Protein	Liquid	High Starch Energy	Wheat Straw	High Fiber Energy	Mineral	Other
Panhandle	11	59	26	0	11	15	7	59	4
West Central	1	85	30	4	4	30	4	52	0
Southwest	1	73	21	9	3	31	3	50	6
North Central	4	71	27	4	2	20	0	57	2
Central	0	80	26	2	4	16	1	54	1
South Central & East	4	86	25	2	2	16	7	54	0
STATE	**2**	**78**	**25**	**4**	**3**	**22**	**3**	**53**	**2**

Note: Row totals are greater than 100% as most producers used more than one type.

Table II-36. Types of supplement fed to stocker cattle on wheat pasture (%).

REGION	None	Hay	Protein	Liquid	High Starch Energy	Wheat Straw	High Fiber Energy	Mineral	Other
Panhandle	10	60	19	2	10	21	8	52	10
West Central	2	76	14	7	9	29	4	46	2
Southwest	3	68	13	6	4	36	7	60	1
North Central	5	78	17	3	7	20	2	60	3
Central	5	81	16	3	7	12	3	61	2
South Central & East	3	76	24	1	10	16	4	63	0
STATE	**4**	**74**	**17**	**4**	**7**	**23**	**4**	**57**	**3**

Note: Row totals are greater than 100% as most producers used more than one type.

Table II-37. Mineral supplement of primary concern to the cow producers (% of respondents who checked at least one of the four mineral types).

REGION	Calcium	Phosphorus	Magnesium	Other
Panhandle	53	20	73	7
West Central	36	28	89	8
Southwest	35	50	79	9
North Central	50	13	75	0
Central	44	33	67	11
South Central & East	29	36	89	7
STATE	**40**	**32**	**79**	**8**

Note: Row totals are greater than 100% as most producers checked more than one type.

Table II-38. Mineral supplement of primary concern to the stocker cattle producers (% of respondents who checked at least one of the four mineral types).

REGION	Calcium	Phosphorus	Magnesium	Other
Panhandle	29	52	71	10
West Central	41	30	78	5
Southwest	43	41	65	4
North Central	28	42	84	2
Central	55	47	66	9
South Central & East	37	45	84	8
STATE	**40**	**42**	**74**	**6**

Note: Row totals are greater than 100% as most producers checked more than one type.

Table II-39. Primary reasons producers gave for feeding a supplement to stocker cattle on wheat pasture (%).

REGION	Nutrients			Energy			Roughage			Gain			Stocking Density			Other		
	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
Panhandle	30*	17*	6*	13	15	21	26	24	18	15	22	24	15	20	27	2	2	3
West Central	31	21	13	3	19	33	26	27	10	17	20	27	17	11	16	7	1	2
Southwest	38	22	12	3	10	21	25	27	16	17	24	26	12	16	12	6	1	12
North Central	33	30	6	6	22	19	26	25	8	17	8	31	8	11	31	11	3	4
Central	38	21	12	2	10	25	31	30	12	15	26	22	10	12	23	5	1	7
South Central & East	33	17	8	3	9	25	29	26	11	17	17	31	10	28	19	8	4	6
STATE	**34**	**22**	**10**	**4**	**14**	**24**	**27**	**27**	**12**	**16**	**20**	**27**	**12**	**15**	**21**	**6**	**2**	**6**

Note: Row totals may not add up to 100% due to rounding errors.

* Example: Nutrients received 30% of all number one counts (most important), 17% of all number two counts and 6% of all number three counts in the Panhandle region.

Table II-40. Reported primary health problem of stockers after placement on wheat pasture (%).

REGION	Bloat	Respiratory Disease	Foot Rot	Polioencephalomalacia	Other
Panhandle	41	57	2	0	0
West Central	39	55	3	0	3
Southwest	57	42	1	0	0
North Central	37	60	2	0	0
Central	33	53	13	1	0
South Central & East	38	54	5	0	3
STATE	41	53	4	0	1

Table II-41. Wheat pasture stockers' typical total death loss and death loss from bloat on the farm of the respondents (%).

REGION	Total Death Loss	Death Loss From Bloat
Panhandle	1.21	0.58
West Central	1.72	0.71
Southwest	1.55	0.68
North Central	1.54	0.56
Central	1.34	0.57
South Central & East	1.09	0.41
STATE	**1.44**	**0.60**

Table II-42. Producers who reported the feeding of Rumensin, Bovatec and Bloat Guard as additives (% of respondents who reported grazing stocker cattle on wheat pasture).

REGION	Rumensin Only	Bovatec Only	Bloat Guard Only	Rumensin & Bovatec	Rumensin & Bloat Guard	Bovatec & Bloat Guard	All Three
Panhandle	10	14	19	0	8	8	0
West Central	9	11	19	2	8	8	2
Southwest	12	14	23	1	4	15	3
North Central	11	11	22	0	5	11	0
Central	9	15	16	3	4	8	3
South Central & East	8	7	24	2	2	1	4
STATE	**10**	**12**	**20**	**1**	**5**	**9**	**2**

Note: Since many respondents did not check any of the additives, row totals do not add up to 100%.

Table II-43. **Reasons and type of feeding for additives reported by stocker cattle producers (%).**

REGION	Rumensin					Bovatec					Bloat Guard	
	Gain only	**Bloat only**	**Both**	**Self fed**	**Hand fed**	**Gain only**	**Bloat only**	**Both**	**Self fed**	**Hand fed**	**Full season**	**High risk**
Panhandle	27*	0*	73*	100	0	30	40	30	88	13	24*	76*
West Central	33	38	29	88	13	50	25	25	91	9	33	68
Southwest	12	53	35	88	13	30	22	48	81	19	46	54
North Central	25	31	44	64	36	42	11	47	75	25	50	50
Central	13	25	63	64	36	31	19	50	72	28	37	63
South Central & East	46	31	23	88	13	29	29	43	50	50	39	61
STATE	**26**	**32**	**42**	**81**	**19**	**36**	**22**	**42**	**78**	**22**	**39**	**61**

* Example: In Panhandle region, respondents fed Rumensin to increase gain only 27% of the time, to decrease bloat only 0% of the time and for both reasons 73% of the time. In the same region, respondents fed Bloat Guard during full season 24% of the time and during high bloat risk periods 76% of the time.

Table II-44. Average beginning weights, rates of gain, and stocking rates of cattle in graze-out period.

REGION	Beginning Weight Steers (lb)	Beginning Weight Heifers (lb)	Rate of Gain Steers (lb/day)	Rate of Gain Heifers (lb/day)	Stocking Rate Steers (acres/hd)	Stocking Rate Heifers (acres/hd)	Stocking Rate Cows with Fall Calves (acres/hd)	Stocking Rate Cows with Spring calves (acres/hd)	Stocking Rate Cows only (acres/hd)
Panhandle	543*	526*	2.2*	2.3*	1.2*	1.6*	2.3*	2.8**	1.5**
West Central	532	520	2.4	2.3	1.1	1.1	1.8**	1.7*	1.6**
Southwest	568	508	2.6	2.5	1.2	1.1	2.2*	1.9*	1.0**
North Central	614	568	2.4	2.3	1.1	1.0	2.4**	1.9**	†
Central	569	543	2.5	2.3	1.1	1.1	2.4*	2.1*	1.0**
South Central & East	486	484	2.1	1.9	1.5	1.7*	2.9**	3.2**	4.0**
STATE	**556**	**526**	**2.4**	**2.2**	**1.2**	**1.2**	**2.3**	**2.2**	**1.7****

Note: † No response
* Less than 25 observations used to calculate.
** Less than 15 observations used to calculate.

Table II-45. When the percentage of total wheat acres to be grazed-out were determined (%).

REGION	Prior To Planting	At End Of Fall-winter Grazing	At Planting	During Fall-winter Grazing Season	Other
Panhandle	38	21	8	25	8
West central	32	11	10	46	3
Southwest	35	14	12	33	6
North Central	29	17	10	40	4
Central	47	10	6	36	1
South Central & East	55	9	9	22	6
STATE	**39**	**13**	**9**	**35**	**4**

Table II-46. Factors that influenced the decision of number of acres to be grazed-out each year (%).

	Cattle prices			Wheat prices			Available capital to purchase cattle			Lack of moisture			Hail or high winds			Cheat			Crop rotation			Income from pasture leasing			Other		
REGION	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**
Panhandle	22[*]	30[*]	7[*]	32	35	14	2	2	10	16	13	31	0	0	5	6	6	14	12	6	14	8	6	2	2	4	2
West Central	22	32	19	56	28	7	0	4	5	3	3	11	0	0	0	9	12	29	0	6	17	5	11	4	4	4	8
Southwest	30	32	11	43	37	8	0	1	12	9	11	26	0	0	1	4	7	22	7	5	12	3	3	5	5	3	3
North Central	23	30	13	34	36	20	0	0	2	1	1	8	0	1	0	23	14	35	8	9	13	6	8	3	6	1	5
Central	38	29	15	31	31	18	1	8	12	5	11	10	0	1	1	8	16	22	6	1	12	3	0	3	9	2	6
South Central & East	37	22	18	25	29	16	4	5	16	9	20	9	0	2	0	1	9	18	5	3	16	0	9	5	18	2	2
STATE	**29**	**30**	**14**	**38**	**33**	**13**	**1**	**3**	**9**	**7**	**9**	**16**	**0**	**1**	**1**	**9**	**11**	**24**	**6**	**5**	**14**	**4**	**6**	**4**	**8**	**3**	**5**

[*] Example: Cattle prices received 22% of all number one counts (most important), 30% of all number two counts and 7% of all number three counts in the Panhandle region.

Table II-47. Lease agreements for fall-winter wheat pasture grazing.

REGION	Livestock Owner %	Wheat Producer %	Both %	Oral Lease %	Written Lease %	Average Acres	One-year Lease %	Multi-year Lease %	Average year of Multi-year Lease
Panhandle	35*	50*	15*	96	4	432	35	65	9.23
West Central	21	68	12	90	10	259	41	59	6.64
Southwest	24	67	9	83	17	321	28	72	8.00
North Central	26	62	12	89	11	325	52	48	8.25
Central	46	42	13	91	9	212	44	56	5.60
South Central & East	30	50	20	91	9	297	21	79	6.87
STATE	**29**	**58**	**13**	**90**	**10**	**303**	**38**	**63**	**7.42**

* Example: In the Panhandle region, 35% of the respondents were the livestock owner, 50% were the wheat producer and 15% were both.

Table II-48. Average wheat pasture rental price for fall-winter grazing.

REGION	Observations	$/acre/ year	Observations	$/cwt/ month	Observations	$/lb of gain	Observations	$/head/ month
Panhandle	1	60	15	2.58	13	0.32	1	10.00
West Central	0	†	18	2.77	15	0.32	5	10.00
Southwest	0	†	8	2.44	20	0.31	2	12.98
North Central	0	†	24	2.91	7	0.32	2	13.50
Central	2	27	9	2.72	11	0.33	1	15.00
South Central & East	3	18	4	2.88	10	0.32	1	10.00
STATE	**6**	**28**	**78**	**2.74**	**76**	**0.32**	**12**	**11.50**

Note: † No Response.

Table II-49. Average wheat pasture rental price for graze-out acreage.

REGION	Observations	$/acre/ year	Observations	$/cwt/ month	Observations	$/lb of gain	Observations	$/head/ month
Panhandle	5	61	5	2.90	9	0.34	0	†
West Central	16	85	3	2.83	13	0.32	2	11.50
Southwest	9	76	2	2.75	14	0.31	1	9.00
North Central	7	75	5	2.85	9	0.33	1	15.00
Central	6	68	4	2.88	10	0.32	0	†
South Central & East	4	49	1	2.50	10	0.32	0	†
STATE	**47**	**74**	**20**	**2.84**	**65**	**0.32**	**4**	**11.75**

Note: † No Response.

Table II-50. Livestock owner and wheat producer responsibilities under the wheat pasture grazing lease agreement. (%)

	Checking livestock			Salt & Minerals			Fencing Materials			Fencing Labor			Fertilizer Cost			Supplemental Feeding			Supplemental Pasture			Water		
REGION	**L**	**W**	**B**	**L**	**W**	**B**	**L**	**W**	**B**	**L**	**W**	**B**	**L**	**W**	**B**	**L**	**W**	**B**	**L**	**W**	**B**	**L**	**W**	**B**
Panhandle	69*	19*	13*	74	26	0	34	59	6	38	59	3	10	87	3	71	19	10	50	43	7	19	71	10
West Central	72	15	13	78	20	2	22	67	11	26	67	7	16	72	12	78	22	0	63	34	3	29	69	2
Southwest	53	24	24	58	26	16	13	76	11	14	75	11	8	87	5	54	37	9	50	43	7	11	81	8
North Central	66	24	10	76	18	5	40	55	5	42	50	8	3	88	10	70	24	5	48	45	6	13	79	8
Central	62	28	10	76	24	0	32	61	7	39	57	4	29	64	7	70	30	0	50	50	0	26	67	7
South Central & East	58	21	21	52	29	19	10	65	25	24	52	24	5	82	14	45	35	20	41	41	18	21	53	26
STATE	**64**	**21**	**15**	**70**	**23**	**6**	**26**	**64**	**10**	**30**	**61**	**8**	**11**	**80**	**8**	**67**	**27**	**6**	**52**	**42**	**6**	**20**	**71**	**9**

Note: L = Livestock Owner; W = Wheat Producer; B = Both.

* Example: In the Panhandle region, the responsibility of checking livestock was assigned to the livestock owner 69% of the time, to the wheat producer 19% of the time and to both 13% of the time.

APPENDIX A

Survey Questionnaire

Dear Producer:

Information requested in this survey will be used by Oklahoma State University and the Oklahoma Agricultural Statistics Service to support wheat production and wheat pasture grazing research programs. Please complete the questionnaire to the best of your ability and return in the enclosed postage paid envelope. Information provided will be confidential. Thank you for your assistance.

F. M. Epplin — Agricultural Economist
Barry L. Bloyd — State Statistician

1. In what county or counties do you farm? ________________________________

2. How many total acres are included in your farming operation (cropland, pastureland, woodland, CRP, other land)?
   ______ acres

3. Of these total acres how many do you:
   - ☐ own? ______ acres
   - ☐ lease? ______ acres

4. Are you a member of? (Check all that apply.)
   - ☐ Oklahoma Wheat Growers Association
   - ☐ Oklahoma Grain and Stocker Producers
   - ☐ Oklahoma Cattlemen's Association

5. How many acres of wheat did you plant in the Fall of 1999?

6. Did you plant any other crop with the wheat, such as rye or ryegrass? ☐ yes ☐ no
   If yes, what else did you plant with the wheat? __________
   On how many of your wheat acres did you use this combination?

7. Rank the following **characteristics** in order of importance when determining the varieties you plant. (Please rank the top **three** (1, 2, 3) with **1** being most important and leave the rest blank.)
   - __ forage yield
   - __ test weight
   - __ drought tolerance
   - __ height of plant
   - __ maturity
   - __ lodging
   - __ grain yield
   - __ coleoptile length
   - __ late frost tolerance
   - __ past success
   - __ pedigree (parentage)
   - __ milling & baking quality
   - __ aluminum or low pH tolerance
   - __ winter hardiness
   - __ insect resistance
   - __ disease resistance
   - __ shattering reputation
   - __ other (specify)

8. Rank the following **sources of information** as to their importance when selecting which variety of wheat to plant. (Please rank the top **three** (1, 2, 3) with **1** being most important and leave the rest blank.)
   - __ extension test plot results
   - __ past performance on my farm
   - __ seed company information
   - __ results of neighboring fields
   - __ research publications
   - __ other (specify)
   - __ seed availability
   - __ county extension service

9. Which of the following best describes your understanding of what the term "first hollow stem" means in reference to wheat production? (Please check one.)
   - ☐ growth stage when I can feel a joint or node above the soil surface
   - ☐ growth stage where the developing head is at or above the soil surface
   - ☐ growth stage when hollow stem can first be identified above the roots
   - ☐ I am not familiar with what "first hollow stem" means

10. Based on the following definitions, how many of your 1999-2000 wheat acres were **planted** for each purpose:

_______ acres **Grain Only.** Never intended to graze the wheat.
_______ acres **Forage Only.** Planned to use only for grazing and/or hay with no grain harvest intended.
_______ acres **Dual-Purpose** Forage plus Grain. Planned to graze in the fall and winter and harvest the grain.

11. How many acres of your 1999-2000 wheat crop will actually be **used** for each purpose?

Grain Only _____ acres **Forage Only** _____ acres **Dual-Purpose** ______ acres

12. This item deals with the variation of production practices according to **intended use** of the wheat acreage. Please complete the information for each of the uses identified in item **10**. Complete all columns that apply to your operation.

		Grain Only	Forage Only	Dual-Purpose
a.	Seeding rate (lbs/acre)	________	________	
b.	Planting dates:			
	target planting date	________	________	
	actual 1999 planting date	________	________	
c.	Variety(s) planted	________	________	
		________	________	________
		________	________	
d.	Fertilizer Used (lbs/acre)	(Include all fertilizer applied: preplant, with drill, and topdress.)		
	anhydrous ammonia (82-0-0)	________	________	
	ammonium nitrate (33-0-0)	________	________	
	urea (46-0-0)	________	________	
	liquid nitrogen (28-0-0)	________	________	
	diammonium phosph (18-46-0)	________	________	
	other ________	________	________	

13. How frequently do you soil test? (Please check one.)
☐every year ☐every 2 years ☐ every 3 years ☐ seldom or never ☐ other

This section of the survey deals with aspects of your fall/winter grazing program. If you did not graze small grain in the 1999-2000 season please skip to item 32.

14. What species of livestock did you graze on 1999-2000 wheat pasture? (Please check all that apply.)
☐ stocker cattle ☐ cows and/or replacement heifers ☐ sheep
☐ dairy cattle ☐ horses ☐ other

15. Which of the following best describes your 1999-2000 fall/winter operation?

	Average Beginning Weight	Stocking Rate	Rate of Gain (lbs/day)
☐ stocker steers	_______lbs	____ acres/steer	
☐ stocker heifers	_______lbs	____ acres/heifer	
☐ cows with fall calves		____ acres/cow	
☐ cows with spring calves		____ acres/cow	
☐ cows only		____ acres/cow	
☐ other _________		____ acres/animal	

16. If you purchased stocker cattle for fall/winter grazing, in what month were they purchased?
☐Jul ☐Aug ☐Sep ☐Oct ☐Nov ☐Dec ☐ Other months

17. Do you usually mass medicate stockers with an antibiotic after purchase and before placement on wheat? ☐yes ☐no

18. Did you use a receiving diet (either your own or a commercial one) for stocker cattle that you purchased? (Check one.)
- ☐ yes, my own receiving diet ______ days at ______ $/head
- ☐ yes, a commercial receiving diet ______ days at ______ $/head
- ☐ no, I purchased my cattle pre-conditioned
- ☐ no, I didn't use a receiving diet

19. Which of the following best describes your feeding program during <u>receiving</u>? (Please check only one box.)
- ☐ grass hay alone
- ☐ alfalfa hay alone
- ☐ grass hay plus a high-protein supplement
- ☐ grass hay plus a high-energy supplement
- ☐ alfalfa hay plus high-energy supplement
- ☐ silage
- ☐ silage plus supplement
- ☐ a complete mixed ration that is a self-fed
- ☐ a complete mixed ration that is hand-fed daily
- ☐ other

20. How many days do you typically have purchased stockers on the farm before placing them on wheat? ___ days

21. How did you determine when to begin grazing your wheat pasture? (Please check only one box.)
- ☐ calendar date of ____________
- ☐ visual assessment of top growth
- ☐ climate conditions
- ☐ after root system was "anchored"
- ☐ recommendation of others
- ☐ other

22. Which of the following best describes the type of supplement that you fed to **cows** and/or **stockers** on wheat pasture? (Check all that apply. Use the left column for cows and right column for stockers.)

Cows	Stockers	
☐	☐	none
☐	☐	hay
☐	☐	protein supplement
☐	☐	liquid supplement
☐	☐	high-starch (grain-based) energy supplement
☐	☐	wheat straw and/or other low-quality roughage
☐	☐	high-fiber (i.e. wheat middling, soybean hull, etc.) energy supplement
☐		a mineral supplement (Please check the mineral of primary concern.) ☐calcium ☐phosphorus ☐magnesium ☐
	☐	a mineral supplement (Please check the mineral of primary concern.) ☐calcium ☐phosphorus ☐magnesium ☐
☐	☐	other ________________________

23. What is the primary reason that you fed a supplement to **stocker** cattle on wheat pasture? (Please rank the top **three** (1, 2, 3) with 1 being most important and leave the rest blank.)
- __ to provide supplemental nutrients such as minerals
- __ to provide additional roughage
- __ to increase stocking density during the fall/winter grazing
- __ to provide additional energy
- __ to maintain an ideal average daily gain
- __ other

24. Did you feed any of the following additives to **stocker** cattle on wheat pasture? (Please check all that apply.)
- ☐ Rumensin (monensin) ☐ to increase gain ☐ to decrease bloat ☐ self fed ☐ hand fed
- ☐ Bovatec (lasalocid) ☐ to increase gain ☐ to decrease bloat ☐ self fed ☐ hand fed
- ☐ Bloat Guard (poloxalene) ☐ during full season ☐ during high bloat risk periods

25. What is the primary health problem of stockers after placement on wheat pasture? (Please check one.)
☐ bloat ☐ respiratory disease ☐ foot rot ☐ polioencephalomalacia ☐ other

26. What is the typical (a) **total death loss** of wheat pasture stockers on your farm? ___% (b) Death **loss** from **bloat**? ___%

27. How do you determine when to terminate fall/winter grazing? (Please check only one box.)
- ☐ calendar date
- ☐ first hollow stem stage of ungrazed wheat
- ☐ first hollow stem stage of grazed wheat
- ☐ recommendation of someone else
- ☐ other

28. What calendar date did you remove the livestock from the wheat that you plan to harvest for grain?

This section of the survey deals with aspects of grazing during the <u>graze-out</u> period. If you are not grazing-out small grain in 2000 please skip to item 32.

29. Which best describes your graze-out operation?

	Average Beginning Graze-out Weight	Graze-out Stocking Rate	Graze-out Rate of Gain (lbs/day)
☐ stocker steers	______lbs	____ acres/steer	
☐ stocker heifers	______lbs	____ acres/heifer	
☐ cows with fall calves		____ acres/cow	
☐ cows with spring calves		____ acres/cow	
☐ cows only		____ acres/cow	
☐ other ________		____ acres/animal	

30. At what point in the season did you determine the percentage of your total wheat acres that would be grazed out?
☐ prior to planting ☐ when livestock were removed from fall/winter pasture
☐ at planting ☐ during the fall/winter grazing season ☐ other

31. Rank the top three factors that influence your decision on how many, if any, acres you graze-out each year. (Please rank the top three (1, 2, 3) with 1 being most important and leave the rest blank)
__ cattle prices __ wheat prices __ available capital to purchase cattle
__ lack of moisture __ hail or high winds __ cheat
__ crop rotation __ income from pasture leasing __ other __________

The following items deal with lease arrangements for wheat pasture grazing. If you did not rent or lease wheat pasture then go to item 36.

32. If you were involved in wheat pasture rental then please answer the following items concerning your most typical fall/winter grazing lease. If you did not rent or lease wheat pasture then go to item 36.
For this agreement, (check one for each item)
a. you are ☐ livestock owner ☐ wheat producer How many acres are under this agreement? _____ acres
b. the lease is ☐ oral ☐ written How many years have these acres been leased? _____ years

33. The most recent rental price for fall/winter grazing was/is (Complete one blank with appropriate units.)
a. $/acre/year $______ b. $/acre/month $
c. $/cwt/month $______ d. $/lb of gain $
e. $/head/month $______ f. other ______ $

34. Under the price you gave in the previous item, who is responsible for the following services? (Check all that apply.)

	Livestock Owner	Wheat Producer	Both		Livestock Owner	Wheat Producer	Both
a. checking livestock	☐	☐	☐	b. salt and minerals	☐	☐	☐
c. fencing materials	☐	☐	☐	d. fencing labor	☐	☐	☐
e. fertilizer cost	☐	☐	☐	f. supplemental feeding	☐	☐	☐
g. supplemental pasture	☐	☐	☐	h. water	☐	☐	☐
i. other ______	☐	☐	☐				

35. The most recent rental price for graze-out acreage was/is (Complete one blank with appropriate units.)
a. $/acre/year $______ b. $/acre/month $
c. $/cwt/month $______ d. $/lb of gain $
e. $/head/month $______ f. other______ $

36. Thank you for your cooperation. In the space provided below, or on a separate sheet, please provide your ideas concerning what research topics in the area of wheat production and wheat pasture grazing should be given highest priority.

APPENDIX B

Reminder Postcard

Oklahoma State University
Dept of Ag Economics
Stillwater OK 74078

Oklahoma Agricultural Statistics
PO Box 528804
Oklahoma City OK 73152

March 2000

Dear Operator:

Last week you were mailed a questionnaire seeking information regarding wheat pasture grazing practices. Your name was selected at random from among all livestock producers in the state. The information you provide will be kept absolutely confidential and aid in research programs at O.S.U.

If you have already completed the questionnaire and returned it to us, please accept our thanks. If you have not completed the questionnaire, please take a few minutes and do so today.

Sincerely yours,

Francis M. Epplin, Professor
Agricultural Economics Department
405/744-7126

Barry L. Bloyd
State Statistician
405/522-6190

CHAPTER III

MORAL HAZARD IN THE RESPONSIBILITY OF INPUT APPLICATION UNDER AGRICULTURAL LEASE AGREEMENTS

INTRODUCTION

The USDA reported that 41% of U.S. farmland was operated under lease agreements in 1997 compared to 35% in 1950 (Hoppe and Wiebe, 2002). Many producers use leasing of agricultural land as a management strategy to conserve limited capital, expand their operation, or to reduce risk. Some landowners prefer to lease out land rather than farm it. The contractual form can vary over time and space, depending on the type of crop, prevailing technology, market structure, and other characteristics of the social and economic environment (Eswaran and Kotwal, 1985). Analysis of agricultural land lease arrangements has been a strong focus of economists since the early writings of Adam Smith and John Stewart Mill (Dasgupta et al., 1999). However, there is a lack of empirical analysis on agricultural lease contracts compared to the rich theoretical literature (Allen and Lueck, 1992; Dasgupta et al., 1999).

Several researches have investigated reasons for the existence of various contractual forms (Alston and Higgs, 1982; Janssen et al., 2002; Otsuka and Hayami, 1988; Stiglitz, 1974). However, all contract types, lease agreements and negotiations involve assignments of responsibilities to supply relevant inputs and tasks to the contracting parties of landlord and tenant.

Based upon economic theory, one of the main goals of an optimal contract should be to achieve efficient resource allocation. To achieve efficiency, it may be necessary to recognize the importance of moral hazard in the input responsibility delegation process. Moral hazard refers to the opportunity for one party to adjust input levels to maximize their own payoffs at the expense of overall efficiency. In an arrangement in which costs, benefits, and resource allocation decisions are shared among two or more parties, resources may not be efficiently allocated if the contract does not assign the expected net present value of benefits in the same proportion as the expected net present value of costs.

Moral hazard also relates to the incentive to shirk from applying efficient amounts of inputs. This problem may result when full observation and monitoring of actions are either impossible or prohibitively costly (Holmstrom, 1979). Asymmetric information between contracting agents, output uncertainty, and existence of absentee landlords, may contribute to monitoring problems. For example, in a grazing lease contract between a landlord (pasture owner) and a cattle owner, the cattle owner cannot easily detect the effort put forth by the landlord if the landlord is responsible for checking the cattle. Although the cattle owner can make some inferences about the landlord's contribution, such as if fencing is inadequate and the cattle are observed walking on a highway rather than in a fenced pasture, this incomplete signal of the landlord's effort level may be insufficient to induce fully efficient effort or an effort level by the landlord that would satisfy a first-best efficient contract.

Timing of grazing initiation and termination is a responsibility in a dual-purpose wheat pasture lease that can be affected by moral hazard. In a dual-purpose system, the wheat is available for grazing by livestock from late November until development of the first hollow stem, usually in early March. Recommended management strategies include delaying livestock placement on the wheat until the plant roots are well anchored, ensuring adequate soil fertility, and removing livestock from the pasture prior to development of the first hollow stem stage of wheat development. Under these conditions, for a given planting date and reasonable stocking densities, fall-winter grazing is not expected to be detrimental to grain yield. However, grain yield will be reduced if the grazing initiation and termination is not done at the correct stage of wheat growth (Redmon et al., 1995; Redmon et al., 1996). If the responsibility of grazing initiation and termination is assigned to the cattle owner whose main goal is to maximize cattle production, wheat grain production may be negatively impacted.

Some empirical studies have found that landlords expect tenant moral hazard in use of inputs. When faced with the decision of issuing either horses or mules to their tenants without work-stock, Kauffman (1993) found that more landlords were willing to pay extra to buy mules. Mules, being sturdier than horses, were a type of physical capital that could stand potential neglect and abuse from the tenants.

Moral hazard can also take form as a mistiming in transplanting or a wrong fertilizer mix application, which can have negative consequences in future land productivity (Eswaran and Kotwal, 1985). It is also possible for the tenant to under-invest in inputs that have productive benefits beyond the lease term. The theoretical literature has shown that farmland owners usually have strong incentives to conserve soil as a means of protecting land value over the long run, whereas tenants are concerned with investments in maintaining productivity only over the expected life of the contract (Lichtenberg, 2001). The landlord may also refrain from applying the long-term optimal level of an input, when the productivity of that input is solely for the lease term. This kind of behavior on the part of both parties is a phenomenon not yet fully explored in the literature (Eswaran and Kotwal, 1985). However, efficient land and resource management choices, selection of inputs, and timely procurement and application of inputs are necessary ingredients for efficient resource allocation in farming operations. Hence, assignment of management and input responsibilities play an important role in determining the efficiency of resource use, which in turn affect the efficiency of agricultural production.

The efficient delegation of responsibilities for providing inputs in contracts has not received attention in the literature since Heady's 1971 paper. Heady showed with a simple one period model that input application can be efficient when the input application levels are divided to the relevant parties according to their share in outputs. However, all inputs are not divisible and Heady did not consider the inputs that have productive benefits beyond the lease period in the model. In an arrangement in which different agents provide non-divisible management and productive inputs, the means to achieve efficient resource allocation should be addressed in the contract design and specification. The challenge is to design a contract in which the expected net present value of benefits is assigned to each party in the same proportion as the expected net present value of costs. In this case, each party, landlord and tenant, will allocate resources in such a manner as to achieve efficient resource allocation.

This study differs in several respects from prior studies on resource allocation under agricultural contracts. First, a two period model is developed that accounts for differences in the productive life of inputs. Second, the possibility of moral hazard by the input provider is acknowledged. Third, data from pasture leases are used to test some of the qualitative propositions. Some pasture leases contain crop-share aspects and others are more nearly characterized as cash-rent arrangements.

OBJECTIVES

The objective of this study is to develop a model for lease contracts to determine the consequence of delegating specific input responsibilities to one of the relevant parties from the efficiency point of view. Some of the implications of the model are then empirically tested using data from Oklahoma statewide farmland leasing surveys conducted in 1998 and 2000.

CONCEPTUAL FRAMEWORK

A model is developed to explain the outcome of delegating different input responsibilities to specific parties (tenant or landlord) in a lease contract. The contract can be either a crop-share or a cash-rent lease. Both landlord and tenant are assumed to be risk neutral. The productive capacity of a specific input is assumed to be identical irrespective of who provides it. The landlord and tenant are assumed to have the same production function. Both are assumed to be price takers and each party is assumed to have the same marginal opportunity cost for the identical input.

Assume that the objective of a two-period and one input model is to maximize net returns to land, V, with respect to a specific input x:

$$V(x) = rV1[(1-\delta)x] + (1-r)V1[(1-\delta)x] + \left(\frac{1}{1+d}\right)V2(\delta x) - wx \tag{1}$$

where: x is the composite level of the applied input in the lease period that includes both quantity and quality; δ is the proportion of the applied input that remains after the end of the lease period; $V1$ is the net returns to land during the lease period; $V2$ is the net returns to land after the end of the lease period; r is the tenant's share of $V1$; $(1-r)$ is the landlord's share of $V1$; d is the discount factor to place a greater preference on value received in the near future relative to the distant future; w is the exogenously determined per unit opportunity cost of the input.

Depending on the nature of the input, the range of δ is $0 \leq \delta \leq 1$. $\delta = 0$ means the applied input is fully used in the contract period and no productivity is left from that input after the contract period ends. For example, all the benefits from using a mineral supplement for livestock in a pasture grazing lease will be captured during the lease period. Hence, livestock mineral supplement has $\delta = 0$. $\delta > 0$ means that some portion (δ) of the applied input carries over to the period after the lease ends. When fencing materials are used during the lease period, some portion of the flow of fencing services will be used during the lease period, but some of the productivity from a permanent fence may remain after the lease terminates. Therefore, for a one year lease, the δ for permanent fencing materials may be greater than zero.

The value of r depends on the form of the contract agreement. The range is $0 < r \leq 1$. If r = 0, then it can not be considered a lease contract between a landlord and a tenant; it may be that a laborer is hired (fixed-wage) by the decision making farmer to help with farming chores, which is not relevant in this case. In a cash-rent contract, the tenant pays a lump-sum fee to the landlord for the contract and receives all the value during the contract period. For a cash-rent tenancy contract, r will be equal to one. For a crop-share tenancy contract: $0 < r < 1$.

In a lease contract, the tenant does not receive any benefit from the applied inputs after the contract period ends, ceteris paribus. So, the objective function for the tenant is:

(2) $$\max V_t(x) = rV1[(1\text{-}\delta)x] - swx$$

where s is the tenant's share in input cost. On the other hand, the landlord receives (1-*r*) portion of the lease period benefit, *V1*, and all of the benefits (*V2*) after the lease period ends, and shares (1-*s*) portion of the input cost, ceteris paribus. Hence, the objective function for the landlord is:

(3) $$\max V_l(x) = (1-r)V1[(1-\delta)x] + \left(\frac{1}{1+d}\right)V2(\delta x) - (1-s)wx$$

All three objective functions are assumed to be well behaved; $V1_x > 0$, $V2_x > 0$, $V1_{xx} < 0$, and $V2_{xx} < 0$, where the subscripts denote partial derivatives. The first-order conditions for (1), (2) and (3) are as follows:

(4) $$rV1_x + (1-r)V1_x + \left(\frac{1}{1+d}\right)V2_x - w = 0$$

(5) $$rV1_x - sw = 0$$

(6) $$(1-r)V1_x + \left(\frac{1}{1+d}\right)V2_x - (1-s)w = 0$$

Different objective functions have different marginal conditions that determine equilibrium input allocations. Solving (4) will give the first best efficient level of x^*. If the applied input level is not equal to x^*, resource allocation from the societal perspective will be inefficient. The scope of the present study is limited to two cases, when $s = 1$ and $s = 0$.

If the tenant is responsible for the entire cost of the input ($s = 1$), he will maximize his objective function (2) and apply the level x_t^* (solving (5)). At $s = 0$, x_t^* is undefined. If $r = 1$ and $\delta = 0$, then the objective function of the tenant (2) is same as the overall objective function (1). In this case, $x^* = x_t^*$. For other relevant cases, $0 < r < 1$ and $0 < \delta \leq 1$, the tenant receives only a portion of full benefit and $V_t < V$. Consequently, the tenant will apply less than the efficient input level ($x_t^* < x^*$) in equating his share of the value of the marginal product with the marginal factor cost. Figure III-1 includes a chart to illustrate the divergence between a societal efficient level of x and the tenant's optimal level of x when $\delta \neq 0$.

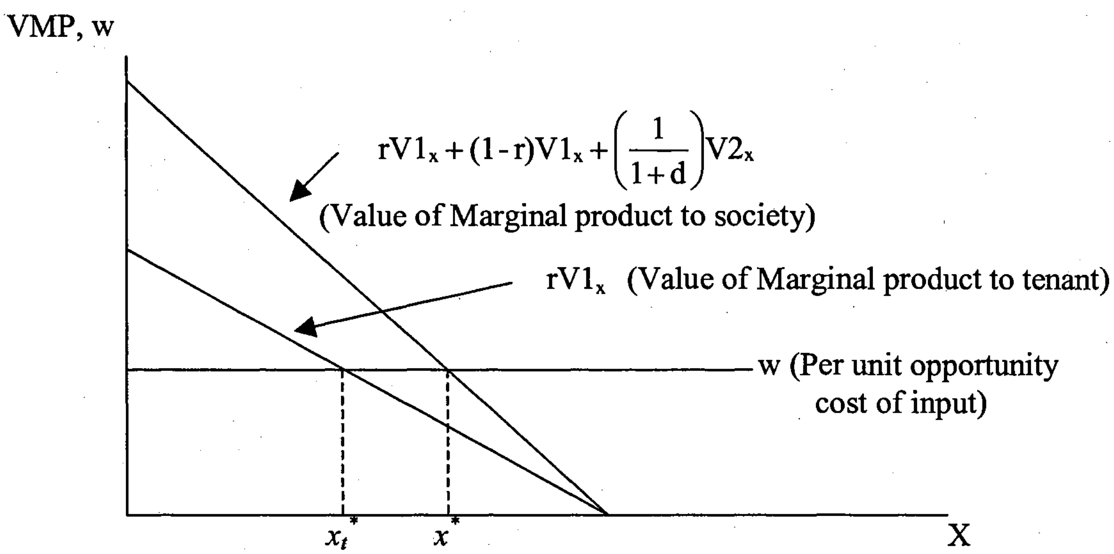

Figure III-1. Application of input by tenant compared to the efficient level ($0 < r < 1$ and $0 < \delta \leq 1$, and $s = 1$).

If the landlord is responsible for the entire cost of the input ($s = 0$), he will solve (6) and apply x_l^*. At $s = 1$, x_l^* is undefined. When $\delta = 1$, $V1$ will be zero and the landlord receives all the benefit from the applied input as $V2$. Therefore, the landlord will apply the efficient level of input, $x_l^* = x^*$, in that case. For other cases, the landlord does not receive all the benefits ($V_l < V$) and will apply an input level that is less than the optimal level. Figure III-2 is used to illustrate the divergence when $\delta \neq 1$.

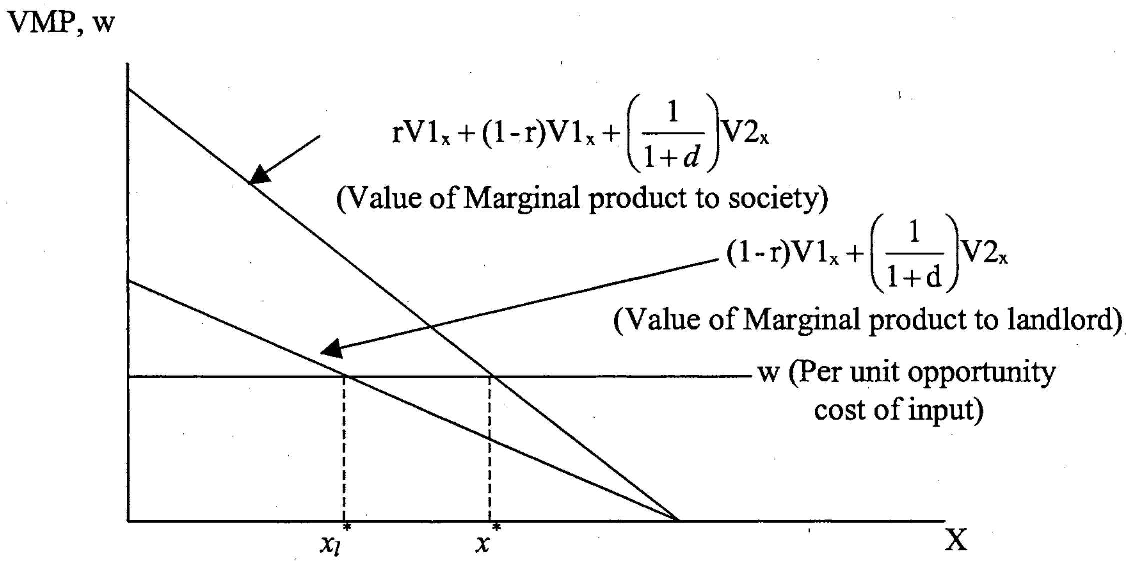

Figure III-2. Application of input by landlord compared to the efficient level ($0 < r \leq 1$ and $0 \leq \delta < 1$, and $s = 0$).

An Illustration with A Power Production Function

In this section, the model presented above is illustrated using a power production process; $y(x) = x^{\beta}$ for $0 < \beta < 1$, where y is the output. Normalizing the output price to 1 and substituting $y(x)$ into the equations (1), (2) and (3) yields (7), (8) and (9), respectively.

(7) $$V(x) = r[(1\text{-}\delta)x]^{\beta} + (1\text{-}r)\,[(1\text{-}\delta)x]^{\beta} + \left(\frac{1}{1+d}\right)(\delta x)^{\beta} - wx$$

(8) $$V_t(x) = r[(1\text{-}\delta)x]^{\beta} - swx$$

(9) $$V_l(x) = (1\text{-}r)[(1\text{-}\delta)x]^{\beta} + \left(\frac{1}{1+d}\right)(\delta x)^{\beta} - (1-s)wx$$

Solving for optimal levels of x, x_t and x_l from the respective first order conditions, yields:

(10) $$x^{*} = \left[\frac{\beta((1\text{-}\delta)^{\beta}(1+d)+\delta^{\beta})}{w(1+d)}\right]^{\frac{1}{1-\beta}}$$

(11) $$x_t^{*} = \left[\frac{r\beta(1\text{-}\delta)^{\beta}}{sw}\right]^{\frac{1}{1-\beta}}$$

(12) $$x_l^{*} = \left[\frac{\beta((1\text{-}\delta)^{\beta}(1+d-r-rd)+\delta^{\beta})}{(1-s)w(1+d)}\right]^{\frac{1}{1-\beta}}$$

V_e, V_e^t, and V_e^l may be derived by substituting x^*, x_t^* and x_l^* into equation 7.

V_e is the net returns to land when applying the efficient level of input, V_e^t is the net returns to land when the tenant is responsible for the entire cost of input and applies his own optimal level x_t^*, and V_e^l is the net returns to land when the landlord is responsible for the entire cost of input and applies his own optimal level x_l^*.

(13)

$$\begin{aligned} V_e(x^*(\delta)) = {} & s(1-\delta)^{\beta}\left[\frac{\beta((1\text{-}\delta)^{\beta}(1+d)+\delta^{\beta})}{w(1+d)}\right]^{\frac{\beta}{1-\beta}} \\ & + (1-s)(1-\delta)^{\beta}\left[\frac{\beta((1\text{-}\delta)^{\beta}(1+d)+\delta^{\beta})}{w(1+d)}\right]^{\frac{\beta}{1-\beta}} \\ & + \left(\frac{1}{1+d}\right)\delta^{\beta}\left[\frac{\beta((1\text{-}\delta)^{\beta}(1+d)+\delta^{\beta})}{w(1+d)}\right]^{\frac{\beta}{1-\beta}} \\ & - w\left[\frac{\beta((1\text{-}\delta)^{\beta}(1+d)+\delta^{\beta})}{w(1+d)}\right]^{\frac{1}{1-\beta}} \end{aligned}$$

(14)

$$V_e^t(x_t^*(\delta, rs)) = s(1-\delta)^\beta \left[\frac{s\beta(1-\delta)^\beta}{sw}\right]^{\frac{\beta}{1-\beta}}$$
$$+ (1-s)(1-\delta)^\beta \left[\frac{s\beta(1-\delta)^\beta}{sw}\right]^{\frac{\beta}{1-\beta}}$$
$$+ \left(\frac{1}{1+d}\right)\delta^\beta \left[\frac{s\beta(1-\delta)^\beta}{sw}\right]^{\frac{\beta}{1-\beta}}$$
$$- w\left[\frac{s\beta(1-\delta)^\beta}{sw}\right]^{\frac{1}{1-\beta}}$$

(15)

$$V_e^l(x_l^*(\delta, r, s)) = r(1-\delta)^\beta \left[\frac{\beta((1-\delta)^\beta(1+d-r-rd)+\delta^\beta)}{(1-s)w(1+d)}\right]^{\frac{\beta}{1-\beta}}$$
$$+ (1-r)(1-\delta)^\beta \left[\frac{\beta((1-\delta)^\beta(1+r-s-sd)+\delta^\beta)}{(1-s)w(1+d)}\right]^{\frac{\beta}{1-\beta}}$$
$$+ \left(\frac{1}{1+d}\right)\delta^\beta \left[\frac{\beta((1-\delta)^\beta(1+d-s-sd)+\delta^\beta)}{(1-s)w(1+d)}\right]^{\frac{\beta}{1-\beta}}$$
$$- w\left[\frac{\beta((1-\delta)^\beta(1+d-s-sd)+\delta^\beta)}{(1-s)w(1+d)}\right]^{\frac{1}{1-\beta}}$$

The difference in net returns to land with respect to δ resulting from these three cases will be illustrated when V_e, V_e^t, and V_e^l are drawn. Figure III-3 and III-4 include two sets, $s = 1$ and $s = 0$, respectively, of charts of three situations with w normalized to 1, $\beta = 0.7$, and $d = 0.1$.

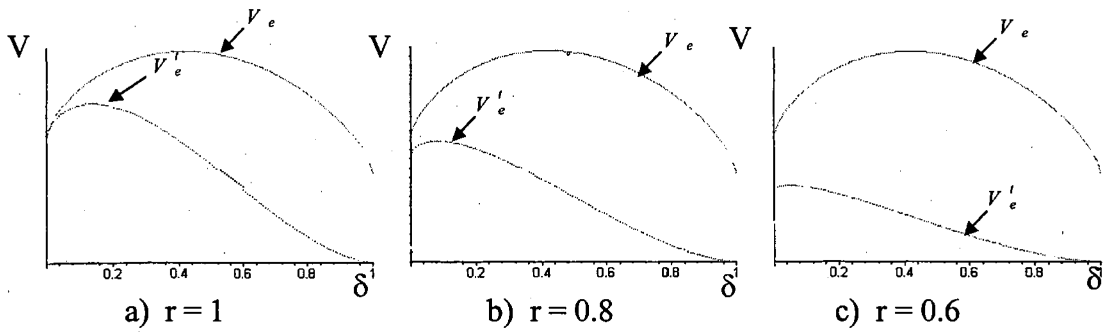

Figure III-3. Net returns to land with respect to the efficient level of input use (x^*), and the tenant's optimal level (x_t^*) of input across different values of *r*, when *s* = 1.

Figure III-3 includes three charts to illustrate the net returns to land when the tenant is responsible for the entire cost (s = 1) of the input, each with a different level of tenant's share (r) in *V1* (net returns to land during the lease period).

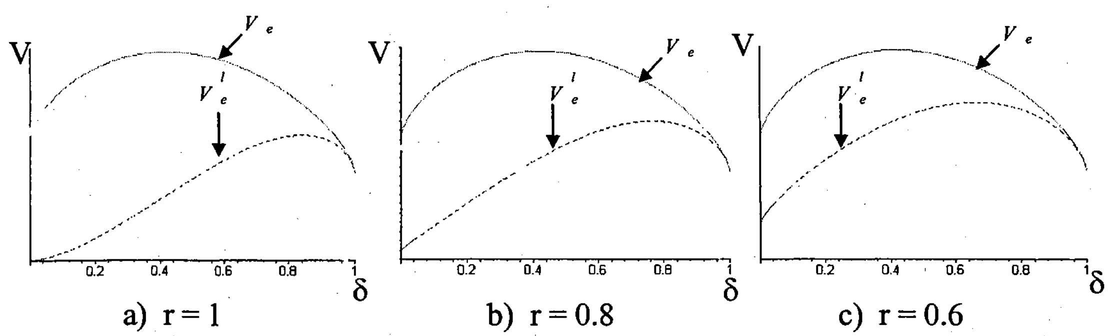

Figure III-4. Net returns to land with respect to efficient level (x^*), and landlord's optimal level (x_l^*) of input across different values of *r*, when *s* = 0.

Figure III-4 includes three charts to illustrate the net returns to land when the landlord is responsible for the entire cost (s = 0) of the input, each with a different level of tenant's share (r) in *V1*. Net returns to land are graphed as a function of δ, the proportion of the applied inputs that remains after the end of the lease period. As δ increases, the responsible party adjusts the application of the input to maximize their own objective function. With the increasing δ, the landlord will capture a greater proportion of the value of the marginal product of the applied inputs. Hence, he will apply more and more input, and as a result V_e^l is an increasing function of δ. On the other hand, increasing δ reduces the value of the marginal product to the tenant. Therefore, he applies less and less input, and V_e^t is a decreasing function of δ.

This model suggests two hypotheses:

1. As δ increases, ceteris paribus, the landlord becomes more and more efficient in taking care of input application under all contract forms. Hence, to achieve efficient input allocation, decisions regarding the use of inputs with a "high" δ should be assigned in the lease to the landlord.

2. As r increases, ceteris paribus, the application of the input by the tenant will be more and more efficient. Hence, to achieve efficient input allocation, decisions regarding the use of inputs with a "high" r should be assigned in the lease to the tenant.

EMPIRICAL EVIDENCE

Data

Data for the empirical analysis were obtained from the Oklahoma statewide farmland leasing surveys conducted in Decembers of 1998 and 2000 (Doye et al., 1999; Doye et al., 2001). Agricultural land leasing is an important component of the farming operation in Oklahoma (True et al., 2001). The Oklahoma Cooperative Extension Service and the Oklahoma Agricultural Statistics Service jointly conducted the surveys. Questionnaires were mailed to individuals involved in farming in Oklahoma. The results were distributed to farmers and other relevant parties by the Oklahoma Cooperative Extension Service. Approximately 624 surveys in 1998 and 528 surveys in 2000 were returned with useable data, which were lumped together. Each questionnaire included a section on wheat pasture grazing leases and a section on other pasture leases. For the analysis, the data from these two sections were used. Each observation was organized as a single lease contract between a tenant and a landlord. The data contained information on the methods of rental price used, the type of respondent – tenant or landlord, the type of agreement – annual or multi-year, oral or written, certain specific tasks or inputs used and the responsible party for each of those, and other similar information. It was assumed in the analysis that the pasture producer was the landlord and livestock owner was the tenant, which would normally be the case.

For the empirical tests, only observations from annual agreements were used. By not using the multi year contracts, the effect of contract length on the distribution of input supply responsibilities between the relevant parties was eliminated. Empirical evidence in the United States indicates that landlords and tenants are more likely to cooperate in sharing information in contracts negotiated for several years, whereas less information is shared in single-year contracts (Dasgupta et al., 1999). Ideally only written contracts would be evaluated. An oral contract suggests that there may be a substantial amount of trust prevailing between landlords and tenants, perhaps a result of long-term acquaintances. This means there may be less of a chance for moral hazard in their actions when the contract is oral. However, there were few (approximately 30%) written contracts reported in this survey, which made it difficult to conduct the relevant tests with only the written contracts. Therefore, data from both the oral and written contracts were combined. In the data set, a specific input is provided by only one of the two parties.

Hypothesis Tests

For the tests, the proportions of the two relevant groups were compared to determine whether the difference of proportions was statistically significant. For example, it was determined how frequently fencing labor was the responsibility of the landlord in a share contract and in a cash-rent contract. The two proportions were tested to determine if the difference supported the implication of the model. Accordingly, each test had one direction (one-sided). The input responsibilities or the groups in the tests were chosen to facilitate a clear identification of the incidence of benefits that would determine the efficient assignments of those inputs. Also, the inputs with clearly distinguishable difference in δ were compared to address the moral hazard issue.

Statistical computations for the tests are described below (Agresti, 1990). If for the first group, n_1 has a binomial distribution with sample size n_{1+}, then the sample proportion is

$$p_1 = \frac{n_1}{n_{1+}}$$

The standard error of p_1 is computed as

$$se(p_1) = \sqrt{\frac{p_1(1-p_1)}{n_{1+}}}$$

Similarly, the sample proportion and standard error of the second group are

$$p_2 = \frac{n_2}{n_{2+}}$$

$$se(p_2) = \sqrt{\frac{p_2(1-p_2)}{n_{2+}}}$$

Assuming two groups represent independent binomial samples, their difference is

$$diff = p_1 - p_2$$

The standard error for the difference is

$$se(diff) = \sqrt{variance(p_1) + variance(p_2)}$$

Using the normal approximation to the binomial distribution, the test statistic is calculated as

$$z = \frac{diff}{se(diff)}$$

z has a standard normal distribution. If the p-value is less than the confidence level, the null hypothesis of $diff = 0$ will be rejected. The FREQ procedure in SAS was used to conduct the hypothesis tests (SAS Institute, 1999).

RESULTS

The questionnaire contained two sections that addressed pasture leases. One section was directed to leases of wheat pasture and the second section was directed toward other types of pasture. The "other pasture lease" section of the questionnaire included a question to determine the major type of forage respondents grew on their acreage. The choices given were: native grassland, Bermuda, sorghum pasture, old world bluestem, and other. Native grassland refers to native prairies that produce forage from indigenous species on land that has never been tilled. Bermudagrass and old world bluestem are introduced perennial species. Sorghum is an annual species that may be used as a forage crop. Most tests were carried out in three groups: "native grassland only"- using the observations that were checked native grassland, "wheat pasture only"- using the observations from the wheat pasture grazing lease section, and 'All'- using all the observations from the other pasture lease section and wheat pasture grazing lease section.

The differentiation between cash-rent and livestock share contracts need some discussion, since it was not directly defined in the survey. Respondents were asked to identify rental price method. The answer to the question of rental price method was used to differentiate between cash-rent and share. If the rental price method was $/acre/year or $/acre/month or $/head/month, the contract was classified as a cash-rent contract because of it's fixed rate nature. On the other hand, if the method was $/lb of gain, the contract was considered a share contract. In this case the output (cattle gains) affects the revenue of both the tenant (livestock owner) and landlord (pasture owner).

Cash-rent versus Share

In a cash-rent contract ($s = 1$) the tenant (livestock owner) will receive all the benefits that would result from using a specific input during the contract period, whereas lease period benefits will be shared among the parties in a share contract. So, the landlord (pasture owner) will have more interest in efficiently applying an input under a share contract than under a cash-rent contract. Hence, to take into account the moral hazard issue, the model suggests that the landlord (pasture owner) will be given the responsibility of providing a specific input more often under a share contract than under a cash-rent contract.

To check the implications of the model, a few relevant input responsibilities were selected. With respect to fencing materials using all the observations, landlords (pasture owners) took care of it 53% of the time in the share contracts and 44% of the time in the cash-rent contracts (Table III-1). With respect to fencing labor, landlords (pasture owners) took care of the responsibility 50% and 36% of the time in share and cash-rent contracts, respectively (Table III-1). As hypothesized, landlords (pasture owners) were responsible for both inputs more often in share contracts compared to cash-rent contracts. The differences of proportions were significant at the 5% level of confidence in the case of fencing labor and at the 10% level of confidence in the case of fencing materials. The differences of proportions also had the correct sign in the other two groups. However, the differences were significant at the 5% level in the "wheat pasture only" group, but only the difference for fencing labor was significant at the 10% level in the "native grassland only" group.

In some winters it may be necessary to provide supplemental feed when wheat pasture is covered by snow. The landlord's (pasture owner) revenue is affected by the well-being and weight gains of the livestock more in the share contracts than in the cash-rent contracts. It was found that in the case of supplemental feeding and supplemental pasture in winter wheat pasture grazing leases, landlords were responsible for the tasks more frequently in share contracts compared to cash-rent contracts (Table III-1), which supports the stated hypothesis. The difference of the proportions was significant at the 5% level for supplemental feed, but it was not significant at the 10% level for supplemental pasture.

Inputs with Different δ

Some inputs have higher δ, the proportion of the applied inputs that remain after the end of the lease period, than others. The inputs with higher δ are more beneficial to the landlord (pasture owner), since landlords will receive any benefits from the leftover inputs after the contract period. Therefore, it is comparatively efficient from the moral hazard point of view that landlords would be responsible more for the inputs with higher δ compared to the ones with lower δ. In this case, the observations from the cash-rent contract only are used to minimize the benefit incentives during the lease period that might be a factor for the landlords in the share contract.

Consider fencing materials and fencing labor. Materials have a higher δ compared to that of labor. It may be beneficial for the landlords to have good quality materials with better longevity. This will increase the land attributes with respect to future leasing activities. Alternatively, fencing labor will mainly include maintaining and fixing the fences, which would clearly benefit more during the contract period. Using all the observations, it was found that landlords (pasture owners) provided fencing materials 43% of the time and fencing labor 37% of the time (Table III-2). The difference was significant at the 5% level of confidence and consistent with the implied hypothesis. The difference also had the same correct sign in two other groups- "native grassland only" and "wheat pasture only".

Fencing materials have a higher δ than the checking livestock activity. Fencing materials have productive benefits beyond the lease period, whereas the benefits of checking livestock accrue solely during the lease period. Under the cash-rent contract, landlords do not have a direct vested interest in the livestock's overall well being. The results supported the hypothesis; landlords were responsible for fencing materials more often than for checking livestock (Table III-2). The differences of proportions were significant at the 5% level of confidence in all three groups.

Declining ecological condition on rangeland and pasture is a common consequence of overgrazing (Ellison, 1960). Native grassland in particular may suffer serious long-term negative effects in terms of the land's reproductive capacity due to overgrazing, whereas overgrazing is not a big problem on winter wheat pasture. Providing supplemental feed is one of the decision variables management can use to control overgrazing problems on native grassland. Good supplemental feeding and pasture activities in the case of native grassland help to limit the exploitation of forage resource for short-term profitability and preserve long-term soil and vegetation resource. From this point of view, it can be said that supplemental feed and supplemental pasture have a higher δ in native grassland leases than in winter wheat pasture leases. The landlords with the intention of maintaining long-term pasture productivity on grazing land will more often be responsible for supplemental feed and supplemental pasture for native grassland than for wheat pasture leases. Results in Table III-3 were consistent with this hypothesis. However, the difference of proportions was significant for supplemental feed and not significant for supplemental pasture at the 5% level of confidence.

SUMMARY AND CONCLUSIONS

Farmland leasing plays an important role in agricultural production in United States. It is important to determine if lease arrangements contribute to or detract from economic efficiency. There have been many analytical studies of contractual forms. However, there is a deficiency in empirical analysis in comparison to the extensive theoretical literature. Delegation of inputs and management responsibilities to the contracting parties is an important aspect of contract design that has received little attention. Since benefits from agricultural inputs may extend beyond the contractual period and since an optimal decision on the part of one party may not result in an efficient resource allocation, leases may be subjected to moral hazard.

When actions cannot be directly monitored because of high cost and output uncertainty, and inputs responsibilities are non-divisible, assignments of responsibilities need to take into account the possibility of moral hazard. Agricultural efficiency is largely affected by the proper use and application of relevant inputs. An important instrument to control moral hazard and increase efficiency is to assign input responsibilities in ways that will induce proper input use incentives. This study was initiated to understand the consequence of delegating specific input responsibilities to one of the relevant parties from the efficiency point of view. Hence, a model was developed and some implications were empirically tested.

Benefits to land with respect to a specific input were divided into two periods: benefit during the lease period and benefit after the lease period. Many agricultural inputs have productive benefits beyond the lease term. The model that was developed showed that the proportion of the marginal product of the applied inputs one receives depends on the party's output share received during the lease period and the proportion (δ) of the applied inputs that remain after the lease period. The agent who receives more value of the marginal product will be the one who will apply the level of input closer to efficient level.

Ceteris paribus, the inputs with higher δ will more likely be the responsibility of the landlord. Also the lower the share of the tenant in output, ceteris paribus, landlord will more likely have the input responsibility. Data from the 1998 and 2000 Oklahoma statewide farmland leasing surveys were used for hypothesis testing. The tests supported the implications of the model to a certain extent. However, some of the results were not as significant as expected.

There were some obvious limitations in the data set. One important aspect not considered is that many contracts are based on long-term relationships and between relatives, which alleviate some of the problems of moral hazard. The presence of many oral contracts, which may be a sign of trust and good mutual understanding, might have influenced some of the tests in the study. The data set also did not have any information about the proximity of the agents' location to the leased land and expectation of the renewal of the contracts with the same parties, which could have played a role in delegation of the input responsibilities. Addressing some of these limitations in future surveys would make the tests better controlled. Future models examining delegation of input responsibilities could be improved by including other relevant technological and institutional factors such as local customs and values.

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Table III-1. Fencing and supplemental feed provided by the landlord (pasture owner) in annual share and annual cash-rent contracts (proportions).

	Share p_1	Cash-rent p_2	*Difference* p_1-p_2	*P-value*	Sample Size
			Fencing		
Native Grassland only					
Fencing Materials	0.52	0.41	0.11	0.155	243
Fencing Labor	0.48	0.33	0.15*	0.085	252
Wheat Pasture only					
Fencing Materials	0.56	0.39	0.17**	0.048	94
Fencing Labor	0.55	0.32	0.23**	0.01	94
All					
Fencing Materials	0.53	0.44	0.09*	0.064	525
Fencing Labor	0.50	0.36	0.14**	0.009	535
			Supplementals		
Wheat Pasture only					
Supplemental Feed	0.29	0.15	0.14**	0.045	97
Supplemental Pasture	0.36	0.26	0.10	0.145	90

** Significant at the 0.05 probability level.
* Significant at the 0.10 probability level.

Table III-2. Proportions of various input responsibilities provided by the landlord (pasture owner) in annual cash-rent contracts.

	p_1	p_2	*Difference* p_1-p_2	*p-value*	Sample Size
	Fencing Materials	**Fencing Labor**			
Native Grassland only	0.41	0.34	0.07*	0.068	434
Wheat Pasture only	0.40	0.31	0.09	0.189	90
All	0.43	0.37	0.06**	0.025	860
	Fencing Materials	**Checking Livestock**			
Native Grassland only	0.40	0.31	0.09**	0.018	440
Wheat Pasture only	0.40	0.16	0.24**	0.008	86
All	0.44	0.33	0.11**	0.0009	874

** Significant at the 0.05 probability level.
* Significant at the 0.10 probability level.

Table III-3. Proportions of supplemental feeding and supplemental pasture provided by the landlord (pasture owner) in native grassland versus in wheat pasture (annual cash-rent contract).

	Native Grassland p_1	*Wheat Pasture* p_2	*Difference* p_1-p_2	*p-value*	*Sample Size*
Supplemental Feed	0.30	0.15	0.15**	0.013	291
Supplemental Pasture	0.30	0.26	0.04	0.32	259

** Significant at the 0.05 probability level.
* Significant at the 0.10 probability level.

VITA 2

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