FORAGE PRODUCTION OF SMALL GRAIN SPECIES AND MIXTURES FROM FALL AND SPRING PLANTINGS

By

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PLANTINGS

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TABLE OF CONTENTS

LIST OF TABLES

Table Page

Table | Page

CHAPTER I

INTRODUCTION

Small grains have been recognized as a valuable source of high-quality forage for grazing livestock. They have been used in various regions of the United States and Canada as a source of forage. Most of the extensive use of small grain pasture occurs in Texas, Oklahoma, and Kansas, where producers typically utilize mainly winter wheat for grazing during its vegetative growth in fall, winter, and early spring.

Small grain forage can be used to produce excellent steer gains or to provide needed protein supplements for dry cows by rationing the amount of grazing time on small grain. They are a good source of feed and provide the animal with an excellent source of protein, vitamin A, and minerals. The stage of maturity at which the plants are harvested is one of the most important factors influencing their forage yield and quality. However, in order to obtain the maximun meat and milk products from ruminant livestock, the time of harvesting the forage for feeding the animal should be considered.

The objectives of this one year forage study on small grains were to:

Compare small grain species and mixtures for seasonal forage production when sown in the fall and spring.

Determine which small grain produces the most hay when fall and spring sown.

Determine the effect of growth stage on hay yield of small grains.

Determine the effect of planting time on growth stage development.

CHAPTER II

LITERATURE REVIEW

Seeding Date And Species

The effect of seeding date on forage production has probably been studied more than any other cultural practice, and indeed it may be one of the most important management factors determining the potential for the fall and winter forage.

Bates (1975-1983), in Ardmore, Oklahoma, compared planting dates for rye (*Secale cereale* L.), oats (*Avena sativa* L.), wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), and triticale (*Triticale hexaploide* Lart.) varieties and strains. The results have consistently shown an advantage to planting wheat and other small grains in mid-September or early-October compared to late-October or early-November for fall and winter forage production (through late-February or early-March). However, in most years, total forage production through May (simulated graze-out) has been slightly greater with later planting dates.

Elder (1960) at Stillwater, Oklahoma, compared six planting dates over four seasons with clipping every 30 days using a winter pasture mixture of rye, wheat, oats, and vetch (Vicia. sativa). September 10, September 25, and October 10 seeding gave the same total forage production through May, but the September 10 seeding date produced twice as much forage before January 1 as the October 10 seeding date. Seeding after October 25 resulted in no measurable forage before March and also decreased total forage production.

In Texas, Holt et al. (1969) also found that the September or early October seeding was important for fall forage production with small grains at College Station, but did not produce highest total forage yields for simulated graze-out. Mid-October seeding produced maximum forage yield.

In Washington, Ciha (1983) evaluated forage production of triticale compared to other spring grain species from an early and a normal date of planting (late April) for the area. Forage yields were not significantly affected by planting date or any of the interactions containing planting date. However, there was a significant increase in percent crude protein with all species except barley when seeded at the normal compared to an early planting date. Triticale CF76 (one of two triticale varieties used in this study) had a mean forage yield averaged over years and planting dates generally lower than barley and oats at heading stage and equal to the spring grain species at the soft dough stage. A similar study was conducted by Bishnoi et al. (1978) in Alabama with forage harvested at bloom and dough stages. Forage and silage yields of both triticales were significantly higher than the other small grain cultivars during both growing seasons.

Total forage production from different varieties of fall seeded small grains were evaluated by McMurphy (1976) at Perkins, Oklahoma. Bonel rye produced a greater quantity of forage than Osage wheat during 1972, 1973, and 1974.

In Oklahoma, Horn et al. (1981) evaluated forage production and digestibility of fall seeded small grain forages. Forage production was measured on two harvest dates (November 29, 1979 and March 18, 1980). Bonel rye produced the most forage on both harvest dates and the greatest amount of digestible dry matter (DDM) per acre.

Holt (1962) in Texas studied behavior and management of small grains for forage production. Frequent clipping resulted in reduced plant development and reduced forage yields. A period of at least 4-6 weeks between clipping was necessary for recovery and regrowth.

During the winter season of 1977-1978, Rommann et al. (1978) in Oklahoma evaluated the forage production of small grain. Total forage yields were 5452 kg/ha, 4449 kg/ha, and 3975 kg/ha, respectively, from Bonel rye, Osage wheat, and Post barley when they were averaged over five locations. Similar evaluation by Rommann et al. (1979) at Haskell, Oklahoma resulted in 8578 kg/ha, 6377 kg/ha, and 7626 kg/ha of total dry matter from Bonel rye, Osage wheat, and Post barley, respectively.

Studies were conducted at Perkins, Oklahoma, from

1979-1980 by Rommann et al. (1980) to determine the forage production of fall seeded small grains. Bonel rye produced significantly higher yield than both Osage wheat and Post barley. There was no significant difference between wheat and barley.

In Georgia, forage production of several varieties of fall seeded small grain species were evaluated under different types of management by Hart et al. (1964). There was not much difference among top varieties of three species (rye, oats, and wheat) with respect to forage yields under simulated rotational grazing. But there was a considerable difference in the time of year the forage was produced. Wrens Abruzzi rye produced considerable grazing from January on through the winter, but oats and wheat produced most of their forage in March and April.

Croy (1983) stated that using a mixtures of more than one species may extend the grazing season since different species have different periods of production. For example, wheat and ryegrass (Lolium multiflorum Lam.) provide a better balanced production system than either alone.

Sprague (1954) in New Jersey reported that rye, wheat, and oats produced 3411, 2142, and 1054 kgs/ha of forage respectively for dairy cows.

Stage of Maturity And Species

The stage of maturity at which the plants are harvested is one of the most important factors influencing their forage quality.

Biological and chemical determinants of quality of spring planted small grain were measured by Cherney and Marten (1982a) in Minnesota. Forage quality differences between species were always greater than differences among cultivars within species. In vitro digestible dry matter (IVDDM) concentration of the average of the four small grain forages ranged from 80 to 58% as maturity progressed from flag leaf to dough stage. Crude protein concentration differences for all species declined with maturation. Another study was conducted by Cherney and Marten (1982b) to examine individual plant parts for quality constituents over a wide range of maturity stages. Leaf blade, leaf sheath, and head contained higher crude protein and IVDDM than stem.

Marten (1982) in Minnesota stated that forage quality of small grains generally decreased as maturity progressed from flag leaf to dough stage. Small grain forage should be harvested at boot stage, if used for rations fed to high producing dairy cows, even though the yield of crude protein and dry matter per acre was much lower at this stage than at dough stage. However, harvest of forage as late as dough stage was recommended for rations of growing animals.

Predicted forage values of whole plant cereals were studied by Fisher and Fowler (1975) in Canada. Forage potential of several species and cultivars of spring and fall sown annual cereals were compared, and the influence of stage of maturity on the measurement of forage potential was determined. Forage samples were taken at 10-day intervals starting at the late boot stage and ending at maturity. Dry weight yield increased significantly up to 30 days post boot stage for both spring and fall sown cultivars, but the dry matter yield advantages were greatest for the barleys, Opel wheat, and oat strain OA-1254 in the spring cereals, and wheats and ryes in the winter cereals.

Larson and Carter (1970) evaluated spring cereals for forage production in North Dakota. Oats, wheat, and barley were used in their study. Crops were harvested at various stages of growth for dry matter and protein yield. Highest dry matter and protein yield of forage per acre were obtained when the grain was in dough stage, except for higher protein yield of oats at milk stage.

Comparison of quality of triticale forage to other fall seeded small grains was made by Brown and Almodares (1976) in Georgia. Percent crude protein of triticale forage at comparable stages of growth was similar to rye, wheat, and oat cultivars. A similar study was conducted by Bishnoi et al. (1978) in Alabama. Triticale and rye silages contained similar amounts of crude protein, ash, and ether extract. They were significantly lower in these constituents than wheat but significantly higher than oats or barley. Triticale can be adequately ensiled, and dough stage harvest produced acceptable yield of good quality silage.

In Alabama, Bishoni and Hughes (1979) studied the agronomic performance and protein content of fall planted triticale, wheat, and rye. Protein content in dry green forage ranged from 25 to 27% in triticale cultivars, which was similar to that found in wheat and rye.

The evaluation of wheat, barley, and oat silages for beef was determined by Oltjen and Bolsen (1978) in Kansas. The results indicated that cereals harvested and fed as silage produced more beef per acre than grain.

McCormick et al. (1962) in Georgia studied systems of utilizing small grain pastures in fattening beef steers. They observed that when yearling steers were fed ground snapped corn (Zea mays L.), cottonseed meal, and Coastal bermudagrass (Cynodon dactylon L. Pers.) hay in dry lot for a short period of time and then transferred to oat or rye pasture for the remainder of the feeding period, they gained faster and more economically than those fed continuously in dry lot. They also observed that yearling steers fattened on a combination of oat pasture and dry lot feeding made cheaper gains than those fattened on a combination of rye pasture and dry lot feeding.

CHAPTER III

MATERIALS AND METHODS

This small grain forage study was conducted at the Agronomy Research Stations at Perkins and Haskell, Oklahoma, in the 1983-1984 growing season.

The experimental design was a split-plot in a randomized complete block arrangement with four replications. Main plots consisted of two seeding dates and subplots consisted of 10 small grain species and mixtures. Species and mixtures were assigned at random within each main plot in each replication. Subplots consisted of 11 rows, 0.25 m apart and 7.6 m long.

The small grain species and mixtures used in this study were Bonel rye (*Secale cereale* L.); Osage wheat (*Triticum aestivum* L.); Post barley (*Hordeum vulgare* L.); Mesquite oats (*Avena sativa* L.); Grazer-I triticale (*Triticale hexaploide* Lart.); 25% rye and 75% wheat; 50% rye and 50% wheat; 75% rye and 25% wheat; 50% wheat and 50% triticale; plus 50% rye and 50% triticale. These species and mixtures were planted at the seeding rates which were determined on weight basis shown in Table 1.

Several clippings were made to determine seasonal forage yield for each species. For all forage samplings, the row sections were hand clipped approximately 5 cm above

Table 1. Seeding rates of small grain species and mixtures.

Species and Mixtures	Seeding Rate
	---Kg/ha---
Bonel rye	57
Osage wheat	67
Post barley	71
Mesquite oats	101
Grazer-I triticale	71
25% rye + 75% wheat	67
50% rye + 50% wheat	62
75% rye + 25% wheat	57
50% wheat + 50% triticale	69
50% rye + 50% triticale	64

the ground. The entire sample was placed in a paper bag and oven dried at temperature of 60 °C for four consecutive days. Seasonal forage yields were recorded and presented on a dry weight basis, expressed in kg/ha.

For all hay harvests, plant material was harvested at three different maturity stages: according to Feekes's scale of cereal growth stages (Jones and Clifford, 1983) 1) flag leaf, 2) boot, 3) ear emergence. Flag leaf stage was defined as when at least 50% of the plants'last leaves are just visible. Boot stage was defined as when at least 50% of the plants had swollen boots and first spikes just visible. Ear emergence stage was defined as when at least 50% of the plants had ears emerged completely. The harvested samples were immediately weighed to determine fresh weight. A subsample of the freshly harvested material was weighed, dried in a forced air dryer at 60 °C for four consecutive days, and reweighed. Hay yield was presented on a dry weight basis, expressed in kg/ha.

Rainfall distribution by months recorded in centimeters of precipitation at Perkins and Haskell for the 1983-1984 growing season is shown in Table 2. Precipitation was well above long term average precipitation and well distributed throughout the growing season (September-May, 1983-1984). A prolonged freeze at both locations from mid-December to early January winterkilled oats and prevented oats from recovery after first harvest was made.

The soil at Perkins was a Zanies loam with the soil test

Table 2. Rainfall distribution by months for the 1983-1984 season.

Month	Perkins		Haskell	
	Average	1983-1984	Average	1983-1984
	cm			
September	9.68	4.88	11.28	5.16
October	8.15	27.03	9.07	20.55
November	4.83	4.47	7.52	8.71
December	3.61	0.74	6.25	0.89
January	3.89	1.12	4.62	2.03
February	3.71	2.72	5.23	7.24
March	5.59	15.04	8.56	10.69
April	8.03	9.25	12.07	9.45
May	12.93	9.80	12.65	15.44
Total	60.42	75.05	77.25	80.16

revealing a pH of 5.2, 9 kg/ha of available N, 62 kg/ha of available P, and 312 kg/ha of available K. Fertilizer applied before planting was 81 kg of actual N/ha and 9 kg of actual P/ha. Species and mixtures were planted on September 16, 1983, and February 3, 1984. A soil crust was formed 10 days after fall planting which caused reduction in some stands especially on barley and oat plots. Seasonal forage yield was determined by harvesting a one meter section of row x 0.25 m on four dates (November 29, March 7, April 6, and May 17) from fall planting, and on one date (May 24) from spring planting. Rows adjacent to harvested area of fall seeded small grains were trimmed to reduce shading. Hay yield was determined by harvesting a separate one meter section of row x 0.25 m at the flag, boot, and ear emergence stages of maturity.

The soil at Haskell was Taloka silt loam. Fertilizer applied at the time of seeding was 90 kg of actual N/ha, 29 kg of actual P/ha, and 56 kg of actual K/ha. Species and mixtures were planted on September 29, 1983, and February 14, 1984. Seasonal forage yield was determined by harvesting 2 rows 1.0 x 0.25 m on three dates (December 12, March 22, and April 11) from fall planting, and on one date (May 22) from spring planting. Rows adjacent to harvested area of fall seeded small grains were trimmed to reduce shading. Hay yield was determined by harvesting 2 separate rows 1.0 x 0.25 m at the flag leaf, boot, and ear emergence stages of maturity.

CHAPTER IV

RESULTS AND DISCUSSION

Perkins

Seasonal forage production by harvest dates from fall seeded small grain species and mixtures for 1983-1984 growing season is shown in Table 3.

Significant differences in yield were found among species and mixtures at the second and fourth harvest dates. At the second harvest date, rye produced as much seasonal forage as wheat and triticale, but significantly higher than barley. Most species produced maximum seasonal forage yields at the fourth harvest date. Barley produced significantly higher yield at the fourth harvest date than any other small grain monocultures. Triticale produced as much seasonal forage as wheat. Rye produced the lowest yield. Increased seasonal forage yields of barley, triticale, and wheat at the fourth harvest date were probably due to warmer temperatures in the spring months. These species have higher optimum temperature requirements during spring than rye which grows better at cooler temperature and has lower optimum temperature requirement than the other small grain species (Leonard and Martin, 1963).

Significant differences in total seasonal forage

Table 3. Perkins fall seeded small grain seasonal forage production seeded September 16, 1983 from 1983-1984 season.

	Harvest Dates				
Species and Mixtures	Nov 29	Mar 7	Apr 6	May 17	Total
	---------------Kg/ha--------------				
Post barley	1742	945b	1053	5817a	9557a*
50% wheat + 50% triticale	1900	1407ab	1545	4547ab	9400a
Grazer-I triticale	1821	1319ab	1575	4124b	8839ab
Osage wheat	1634	1358ab	1654	3258bc	7904abc
75% rye + 25% wheat	2136	1683a	2067	1919cd	7805abc
50% rye + 50% triticale	1821	1732a	2057	2096cd	7707abc
Bonel rye	1762	1683a	2087	1693d	7224bc
50% rye + 50% wheat	1959	1506a	1693	1742d	6900bc
25% rye + 75% wheat	1575	1309ab	1683	1801d	6368c
Mesquite oats	1781	0	0	0	1781d
C.V (%)	18	22	26	30	18

*Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test (no significant differences on November 29 and April 6 harvests).

production were observed among fall seeded small grains. Barley, triticale and wheat yielded the same. Rye produced less seasonal forage yield than barley. Oats produced the lowest yield. Mixtures produced as much seasonal forage as their best monoculture components.

Total forage (hay) production from spring seeded small grains for 1984 season is shown in Table 4. There were significant differences in total forage production among spring seeded small grains. Rye produced as much forage as barley, but significantly higher than the other small grain monocultures. Triticale, oats, and wheat yielded the same. There were no significant differences in total forage yield between mixtures and their best monoculture components.

Hay yields of fall and spring seeded small grains increased with the advance in the stage of maturity (Tables 5 and 6). All fall seeded small grain monocultures produced more hay at similar stages than spring seeded small grain monocultures. Species varied in the time required to reach flag leaf, boot, and ear emergence stages of maturity. Rye was the earliest species to reach all stages of maturity and wheat was one of the latest ones. All species from fall seeded small grains reached each maturity stage earlier than spring seeded small grains, but it took longer for them to progress from one stage to another stage of maturity than spring seeded small grains.

Hay yields of fall seeded small grains at flag leaf, boot, and ear emergence stages of maturity for 1983-1984 season are shown at Table 5. Significant differences in

Table 4. Perkins spring seeded small grain total forage (hay) production seeded February 4, 1984, harvested May 24, 1984.

Species and Mixtures	Total production
	-----Kg/ha-----
Bonel rye	3947a*
25% rye + 75% wheat	3730ab
50% rye + 50% wheat	3632abc
75% rye + 25% wheat	3494abcd
50% rye + 50% triticale	3366abcd
Post barley	3209abcd
Grazer-I triticale	2864bcd
Mesquite oats	2667cd
Osage wheat	2500d
50% wheat + 50% triticale	2461d
C.V (%)	20

*Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Table 5. Perkins fall seeded small grain hay production at three stages of maturity. 1983-1984 season.

	Stage of Maturity					
	Flag leaf		Boot		Ear emergence	
Species	Date	Kg/ha	Date	Kg/ha	Date	Kg/ha
Rye	Apr 4	7648a	Apr 11	11358a	Apr 22	12352a*
Wheat	Apr 17	8071a	Apr 29	10905a	May 7	13268a
Barley	Apr 15	4587b	Apr 27	6644b	May 3	12205a
Oats	Apr 19	4222b	Apr 29	7293b	May 12	7785b
Triticale	Apr 12	5010b	Apr 23	11220a	May 8	13947a
C.V (%)		20		13		17

*Means followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test.

Table 6. Perkins spring seeded small grain hay production at three stages of maturity during 1984 season.

	Stage of Maturity					
	Flag leaf		Boot		Ear emergence	
Species	Date	Kg/ha	Date	Kg/ha	Date	Kg/ha
Rye	______	______‡	May 10	3406NS	May 14	4695NS†
Wheat	May 17	1713NS	May 21	2608NS	May 26	3504NS
Barley	May 10	1516NS	May 14	2746NS	May 19	3278NS
Oats	May 10	1240NS	May 16	2392NS	May 21	3287NS
Triticale	May 12	1122NS	May 16	2067NS	May 21	3494NS
C.V (%)		27		26		20

†NS = Not significant

‡Rye was not harvested at flag leaf stage.

yield were observed among fall seeded small grain species at each stage of maturity. Wheat and rye yielded the same, but their yields were significantly higher than the other small grains at flag leaf stage. At boot stage, rye, triticale, and wheat produced the same amount of hay, but significantly higher than oats and barley. At ear emergence stage, triticale, wheat, rye, and barley yielded the same. Oats produced the lowest yield.

Hay yields of spring seeded small grains at flag leaf, boot, and ear emergence stages of maturity for 1984 season are shown in Table 6. Rye was not harvested at flag leaf stage. There were no significant differences in yield among small grains at all stages of maturity. All species produced the same amount of hay at each stage of maturity.

Haskell

Seasonal forage production by harvest dates from fall seeded small grain species and mixtures for 1983-1984 growing season is shown in Table 7. Significant differences in yield were found among fall seeded small grain species and mixtures at each harvest date. At the first harvest date, oats produced significantly higher yield than any other small grain monocultures. Rye, barley, wheat, and triticale yielded the same amount of seasonal forage yield. At the second harvest date, rye and triticale yielded the same, but their yields were significantly higher than wheat and barley. Barley produced the lowest yield. At the third harvest date, wheat produced as much seasonal forage yield

Table 7. Haskell fall seeded small grain seasonal forage production seeded September 29, 1983 from 1983-1984 season.

Species and Mixtures	Harvest Dates Dec 12	Mar 22	Apr 11	Total
	-------------	Kg/ha	------------	
50% rye + 50% triticale	1668b	1727a	1629cde	5025a*
50% rye + 50% wheat	1270bcd	1535ab	2082a	4887a
50% wheat + 50% triticale	1634bc	1540ab	1698bcd	4872a
75% rye + 25% wheat	1599bcd	1718a	1540de	4857a
Bonel rye	1668bcd	1688a	1398e	4754a
Grazer-I triticale	1176d	1609ab	1909ab	4695a
25% rye + 75% wheat	1535bcd	1265bc	1860abc	4660a
Osage wheat	1220cd	1142c	2023a	4385a
Post barley	1560bcd	453d	1688bcd	3701b
Mesquite oats	2106a	0	0	2106c
C.V (%)	17	17	9	9

*Means followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test.

as triticale, but significantly higher than barley and rye. Rye produced the lowest seasonal forage yield.

There were significant differences in total seasonal forage production among fall seeded small grains. Rye, triticale, and wheat yielded the same, but their yields were significantly higher than barley and oats. Oats produced the lowest yield. There were no significant differences in seasonal forage yield between mixtures and their best monoculture components.

Total forage (hay) production from spring seeded small grains for 1984 season is shown in Table 8. Significant differences were observed in total forage prooduction from spring seeded small grains. Rye produced as much forage yield as barley and oats, but significantly higher than triticale and wheat. Mixtures produced as much total forage yield as their best monoculture components.

Hay yields of fall seeded small grains at flag leaf, boot, and ear emergence stages of maturity for 1983-1984 season are shown in Table 9. Rye and triticale were not harvested at flag leaf stage of maturity. There were no significant differences in yield among small grains at all stages of maturity. All species produced the same amount of hay at each stage of maturity.

Hay yields of spring seeded small grains at flag leaf, boot, and ear emergence stages of maturity for 1984 season are shown in Table 10. Rye at flag leaf and boot stages of maturity and barley at boot stage of maturity were not harvested. Significant differences in yield were observed

Table 8. Haskell spring seeded small grain total forage (hay) production seeded February 14, 1984, harvested 22 May, 1984.

Species and Mixtures	Total production
	----Kg/ha----
Bonel rye	6778a*
50% rye + 50% triticale	6358ab
Post barley	6296ab
75% rye + 25% wheat	6192ab
50% rye + 50% wheat	6053ab
Mesquite oats	5997ab
25% rye + 75% wheat	5076bc
50% wheat + 50% triticale	4679c
Grazer-I triticale	4180c
Osage wheat	3848c
C.V (%)	15

*Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Table 9. Haskell fall seeded small grain hay production at three stages of maturity. 1983-1984 season.

	Stage of Maturity					
	Flag leaf		Boot		Ear emergence	
Species	Date	Kg/ha	Date	Kg/ha	Date	Kg/ha
Rye	_____	_____‡	Apr 11	11919NS	Apr 17	10872NS†
Wheat	Apr 23	9706NS	Apr 30	13688NS	May 14	14204NS
Barley	Apr 19	9056NS	Apr 26	12169NS	Apr 30	12553NS
Oats	Apr 23	7755NS	Apr 30	10642NS	May 7	11037NS
Triticale	_____	_____	Apr 11	8367NS	Apr 26	11995NS
C.V (%)		18		25		13

†NS = Not significant

‡Rye and triticale were not harvested at flag leaf stage.

Table 10. Haskell spring seeded small grain hay production at three stages of maturity during 1984 season.

	Stage of Maturity					
	Flag leaf		Boot		Ear emergence	
Species	Date	Kg/ha	Date	Kg/ha	Date	Kg/ha
Rye	______	_____	_______	_____‡	May 16	6778b*
Wheat	May 22	3848b	May 29	4790b	June 6	6720b
Barley	May 16	5947a	_______	_____	May 22	7016b
Oats	May 16	5997a	May 22	6976a	May 29	9377a
Triticale	May 16	4180b	May 22	5086b	May 29	7323b
C.V (%)		14		10		12

*Means followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test.

‡Rye at flag leaf and boot stages of maturity and barley at boot stage of maturity were not harvested.

at each stage of maturity. At flag leaf stage, oats and barley produced significantly higher yield than triticale and wheat. At boot stage, oats produced significantly higher yield than wheat and triticale. At ear emergence stage, oats produced significantly higher yield than any other species. The higher yield of oats at each stage of maturity is attributed to warmer temperatures in the spring months which increased oat spring forage potential, because oats has higher optimum temperature requirement than species such as rye or the other small grains that grow better at cooler temperature (Leonard and Martin, 1963).

The results of this one year forage study in no way are an endorsement or recommendation for farmers in Oklahoma. However, they indicate that fall seeded small grains produce higher forage yields than spring seeded ones. Additional studies should be carried out to specify optimum early planting for maximum fall and winter forage production for specific locations.

CHAPTER V

SUMMARY AND CONCLUSIONS

A field experiment was conducted to evaluate the forage production of small grain species and mixtures from fall and spring plantings at the Agronomy Research Stations at Perkins and Haskell, Oklahoma in the 1983-1984 growing season.

Perkins

Significant differences in total seasonal forage production were observed among fall seeded small grains. Barley, triticale and wheat yielded the same. Rye produced less seasonal forage yield than barley. Oats produced the lowest yield.

There were significant differences in total forage (hay) production among spring seeded small grains. Rye produced as much forage yield as barley, but significantly higher than the other small grain monocultures. Triticale, oats, and wheat yielded the same. Mixtures produced as much seasonal forage yield as their best monoculture components when they were planted in fall or spring.

Hay yields of fall and spring seeded small grains increased with the advance in the stage of maturity. All fall seeded small grain monocultures produced more hay at comparable stages than spring seeded ones. All fall seeded small grain species reached each maturity stage earlier than when spring seeded, but it took longer for them to progress from one stage to another stage of maturity than spring seeded small grains.

Significant differences in hay yield were found among fall seeded small grain species at each stage of maturity, whereas there were no significant differences in hay yield among spring seeded small grains at each stage of maturity.

Haskell

Significant differences were observed in total seasonal forage production among fall seeded small grains. Rye, triticale, and wheat produced the same, but their yields were significantly higher than barley and oats. Oats produced the lowest yield.

There were significant differences in total forage (hay) production among spring seeded small grains. Rye produced as much forage yield as barley and oats, but significantly higher than triticale and wheat. There were no significant differences in seasonal forage yield between mixtures and their best monoculture components when they were planted in fall or spring.

There were no significant differences in hay yield among fall seeded small grains at each stage of maturity, However there were significant differences in hay yield among spring seeded small grains at each stage of maturity.

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APPENDIXES

Table 11. Analysis of variance for Perkins fall seeded small grain seasonal forage production harvested on November 29, 1983.

Source	df	MS	F value
Total	39		
Replications	3	87678	
Species	9	102455	0.931NS†
Error	27	110067	
CV (%) = 18			

†NS = Not significant

Table 12. Analysis of variance for Perkins fall seeded small grain seasonal forage production harvested on March 7, 1984.

Source	df	MS	F Value
Total	35		
Replications	3	56187	
Species	8	246299	2.415*
Error	24	101977	
CV (%) = 22			

*Denotes significant difference (P = 0.05)

Table 13. Analysis of variance for Perkins fall seeded small grain seasonal forage production harvested on April 6, 1984.

Source	df	MS	F value
Total	35		
Replications	3	675397	
Species	8	435355	2.260NS†
Error	24	192637	
CV (%) = 26			

†NS = Not significant

Table 14. Analysis of variance for Perkins fall seeded small grain seasonal forage production harvested on May 17, 1984.

Source	df	MS	F Value
Total	35		
Replications	3	671019	
Species	8	9185551	11.452*
Error	24	802091	
CV (%) = 30			

*Denotes significant difference (P = 0.05)

Table 15. Analysis of variance for Perkins fall seeded small grain total seasonal forage production from 1983-1984 season.

Source	df	MS	F value
Total	39		
Replications	3	1809414	
Species	9	19608684	11.390*
Error	27	1721524	
CV (%) = 18			

*Denotes significant difference (P = 0.05)

Table 16. Analysis of variance for Perkins spring seeded small grain total forage (hay) production seeded February 3, 1984, harvested May 24, 1984.

Source	df	MS	F Value
Total	39		
Replications	3	1014783	
Species	9	1142761	2.845*
Error	27	401644	
CV (%) = 20			

*Denotes significant difference (P = 0.05)

Table 17. Analysis of variance for Perkins fall seeded small grain hay production harvested at flag leaf stage from 1983-1984 season.

Source	df	MS	F Value
Total	19		
Replications	3	2669999	
Species	4	13098133	9.385*
Error	12	1395707	
CV (%) = 20			

*Denotes significant difference (P = 0.05)

Table 18. Analysis of variance for Perkins fall seeded small grain hay production harvested at boot stage from 1983-1984 season.

Source	df	MS	F value
Total	19		
Replications	3	13420596	
Species	4	21415261	14.403*
Error	12	1486847	
CV (%) = 13			

*Denotes significant difference (P = 0.05)

Table 19. Analysis of variance for Perkins fall seeded small grain hay production harvested at ear emergence stage from 1983-1984 season.

Source	df	MS	F Value
Total	19		
Replications	3	5315534	
Species	4	23286650	5.538*
Error	12	4204897	
CV (%) = 17			

*Denotes significant difference (P = 0.05)

Table 20. Analysis of variance for Perkins spring seeded small grain hay production harvested at flag leaf stage from 1984 season.

Source	df	MS	F value
Total	15		
Replications	3	166108	
Species	3	285199	2.043NS†
Error	9	139586	
CV (%) = 27			

†NS = Not significant

Table 21. Analysis of variance for Perkins spring seeded small grain hay production harvested at boot stage from 1984 season.

Source	df	MS	F Value
Total	19		
Replications	3	525836	
Species	4	988239	2.027NS†
Error	12	487539	
CV (%) = 26			

†NS = Not significant

Table 22. Analysis of variance for Perkins spring seeded small grain hay production harvested at ear emergence stage from 1984 season.

Source	df	MS	F value
Total	19		
Replications	3	303877	
Species	4	1407591	2.743NS†
Error	12	513191	
CV (%) = 20			

†NS = Not significant

Table 23. Analysis of variance for Haskell fall seeded small grain seasonal forage production harvested on December 12, 1983.

Source	df	MS	F value
Total	39		
Replications	3	1055222	
Species	9	299452	4.268*
Error	27	70170	
CV (%) = 17			

*Denotes significant difference (P = 0.05)

Table 24. Analysis of variance for Haskell fall seeded small grain seasonal forage production harvested on March 22, 1984.

Source	df	MS	F Value
Total	35		
Replications	3	631193	
Species	8	677174	11.454*
Error	24	59123	
CV (%) = 17			

*Denotes significant difference (P = 0.05)

Table 25. Analysis of variance for Haskell fall seeded small grain seasonal forage production harvested on April 11, 1984.

Source	df	MS	F value
Total	35		
Replications	3	268924	
Species	8	205302	7.429*
Error	24	27634	
CV (%) = 9			

*Denotes significant difference (P = 0.05)

Table 26. Analysis of variance for Haskell fall seeded small grain total seasonal forage production from 1983-1984 season.

Source	df	MS	F Value
Total	39		
Replications	3	1773878	
Species	9	3150637	18.851*
Error	27	167134	
CV (%) = 9			

*Denotes significant difference (P = 0.05)

Table 27. Analysis of variance for Haskell spring seeded small grain total forage (hay) production seeded on February 14, 1984, harvested on May 22, 1984.

Source	df	MS	F value
Total	39		
Replications	3	386453	
Species	9	4150664	6.087*
Error	27	681945	
CV (%) = 15			

*Denotes significant difference (P = 0.05)

Table 28. Analysis of variance for Haskell fall seeded small grain hay production harvested at flag leaf stage from 1983-1984 season.

Source	df	MS	F Value
Total	11		
Replications	3	6815444	
Species	2	3944993	1.521NS†
Error	6	2593408	
CV (%) = 18			

†NS = Not significant

Table 29. Analysis of variance for Haskell fall seeded small grain hay production harvested at boot stage from 1983-1984 season.

Source	df	MS	F value
Total	19		
Replications	3	6340154	
Species	4	15848351	1.894NS†
Error	12	8368345	
CV (%) = 25			

†NS = Not significant

Table 30. Analysis of variance for Haskell fall seeded small grain hay production harvested at ear emergence stage from 1983-1984 season.

Source	df	MS	F Value
Total	19		
Replications	3	10040214	
Species	4	7275067	3.122NS†
Error	6	2330329	
CV (%) = 13			

†NS = Not significant

Table 31. Analysis of variance for Haskell spring seeded small grain hay production harvested at flag leaf stage from 1984 season.

Source	df	MS	F value
Total	15		
Replications	3	467985	
Species	3	5184505	11.321*
Error	9	457944	
CV (%) = 14			

*Denotes significant difference (P = 0.05)

Table 32. Analysis of variance for Haskell spring seeded small grain hay production harvested at boot stage from 1984 season.

Source	df	MS	F Value
Total	11		
Replications	3	1426602	
Species	2	5624840	17.607*
Error	6	319465	
CV (%) = 10			

*Denotes significant difference (P = 0.05)

Table 33. Analysis of variance for Haskell spring seeded small grain hay production harvested at ear emergence stage from 1984 season.

Source	df	MS	F value
Total	19		
Replications	3	327503	
Species	4	4900630	6.658*
Error	12	736054	
CV (%) = 12			

*Denotes significant difference (P = 0.05)

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