VARIETAL AND CLIPPING EFFECTS ON SEASONAL FORAGE DISTRIBUTION, GRAIN YIELD AND ECONOMIC RETURNS FOR WINTER WHEAT UTILIZED AS A DUAL-PURPOSE CROP

By

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CHAPTER I

INTRODUCTION

In the Southern Great Plains, winter wheat (Triticum aestivum L.) is grown extensively as a dual-purpose crop. Winter wheat is grown primarily for grain production, but it is also utilized as a high quality forage for livestock. Every year in Oklahoma 35 to 55 percent of the wheat acreage is grazed by stockers (Bos taurus L.). The general practice is to graze the wheat during the vegetative growth stage in the fall, winter and early spring, then remove cattle to allow reproductive development for a grain crop.

Farm income can potentially be improved by utilizing both forage and grain. In Oklahoma this is very important since cattle and wheat are the top two commodities in terms of cash receipts. Oklahoma was the second leading hard red winter wheat producer in the United States, with over 7 million acres planted (Oklahoma Department of Agriculture, 1987). Also, Oklahoma was the fourth leading state in cattle and calf inventories with over 5 million, 1.2 million of which were stocker calves. However, due to climatic effects on wheat forage availability and cattle prices, acreage of wheat grazed varies from year to year.

Traditionally, variety selection has been based upon grain yield with little or no attention to forage productivity. However, varietal differences do exist for forage production. In a grazing plus grain system, varieties capable of producing larger amounts of fall and winter forage are important. The profitabilty of beef production is highly dependent upon available forage during the winter months when wheat growth decreases under low temperatures, drought stress or snow cover, but stocking rates remain the same.

If climatic conditions allow, wheat intended for grazing should be planted earlier than wheat intended solely for grain. This promotes early establishment of wheat pasture, and helps ensure a plentiful forage supply before the winter dormant period.

Substantial variation exists in the literature concerning the effect of grazing on grain yield. Removal of forage by cattle can have an adverse effect upon grain yield. However, if grazing intensity is moderate and grazing is terminated before growing points reach grazing height, grain yield may not be affected.

Utilizing winter wheat for both forage and grain reduces the economic risk involved with producing either product alone, and offers the producer a means of diversification and management alternatives. For producers to make optimum economic decisions on wheat utilization, it is important to know which varieties are best adapted to forage plus grain management systems if genetic differences indeed exist. The objectives of this study are:

1. Evaluate varietal differences for fall, spring and total forage production, the persistence of these differences across environments, and the relationship between fall and spring forage production.
2. Determine the effects of date of grazing termination on grain yield and yield components.
3. Determine whether wheat varietal selection affects economic returns in grain plus forage management systems, and whether genotype by environment interactions are significant for economic return in Oklahoma.

CHAPTER II

LITERATURE REVIEW

Grazing winter wheat during vegetative growth is a common practice in the Southern Great Plains when climatic conditions are favorable (Winter and Thompson, 1987). Wheat will go into a dormant period during the winter months, when temperatures remain low enough that growth ceases. Any forage produced before that time may be lost to low temperatures if it is not utilized as a feed source for grazing. All small grains meet or exceed the nutrient requirements of grazing livestock, regardless of class or species (Horn, 1983).

One of the limiting factors to the dual-purpose production of winter wheat is fall and winter forage quantity. When grazing wheat, low forage availability during mid-winter to late-winter may necessitate feeding of supplemental hay and grain (Denman and Arnold, 1970). Huffine et al. (1960) reported that the period of forage production (fall, winter or spring) for any variety of small grain is just as important or even more so than the total forage yield.

Worrall and Gilmore (1985) reported significant differences among varieties for early season forage production. However, they defined early season forage as that produced before March 15. They concluded that one of the key management decisions a producer must make is which variety to plant. This decision must be based on grain yield potential, desired grain yield, varietal adaptation and amount and timing of forage harvests.

Management practices used to maximize forage production differ from those recommended for grain production (Donnelly and McMurphy, 1983). For maximizing grazing potential, an earlier planting date, a higher seeding rate and increased amounts of fertilizer are often used. Higher seeding rates are used to provide more fall and winter forage and to offset plant losses incurred through trampling, which can eventually contribute to reduced grain yields. If moisture is available, wheat intended for grazing should be planted earlier than wheat intended for grain only (Donnelly and McMurphy, 1983). Earlier planting provides quick establishment of wheat pasture, which helps ensure adequate amounts of fall and winter forage and a longer grazing season. To produce enough fall forage to carry cattle through the winter, planting in the Rolling Plains of Texas should be near the middle of September (Worrall and Gilmore, 1985). Holt et al. (1969) working at College Station, Texas also found that a September or early October planting date was best for fall and winter forage production.

Nitrogen is the primary nutrient deficiency usually associated with reduced forage yields (Donnelly and McMurphy, 1983). Grazing cattle will consume large amounts of nitrogen present in wheat forage, eventually depleting soil nitrogen. Thus, remaining nitrogen levels in the soil are insufficient to produce more forage or satisfactory grain yields. According to Johnson and Tucker (1982), 60 lb of nitrogen per acre are removed with every 2000 lb per acre of forage removed. Nitrogen requirements should be based upon desired grain yield and expected forage removal during the grazing season.

Reports of grazing effects on grain yield have been quite variable. Sharrow and Motazedian (1987) suggest that variations on reported effects of grazing on grain yield are due to grain yield interactions with factors such as climate, agronomic practices and grazing management. The interaction between management and climate is very important in determining the profitability of dual-purpose wheat. Most research shows that in years with favorable growing conditions grazing will not reduce grain yields if grazing intensity is not too severe and grazing is terminated before or at early joint (Hubbard and Harper, 1949; Christiansen et al., 1989). During years when moisture is not a limiting factor, grazing can increase grain yield by reducing the amount of lodging (Kiesselbach and Lyness, 1948). However, wheat grazing can reduce grain yields if stress resulting from forage removal is severe and prolonged, such as during a year of unfavorable growing conditions (Christiansen, 1983).

The development and growth of the wheat plant is governed primarily by factors such as temperature, nutrient supply, and moisture, all of which may be altered due to the presence of grazing animals (Christiansen, 1983). In the fall, winter and early spring, vegetative growth of winter wheat is characterized by excessive production of tillers. Wheat plants usually produce many more tillers than will ever reach maturity (Evans et al., 1975). Swanson and Anderson (1951) at Hays, Kansas have shown that a normal crop of wheat will produce 6 to 7 million tillers per acre by early joint, but only 2 to 3.5 million of these will reach maturity and produce grain. Swanson and Anderson (1951) reported that winter wheat is able to adjust to the removal of tillers by grazing (fall, winter and early spring) if removal occurs before jointing.

In the spring, as temperatures increase, vernalized tillers begin reproductive growth. Soon, at the early joint stage, the growing points move to the soil surface as the stem internodes begin expanding. Growth becomes more erect and excessive tillers begin to senesce. The growing point has become the spike with immature spikelets already initiated. It is well established that removal of these spikes will greatly reduce grain yield (Hubbard and Harper,1949). Depending on growing conditions, the date of jointing can vary considerably from year to year (Dunphy et al., 1982). Even though many publications list a common date for grazing termination in a given region, careful dissection of the wheat plants to determine the early joint stage of development should be used as an indicator of grazing termination dates (Hubbard and Harper, 1949). Qualset and Stanley (1968) recommend that grazing should be terminated before growing points are 30 to 50 millimeters above ground.

The profitability of dual-purpose wheat is influenced by the total animal and grain production from it (Dann et al., 1983). Economic returns from dual-purpose wheat are also dependent upon beef and grain prices. Productivity of beef and grain, plus the price received for both vary from year to year making decisions concerning the most profitable way to use them difficult. Budgets can be used to clarify the impact of grain and forage production on potential income (Doye and Krenzer, 1989). Budgets include information about the specific resources and management practices used in a particular production process, and can be tailored to fit different cost scenarios (Doye and Krenzer, 1989).

CHAPTER III

MATERIALS AND METHODS

Studies were conducted in six environments over the 1987-1988 and 1988-1989 growing seasons. The first year included locations at Cherokee and Purcell, while in 1988-1989 studies were repeated at Cherokee and Purcell and added at Retrop and Ringling. Respective soil types and families at those locations were: Dale silt loam, fine-silty, mixed, thermic Pachic Haplustolls; Kirkland silt loam, fine, mixed, thermic Udestic Paleustolls; St. Paul silt loam, Fine-silty, mixed, thermic Pachic Argiustolls; and Zaneis-Wing complex, Fine-loamy, mixed, thermic Udic Arguistolls, respectively. All of the locations were non-irrigated upland sites where wheat was the previous crop.

To simulate actual farming practices, all experiments were conducted in farmer's fields where all field work including seedbed preparation and anhydrous ammonia application was performed by the farmer. Before planting, soils were tested for levels of nitrogen, phosphorous and potassium. Fertilizer was applied in the proper amounts at planting to obtain a grain yield of 50 bu/A. Planting started as soon after September 1 as moisture was available, using 1.5 million seeds per acre. Planting dates for individual locations are shown in Table I.

Plots were topdressed in the spring to replace soil nitrogen removed with the forage harvests. Amounts of nitrogen used for topdressing were based on 30 lbs of nitrogen used for every 1000 lbs of forage removed. All plots at a location received the same amount of nitrogen based on the average amount of forage removed by higher yielding varieties at that location. Weeds and insects were controlled with Glean and Malathion or Lorsban as needed.

A randomized complete block design with four replications was used in the study. Plots were planted in a split-plot arrangement consisting of eighteen varieties as main-plots and two clipping treatments as sub-plots. One sub-plot was clipped until dormancy, and the other was clipped until early-joint. Clipping was terminated at early joint to avoid removal of any growing points. For this study, early joint was defined as when the growing points were at or near the soil surface. Tiller dissection was used to observe the height of the growing points. Clipping dates for each location are shown in Table I.

Each sub-plot consisted of 5 rows spaced 10 inches apart and having a length of 22 feet. A modified self-propelled Kincaid clipper was used for forage harvests to simulate grazing cattle. When the forage reached a height of approximately 8 inches, plots were clipped to a height of 2 inches. The entire plot was clipped but only the center 15 feet used for yield determinations. Subsamples taken at each clipping for yield determinations were oven-dried at 35^{0}C to a constant weight.

Measurements at each location included fall forage, spring forage, plant height, heads per meter of row, kernels per head, weight per kernel, grain yield and test weight. Forage clipped before the winter dormant period was called fall forage. Forage clipped after wheat regrowth had begun in the spring but before the growing point had moved above the soil surface (early joint stage) was called spring forage. Fall and spring forage yields were then added to give total forage yield. Plant height and heads per meter of row were measured between heading and maturity. At maturity, 25 heads from each plot were harvested to determine kernels per head and weight per kernel. All counts and measurements for yield components and height were performed on the middle row of each plot. Grain was harvested with an Almaco plot combine, after plots were trimmed to 15 feet. Harvest dates for each location are shown in Table I.

An analysis of variance was conducted to determine clipping treatment effects on grain yield and grain yield components at Cherokee and Purcell during the 1987-88 season. Only the sub-plots that were clipped until early joint were used to evaluate varietal effects on fall, spring and total forage yield and total returns per acre. Therefore, the analysis of variance for forage yields and returns per acre were conducted according to a randomized complete block design. For the analysis of forage production, each year-location combination was treated as an individual environment with varieties considered fixed factors and environments considered random factors. Variety means were statistically separated according to the least significant difference (LSD) multiple range test. All statistical analyses were generated with SAS (1987).

Variety x environment (GE) interactions were anticipated for fall, spring and total forage yields. According to Moll et al. (1978), the GE interaction could arise from varietal differences in responsiveness across environments and/or differences in correlations among pairs of varieties across environments. These components of the variety x environment interaction were calculated according to Moll et al. (1978). The contribution of varietal differences in responsiveness to environments was estimated by $\sum_{i<i'} (Si-Si')^2/p$, where the Si's may be considered to be measures of varietal responsiveness to environmental variation, and p represents the number of varieties. The contribution due to differences in correlations among pairs of varieties was estimated by $2 \sum_{i<i'} (1-rii')SiSi'/p$, where rii' is the correlation between varieties i and i' across environments. The smaller the correlation the greater the contribution to the interaction. The average of the correlations ($\bar{r}ii'$), for the ith variety with each of the other 17 varieties, was also calculated.

Values for Shukla's (1972) stability-variance statistic ($\sigma^2 i$), for fall, spring and total forage production were generated from GE means with a computer program developed by Kang (1989). This program partitions the variety x environment interaction into variance components corresponding to each variety, such that $\sigma^2 i$ is an unbiased estimate of the variance for variety i. The stability variance of each variety was tested for significance by an F test. The test statistic equaled the stability variance of variety i divided by the within-environment variance. Degrees of freedom were s-1 and st(r-1), where s=no. of environments, t=no. of varieties and r=no. of replications. The variety x environment interaction sums of squares was also partitioned into components representing heterogeneity of fitted regressions of variety mean on environmental mean (linear) and pooled deviations from the fitted regressions (nonlinear) (Perkins and Jinks, 1968).

An economic evaluation of forage and grain yields for individual plots was performed for Cherokee and Purcell locations in 1987-88 only due to low grain yields and high C.V.'s in other environments affected by drought and/or hail damage. Two enterprise budgets, one for wheat grain and pasture (Table II) and another for 100 head of stocker steers (Table III), were used to evaluate inputs and returns.

The enterprise budget for wheat grain and pasture assumed a price of \$3.50 per bushel of wheat along with dockage for low test weight. Discounts for low test weight were: test weights of 60 lbs/bu and above were not discounted, above 58 lbs/bu and below 60 lbs/bu were discounted \$0.005/bushel, above 56 lbs/bu and below 58 lbs/bu were discounted \$0.03/ bushel, above 54 lbs/bu and below 56 lbs/bu were discounted $0.05/bushel, and any test weights below 51 lbs/bu were discounted $0.12 dollars per bushel.

The enterprise budget for stocker steers was used to estimate forage value through stocker returns per head. Pounds of gain per head for the entire grazing season was built into the budget. Using the values obtained from these budgets, and assuming that it takes 10 lbs of dry matter per pound of gain, returns for grain, forage, and total returns per acre were calculated.

CHAPTER IV

RESULTS AND DISCUSSION

Variety x environment interactions for fall, spring and total forage production were highly significant (Table IV). The range in environment means was 600 to 2596 pounds per acre in the fall and 306 to 1233 pounds per acre in the spring. Despite those interactions in forage yield, significant differences were found among varieties for fall forage production, or forage produced before winter dormancy (Table IV). The best varieties for fall forage produced almost twice as much as the poorest varieties, indicating a potential two-fold difference in beef production from wheat pasture depending on variety selection (Table V). In contrast to fall forage production, there were no significant differences among varieties for average spring forage production (Tables IV and V). Significant differences existed among varieties for total forage production (Table IV). Since average fall forage production exceeded average spring forage production by almost two-fold, differences in total forage yield were predominantly determined by differences in fall forage yield. Thus, fall and total forage were significantly correlated (r=0.92,

$P<0.01$), while spring and total forage were not correlated ($r=0.08$, $P>0.05$). A significant negative correlation ($r=-0.29$, $P<0.01$) existed between fall and spring forage.

Because variety x environment interactions constituted a significant portion of the phenotypic expression of forage yield, particularly in the spring, further examination of these interactions was warranted. Using procedures described by Moll et al. (1978), the total variety x environment interaction was partitioned into components representing varietal differences in responsiveness to environmental variation and differences in correlation of varietal responses to environmental variation. For fall forage production the contribution due to varietal differences in responsiveness across environments accounted for only 27% of the total interaction, while 73% of the interaction was accounted for by differences in correlations among pairs of varieties. For spring forage production, the proportion due to differences in correlations among pairs of varieties increased to 80% of the interaction, indicating that varieties showed different patterns of response to environments.

The range in average correlations among varieties ($\bar{r}_{ii'}$) was 0.91 to 0.97 and 0.84 to 0.93 for fall and spring forage production, respectively (Table VI). The lower correlations observed in the spring again indicated differing response patterns, particularly for Agripro

Thunderbird, AGSECO 7837, Siouxland, and TAM W-101 ($\bar{r}ii'$ ranged from 0.84 to 0.86). These varieties, however, showed very similar responses to all other varieties in the fall ($\bar{r}ii'$ ranged from 0.95 to 0.97). Chisholm and Cody were the only varieties which had unusually low average correlations ($\bar{r}ii'$ ranged from 0.91 to 0.92) in the fall.

Moll et al., (1978) suggested that varieties which respond differently to environments, i.e., whose responses are poorly correlated, should not be used in the calculation of environmental indexes for regression analysis. Variety x environment interactions for forage yield were largely influenced by different response patterns of varieties. Under those conditions, characterization of varietal responses by the regression of genotypic means on environment means (Eberhart and Russell, 1966) would not provide useful insight into stability of forage yield. The stability variance, o^2i, was therefore calculated for each variety to provide an unbiased estimate of the variety x environment interaction variance. A variety was considered stable if its stability variance was equal to the within-environmental variance (Shukla, 1972). Smaller stability variance values indicate lesser contribution to the total interaction and thus, greater stability across environments.

Partitioning of the variety x environment interaction into o^2i components indicated that only three varieties were unstable for fall forage, while over half of the varieties for spring forage were unstable (Table VII). Cody was the only variety classified as unstable for both fall and spring forage yields. The lack of stability for spring forage was not caused by the linear effect of environment mean, as indicated by the nonsignificant heterogeneity term in Table VIII. The effect of environment mean as a covariate was therefore not removed from the stability variance value. The few unstable varieties for fall forage production indicates a high level of varietal stability across environments for fall forage production. On the other hand, varieties showing stable spring forage production were more difficult to find. It is noteworthy that the four varieties previously noted for their unusually low correlations (rii') in the spring, also had unusually high stability variance (o^2i). Cody and Chisholm were also noted for lower rii''s in the fall, and showed significant stability variances in the fall as well. Varieties with low stability variance (Table VII) and high mean yield (Table V), such as Agripro Wrangler or Arkan, are preferred over varieties that are low yielding and stable, such as Century, or varieties that are high yielding and unstable, such as Agripro Victory.

Forage production capability may be far more important in variety selection than previously reported by Worrall and Gilmore (1985) for early season forage production. The larger early season forage differences in this study compared to Worrall and Gilmore (1985) could be due to variations in weather patterns, production practices, or in the time frames used to define early season forage production. They considered all forage produced prior to jointing as early season forage since they did not have a pronounced dormant period like that in Oklahoma. Our total forage production is comparable to their early season forage production in that varietal differences were not as large as those for our fall forage production.

Since producers who graze stocker cattle on wheat pasture frequently find that the amount of forage produced in the fall limits the stocking rate which wheat pasture can support, and since varietal differences in spring forage were more sensitive to environment, fall forage capability appears most meaningful. However, total forage produced prior to jointing does impact profit from a dual-purpose wheat crop.

Grain yield and yield components measured at Cherokee and Purcell were reported separately due to a significant variety x location interaction (Table IX). However, there was no significant variety x clipping interaction for any character, suggesting varieties followed similar trends in response to clipping treatments. Grain yield was significantly reduced at both locations when clipping was continued until early joint. At Cherokee, those plots clipped until dormancy averaged 34.5 bushels per acre compared to 25.6 bushels per acre for those clipped until early joint, a 26% reduction in grain yield (Table IX). Removing forage until dormancy compared to early joint at Purcell averaged 40.9 and 35.7 bushels per acre respectively, which represents a 13% reduction in grain yield (Table IX). These yield reductions are in contrast to those of Dunphy et al. (1982) who reported no significant grain yield reductions when clipping was continued until early joint, but similar to those reported by Winter and Thompson (1987).

Although significant grain yield reductions occurred at Purcell, none of the grain yield components were significantly reduced by clipping until early joint (Table IX). The grain yield reduction at Purcell was not large enough to accurately tell which yield components accounted for the reduction. At Cherokee, all grain yield components were significantly reduced by clipping until early joint (Table IX). Clipping until early joint reduced kernel weight by 9 percent, heads per meter, 7 percent, and kernels per head, 4 percent compared to clipping until dormancy.

Clipping treatment effects were significant at both locations for plant height. At Cherokee those plots clipped until dormancy were 12 percent taller than those plots clipped until early joint (Table IX). At Purcell, plots clipped until dormancy were only 3 percent taller than those clipped until early joint (Table IX). No lodging occurred at either location.

The detrimental effect of later forage removal on grain yield represents a substantial decrease in possible grain production. Stress effects on wheat plants from clipping were sometimes heightened due to weather conditions experienced directly after clipping.

Test weight is an important factor used in calculating returns per acre since low test weight wheat is commonly discounted. Test weight was measured for each variety but was not included in the yield component discussion since weight per kernel was more appropriate. Test weight differences among varieties ranged from 49.9 to 59.4 pounds per bushel at Cherokee, and from 53.9 to 60.7 pounds per bushel at Purcell.

Varietal effects upon grain, forage and total returns at Cherokee and Purcell were reported separately due to a significant variety x location interaction. Returns were calculated for individual plots and only for those plots clipped until early joint, since cattle are seldom removed from wheat pasture in December. Budgets used to calculate returns for individual plots are shown in Tables II and III. No payments from participation in government programs are included in returns per acre. Also, the budgets contain no interest or tax costs pertaining to land.

None of the varieties at Cherokee produced enough grain to cover the cost of production specified in the wheat grain and pasture budget (Table X). However, grain production costs were slightly high since nitrogen removed by forage consumption was charged against the grain budget. Purcell produced better grain yields and thus had better returns per acre for grain yield (Table X). The varietal effect on returns from grain was large at both Cherokee and Purcell. A difference among varieties as much as $55.95 per acre was found at Cherokee and $68.52 per acre at Purcell (Table X).

Differences among varieties for returns from forage were not as large as those for grain. Varieties at Cherokee differed by as much as $22.49 per acre, while varietal differences at Purcell were $21.86 per acre (Table X).

Total returns per acre were simply the sum of grain and forage returns per acre (Table X). Total returns per acre differed among varieties at Cherokee by as much as $69.04 and by as much as $83.70 at Purcell.

Variety selection has a major impact on economic returns per acre for wheat used in a forage plus grain system (Table X). In most cases the varieties that produced the best forage yields did not produce the best grain yields. Differences in grain yield tended to contribute more to differences in total returns per acre than forage yield differences. This may be caused by the larger difference in grain returns by varieties as compared to the differences between varieties for forage returns. The smaller difference between varieties for forage returns may be partially due to the 10 pounds of forage it takes to produce one pound of beef.

Total returns in a grazing plus grain system are dependent upon the prices received and the yields of both forage (beef) and grain. Variability in commodity prices and production from year to year make decisions on the best way to manage wheat in a grazing plus grain system difficult. Generally, no single variety will provide the best economic return for both grain and forage (Table X). Variety selections must be made according to intended use. Certain varieties are more adapted to grain only systems, while other varieties work better with grazing systems, or grazing plus grain systems. Varieties which provide an economical combination of forage and grain are better suited to grazing plus grain systems.

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APPENDIX A

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FORAGE YIELDS, GRAIN YIELDS

ECONOMIC EVALUATION

TABLE I

PLANTING, CLIPPING AND HARVEST
DATES FOR SIX WHEAT TRIALS

Location	Planting	Clip 1	Clip 2	Clip 3	Grain Harvest
	---1987-1988---				
Cherokee	Sept. 3	Oct. 23	Nov. 20	Mar. 27	June 26
Purcell	Sept. 2	Oct. 6	Nov. 6	Mar. 16	June 15
	---1988-1989---				
Cherokee	Sept. 22	Nov. 18	------	Mar. 25	------
Purcell	Sept. 26	Nov. 10	Dec. 16	Mar. 23	June 19
Retrop	Sept. 8	Oct. 21	------	Mar. 22	------
Ringling	Sept. 9	Nov. 11	Jan. 6	Mar. 18	May 31

Clip 1 & 2 Correspond to the clipped until dormancy treatment.
Clip 3 Corresponds to the clipped until early joint treatment.

TABLE II

WHEAT GRAIN AND PASTURE BUDGET

			Quantity		Value	
Operating Inputs	Units	Price	Cherokee	Purcell	Cherokee	Purcell
Wheat Seed	bu	$4.50	1.5	1.5	$6.75	$6.75
18-46-0 Fert	cwt	9.80	1.0	1.0	9.80	9.80
Nitrogen (N)	lbs	0.17	100.0	0.0	17.00	0.00
Fert. Applic.	acre	2.00	2.0	1.0	4.00	2.00
Anhydrous	lbs	0.11	44.0	200.0	4.84	22.00
Herbicide	oz	16.00	0.165	0.165	2.64	2.64
Custom Harvest	acre	16.00	1.0	1.0	16.00	16.00
Custom Hauling	bu	0.14	25.6	35.7	3.58	5.00
Ann. Operating Cap.	dol	0.09	39.0	43.7	351	3.93
Labor Charges	hr	3.22	2.9	2.9	9.40	940
Mach. Fuel, Lube, Repair	acre				15.63	15.63
Total Operating Cost					93.15	93.15
Fixed Costs						
Machinery						
Interest at 9.0%	dol					$10.96
Depr.,Tax,Insur.	dol					16.95
Land						
Interest at 0.0%	dol					0.00
Taxes	dol					0.00
Total Fixed Costs						27.91

TABLE III

100 HEAD STOCKER STEER BUDGET

Operating Inputs	Units	Rate Per Unit	Number of Units	Total Units	Price	Value
Str Calves (4-5)	cwt	1.02	4.0	4.08	$77.00	$314.16
Sm Gr Past	aums	1.89	1.0	1.89	0.00	0.00
Prairie Hay	tons	0.15	1.0	0.15	35.00	5.25
Salt & Minerals	lbs	11.25	1.0	11.25	0.09	1.01
21-25% Prot. Sup.	lbs	45.00	1.0	45.00	0.07	3.15
Starter Ration	cwt	0.60	1.0	0.60	8.00	4.80
Vet Medicine	hd	1.00	1.0	1.00	5.00	5.00
Trucking	cwt	9.50	1.0	9.50	0.50	4.75
Sales Commission	hd	1.00	1.0	1.00	3.50	3.50
Tractor Fuel & Lube						4.39
Tractor Repair Cost						1.77
Equipment Fuel and Lube						0.25
Equipment Repair						0.30
Total Operating Cost						348.33
Capital Cost						
Annual Operating Capital				133.67	$0.09	$12.03
Tractor Investment				39.71	0.09	3.57
Equipment Investment				9.75	0.09	0.88
Total Interest Charge						16.48
Ownership Cost (Depreciation, Taxes, Insurance)						
Tractor		dol				$5.59
Equipment		dol				2.11
Total Ownership Cost						7.69
Labor Costs						
Machinery Labor		hrs		0.908	$3.25	$2.95
Equipment Labor		hrs		0.150	3.00	0.45
Livestock Labor		hrs		1.700	3.00	5.10
Total Labor Cost						8.50

TABLE IV

ANALYSIS OF VARIANCE FOR FALL, SPRING AND TOTAL WHEAT FORAGE PRODUCTION ACROSS SIX ENVIRONMENTS

Source	df	Fall	Spring	Total
		----------------Mean Squares-----------------		
Environment	5	55240616**	7562996**	49433231**
Rep(Env)	18	772222**	454251**	1986021**
Variety	17	1319259**	68078	1251275**
Env x Variety	85	193442**	59501**	256676**
Error	306	127753	23161	150768
Mean (lb/A)		1268	662	1930
CV (%)		28.2	23.0	20.1

** = Significant at the P=.01 level.

TABLE V

VARIETAL MEAN FALL, SPRING AND TOTAL FORAGE PRODUCTION
ACROSS SIX ENVIRONMENTS

Brand/Entry	Fall	Spring	Total
	---------------	Lb/Ac	---------------
Agripro Abilene	1227	603	1831
Agripro Mesa	1167	731	1898
Agripro Stallion	1439	611	2050
Agripro Thunderbird	1558	632	2190
Agripro Victory	1704	610	2314
Agripro Wrangler	1659	702	2361
AGSECO 7837	1235	731	1966
AGSECO 7846	897	676	1573
Arkan	1379	696	2075
Century	1293	550	1843
Chisholm	1068	658	1727
Cody	1168	682	1850
Pioneer 2157	1399	630	2029
Pioneer 2172	1266	665	1931
Pony	964	633	1597
Siouxland	1353	670	2023
TAM W-101	908	668	1575
TAM 200	1132	768	1900
Mean	1268	662	1930
LSD (P=.05)	250	N.S.	288

TABLE VI

AVERAGE CORRELATIONS (rii')[1] BETWEEN PAIRS OF VARIETIES FOR FALL, SPRING AND TOTAL FORAGE PRODUCTION

Brand/Entry	Fall	Spring
Agripro Abilene	0.94[2]	0.92
Agripro Mesa	0.97	0.88
Agripro Stallion	0.95	0.91
Agripro Thunderbird	0.97	0.84
Agripro Victory	0.93	0.92
Agripro Wrangler	0.95	0.89
AGSECO 7837	0.97	0.85
AGSECO 7846	0.96	0.87
Arkan	0.96	0.89
Century	0.97	0.92
Chisholm	0.91	0.89
Cody	0.92	0.91
Pioneer 2157	0.94	0.89
Pioneer 2172	0.97	0.92
Pony	0.95	0.93
Siouxland	0.95	0.86
TAM W-101	0.96	0.86
TAM 200	0.96	0.91

1 Moll et al. (1978)

2 Average of the 17 simple correlations of each variety with all other varieties.

TABLE VII

STABILITY-VARIANCE VALUES[1] FOR FALL, SPRING AND TOTAL FORAGE PRODUCTION ACROSS SIX ENVIRONMENTS

Brand/Entry		FALL	SPRING
Agripro	Abilene	215019	17863
Agripro	Mesa	31963	94845**
Agripro	Stallion	155109	25637
Agripro	Thunderbird	237334	96125**
Agripro	Victory	355054*	22212
Agripro	Wrangler	143083	46937
AgSeCo	7837	138159	104868**
AgSeCo	7846	75309	68726*
	Arkan	132346	75035**
	Century	30196	16049
	Chisholm	720719**	47711
	Cody	371778*	61353*
Pioneer	2157	210592	86569**
Pioneer	2172	40995	29469
	Pony	190581	7906
	Siouxland	212962	79174**
	TAM W-101	82077	73262**
	TAM 200	138686	117291**

1 Stability variance values as calculated by Shukla (1972).

**, * Stability variance values significantly greater than within environmental variance based on F test at P=.01 and P=.05 levels respectively.

TABLE VIII

TEST OF HETEROGENEITY REMOVED FROM VARIETY X ENVIRONMENT INTERACTION BY ENVIRONMENTAL INDEX FOR FALL AND SPRING FORAGE PRODUCTION

FALL

Source	df	MS
Genotype x Environment	85	193442**
Heterogeneity	17	299057**
Pooled Deviations	68	167039*
Pooled Error	306	127754

SPRING

Source	df	MS
Genotype x Environment	85	59502**
Heterogeneity	17	61308**
Pooled Deviations	68	59050**
Pooled Error	306	23161

*,** Significant at P=.05 and .01 levels respectively, when tested against pooled error.

TABLE IX

CLIPPING EFFECT ON GRAIN YIELD, HEADS/M, KERNELS/HEAD WEIGHT/KERNEL, TEST WEIGHT AND HEIGHT FOR CHEROKEE AND PURCELL

Clipping Treatment	Yield	Heads/ meter	Kernels/ head	Weight/ kernel	Height
	Bu/a			mg	cm.
			CHEROKEE		
Dormancy	34.5**	170	22.1**	22.0**	98.8**
Early Joint	25.6**	157	21.0**	20.0	86.9**
			PURCELL		
Dormancy	40.9*	170	21.3	23.0**	35.9**
Early Joint	35.7*	162	21.2**	23.0*	34.7**

*,** Varietal means within a location significant at P=.05 and .01 levels, respectively.

TABLE X

GRAIN, FORAGE AND TOTAL RETURNS PER ACRE AT CHEROKEE AND PURCELL

Brand/Entry	Cherokee Grain	Cherokee Forage	Cherokee Total	Purcell Grain	Purcell Forage	Purcell Total
	$/Acre					
Agripro Abilene	-7.85	51.50	43.66	25.19	42.33	67.52
Agripro Mesa	-15.55	51.43	35.89	4.30	49.99	54.30
Agripro Stallion	-25.42	47.06	21.65	17.83	52.45	70.28
Agripro Thunderbird	-15.32	57.08	41.77	32.18	60.07	92.25
Agripro Victory	-61.67	60.91	-0.76	4.93	54.87	59.80
Agripro Wrangler	-38.61	55.66	17.05	-15.97	57.33	41.37
AGSECO 7837	-46.55	54.74	8.20	-36.34	44.89	8.55
AGSECO 7846	-39.99	43.60	3.61	-15.07	38.21	23.14
Arkan	-42.01	55.75	13.74	-16.58	56.13	39.56
Century	-31.17	47.95	16.77	21.29	48.65	69.94
Chisholm	-21.16	38.95	17.78	17.05	39.03	56.09
Cody	-63.80	38.42	-25.38	17.68	52.37	70.04
Pioneer 2157	-30.18	46.56	16.38	5.62	57.36	62.99
Pioneer 2172	-18.69	49.29	30.60	5.21	52.49	57.70
Pony	-29.46	42.48	13.02	-6.50	46.78	40.28
Siouxland	-45.41	58.14	12.74	-0.21	48.35	48.14
TAM W-101	-34.85	50.03	15.18	4.47	45.02	49.49
TAM 200	-19.94	59.76	39.83	-0.38	47.82	47.45
Mean ($/A)	-32.65	50.52	17.87	3.59	49.68	53.27
LSD (P=.05)	24.07	11.01	30.71	22.31	12.28	27.03

APPENDIX B

FORAGE YIELDS AT INDIVIDUAL LOCATIONS

TABLE I

ANALYSIS OF VARIANCE FOR FALL, SPRING AND TOTAL WHEAT FORAGE PRODUCTION AT INDIVIDUAL LOCATIONS

		------1987-88-----		------------------1988-89-----------------			
				Fall			
Source	df	Cherokee	Purcell	Cherokee	Purcell	Retrop	Ringling
		---------------------------Mean Squares---------------------------					
Rep	3	386034	1114533**	923525**	51423	157491**	2000323**
Variety	17	598004**	483783*	381502**	454777**	116269**	251618
Error	51	226826	225085	37276	18436	33736	225333
Mean (lb/A)		2165	2596	696	835	600	713
CV (%)		22.0	18.2	27.7	16.2	30.6	66.5
				Spring			
Rep	3	243769**	111206**	664092**	31596	8929	1665916**
Variety	17	108453**	26640	55322**	67592**	32925**	80690
Error	51	27538	15978	19360	19004	6991	48081
Mean (lb/A)		788	306	510	656	478	1233
CV (%)		21.0	41.2	27.2	21.0	17.4	17.7
				Total			
Rep	3	560807*	1300698**	3097620**	5382	134247*	6817319**
Variety	17	640453**	540429*	498716**	400477**	188534**	279054
Error	51	205675	254813	76239	35285	37765	290502
Mean (lb/A)		2952	2903	1207	1490	1077	1947
CV (%)		15.3	17.3	22.8	12.6	18.0	27.6

*,** Significant at the P=.05 and .01 levels, respectively.

TABLE II

FALL FORAGE MEANS FOR TWO LOCATIONS IN 1987

Brand/Entry	Cherokee	Purcell
Agripro Abilene	2348	2279
Agripro Mesa	2132	2555
Agripro Stallion	2115	2702
Agripro Thunderbird	2567	3282
Agripro Victory	2893	2926
Agripro Wrangler	2532	3010
AGSECO 7837	2040	2237
AGSECO 7846	1819	2067
Arkan	2458	2869
Century	2250	2640
Chisholm	1371	2037
Cody	1612	2802
Pioneer 2157	1965	2966
Pioneer 2172	2160	2691
Pony	1751	2447
Siouxland	2636	2564
TAM W-101	1959	2188
TAM 200	2359	2470
Mean	2165	2596
LSD	676	673
%CV	22.0	18.2

TABLE III

SPRING FORAGE MEANS FOR TWO LOCATIONS IN 1987

Brand/Entry	Cherokee	Purcell
Agripro Abilene	662	195
Agripro Mesa	874	366
Agripro Stallion	636	363
Agripro Thunderbird	769	229
Agripro Victory	667	281
Agripro Wrangler	721	330
AGSECO 7837	1160	387
AGSECO 7846	730	166
Arkan	800	412
Century	553	203
Chisholm	906	245
Cody	633	259
Pioneer 2157	757	387
Pioneer 2172	721	377
Pony	733	287
Siouxland	762	262
TAM W-101	966	443
TAM 200	1134	325
Mean	787	306
LSD	235.5	179.4
%CV	21.0	41.2

TABLE IV

TOTAL FORAGE MEANS FOR THE TWO LOCATIONS IN 1987

Brand/Entry	Cherokee	Purcell
Agripro Abilene	3010	2474
Agripro Mesa	3006	2922
Agripro Stallion	2751	3066
Agripro Thunderbird	3336	3511
Agripro Victory	3560	3207
Agripro Wrangler	3253	3340
AGSECO 7837	3199	2624
AGSECO 7846	2548	2233
Arkan	3258	3281
Century	2802	2843
Chisholm	2276	2282
Cody	2245	3061
Pioneer 2157	2721	3353
Pioneer 2172	2880	3068
Pony	2483	2734
Siouxland	3398	2826
TAM W-101	2924	2632
TAM 200	3493	2795
Mean	2952	2902
LSD	643.8	716.5
C.V.	15.3	17.3

TABLE V

FALL FORAGE MEANS FOR THE FOUR LOCATIONS IN 1988

Brand/Entry	Cherokee	Purcell	Retrop	Ringling
Agripro Abilene	563	725	457	992
Agripro Mesa	557	668	620	470
Agripro Stallion	1102	1210	584	919
Agripro Thunderbird	979	921	636	963
Agripro Victory	1493	1285	866	760
Agripro Wrangler	974	1585	871	983
AGSECO 7837	765	950	703	716
AGSECO 7846	370	440	463	223
Arkan	641	913	817	577
Century	810	910	588	562
Chisholm	723	798	468	1013
Cody	673	501	755	667
Pioneer 2157	643	1157	717	945
Pioneer 2172	646	987	544	569
Pony	214	356	255	763
Siouxland	713	661	633	912
TAM W-101	329	328	431	210
TAM 200	342	631	390	603
Mean	696	835	600	713
LSD	267.9	202.1	250	693
%CV	27.7	16.2	30.6	66.5

TABLE VI

SPRING FORAGE MEANS FOR THE FOUR LOCATIONS IN 1988

Brand/Entry	Cherokee	Purcell	Retrop	Ringling
Agripro Abilene	556	544	434	1229
Agripro Mesa	409	954	402	1379
Agripro Stallion	397	659	384	1228
Agripro Thunderbird	541	507	703	1042
Agripro Victory	572	512	407	1222
Agripro Wrangler	724	601	491	1342
AGSECO 7837	454	650	514	1222
AGSECO 7846	666	837	470	1190
Arkan	298	781	505	1380
Century	412	536	403	1193
Chisholm	606	703	411	1079
Cody	597	673	494	1434
Pioneer 2157	434	687	572	945
Pioneer 2172	600	555	559	1180
Pony	438	677	393	1272
Siouxland	661	446	628	1262
TAM W-101	397	694	381	1126
TAM 200	434	786	454	1475
Mean	510	656	478	1233
LSD	195.8	192.9	122.3	308.9
%CV	27.2	21.0	17.4	17.7

TABLE VII

TOTAL FORAGE MEANS FOR THE FOUR LOCATIONS IN 1988

Brand/Entry	Cherokee	Purcell	Retrop	Ringling
Agripro Abilene	1119	1269	891	2221
Agripro Mesa	966	1623	1022	1849
Agripro Stallion	1499	1869	969	2146
Agripro Thunderbird	1520	1428	1339	2005
Agripro Victory	2066	1797	1273	1981
Agripro Wrangler	1699	2186	1362	2325
AGSECO 7837	1219	1600	1216	1938
AGSECO 7846	1036	1277	932	1414
Arkan	940	1694	1321	1957
Century	1222	1445	991	1755
Chisholm	1329	1501	880	2092
Cody	1270	1174	1250	2101
Pioneer 2157	1076	1844	1288	1889
Pioneer 2172	1246	1542	1103	1748
Pony	652	1033	648	2035
Siouxland	1374	1107	1262	2175
TAM W-101	726	1022	812	1336
TAM 200	776	1417	844	2078
Mean	1207	1490	1077	1947
LSD	386.2	286.5	122.3	794.2
%CV	22.8	12.6	18.0	27.6

VITA

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Master of Science

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