Fall Seeding Date and Species Effects on Spring Forage Yield of Winter Cereals

V. S. Baron, A. C. Dick, D. F. Salmon, and J. G. McLeod

Research Question

Alberta is a short-growing-season area where producers of ruminant livestock must feed conserved forage for 200 d or more each year. Extending the grazing season in spring or fall could have significant cost benefits for these producers. The feasibility of using spring-planted winter cereals either as monocrops or in mixtures with spring cereals has been demonstrated. It has been suggested that winter cereals may also provide alternative spring pasture to perennial grasses. The objective of this study was to determine the effects of seeding date on spring pasture production of three winter cereal species.

Literature Summary

Extension of the grazing season is a current research priority since significant cost savings to the livestock grazier can be effected. It has been shown that spring-planted winter cereals can be used to extend fall grazing and it has been suggested that fall-planted winter cereals may provide early spring pasture. Experiments relating to seeding date effects on winter cereals have confined observations to variables relating to grain production. It has been shown that optimum seeding dates differ for location according to climate and that deviation from this optimum, either earlier or later, generally results in yield reductions and some of the reasons have been explored. The effect of grazing on subsequent grain production has also been explored. There is little information on the effects of management practices on spring pasture production of winter cereals.

Study Description

This study was conducted for 2 yr at Lacombe, Alberta, Canada. Plots were seeded to 'Norstar' winter wheat, 'Pika' winter triticale, or 'Muskateer' fall rye on 15 August, 1 September, or 15 September each year. Fall observations included temperature and rainfall, time for crop emergence, and number of leaves and tillers produced per plant prior to winter dormancy. Spring weather records were kept from 1 April. The first clipping of plots occurred when crop canopy measured with a disk height meter was about 2 in. and a second followed 1 wk later. Herbage dry matter yields were determined. Crop growth stages, position of the growing point, and disk heights were recorded prior to each clipping.

Applied Question

Does seeding date for winter annual cereals affect spring pasture yield and earliness of usable pasture?

Although year to year variations were large, earlier seeding generally produced higher yields and pasture was available earlier in the spring. Spring pasture yield showed a positive linear relationship to fall growing degree days.

Do adapted winter cereal species differ in time and quantity of spring forage production or in response to fall seeding date?

It appears that fall rye may have some advantage over winter triticale or winter wheat for spring forage production. In both years, rye produced harvestable forage earlier than the other two species. In one of the 2 yr, dry matter yields of

Full scientific article from which this summary was written begins on page 110 of this issue.

rye were greater than the others. All species showed similar trends and relationships between seeding date and dry matter yield and harvest date. The growing point of rye remained below clipping height more consistently across clippings and seeding dates than the other species, which may allow a longer grazing period.

Forage

Fall Seeding Date and Species Effects on Spring Forage Yield of Winter Cereals

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A current research priority in short-season growing areas of Alberta is to increase cost efficiency of ruminant livestock production by extending the grazing season. The use of winter cereals is a potential source of earlier spring pasture than is provided by perennial grasses. This study determines the effect of fall seeding date on spring forage production of winter wheat (*Triticum aestivum* L.), fall rye (*Secale cereale* L.), and winter triticale (× *Triticosecale* Wittmack). One cultivar of each species (S) was seeded at Lacombe, AB, on 15 Aug., 1 Sept., and 15 Sept. in 1992 and 1993. Tiller and leaf numbers were recorded in the fall after dormancy. Spring clippings were taken when new growth was approximately 2 in. tall (as assessed by a disk height meter) and 1 wk later. Year and year × planting date effects were significant for most variables measured. Winter triticale and wheat were generally similar in treatment response while fall rye differed in some respects. Each delay of seeding resulted in smaller plants in the fall with fewer leaves and tillers. First clip yield varied from year to year, but was positively related to tiller or leaf number in the fall. Within the range of seeding dates used, earlier seeding produced earlier spring pasture. Fall rye tended to produce forage earlier and in greater quantity than the other two species. Dry matter yield generally increased linearly with increasing fall growing degree days (GDD) after planting. The use of early-planted fall rye for spring pasture in the western Parkland of the Canadian prairies is recommended.

EARLIER SPRING GRAZING would be advantageous in the Parkland vegetation zone of the Canadian prairies where the growing season is short. An estimated 200 000 acres of fall rye, winter wheat, and winter triticale are planted each fall for grain production. The number of acres of winter cereals grazed is undocumented; however, it is acknowledged to be much smaller than the area of winter wheat grazed in Texas, Oklahoma, and adjacent states. The use of winter cereals in western Canada is not as extensive as in the USA because of a much shorter growing season, and a limited number of varieties available that have adequate winter hardiness and suitable agronomic characteristics for grain production (Salmon et al., 1996). More acres of winter rye are grown than winter wheat and triticale because it is more winter hardy. The grazing period is limited, as the time interval between planting and freeze-up (early September to 1 November) and between snowmelt in the spring and jointing (mid-April to mid-May) is short.

Most research has concentrated on the effects of fall and spring grazing on subsequent grain yield (Kilcher, 1982; Poysa, 1985) rather than on how management affects spring forage yield for grazing. Klebesadel (1969) observed that very early planting (the first week of August) of fall rye in Alaska resulted in relatively high spring forage yield that was also 1 to 3 wk earlier than smooth bromegrass (*Bromus inermis* Leyss.). Grain yield and winter survival are criteria most often used to determine optimum seeding dates for winter cereals. In southern Saskatchewan and Alberta, optimum seeding dates for winter wheat based on these criteria are 15 August to 1 September (Fowler, 1982). Within-year optimum seeding dates may be as late as 15 September because of climate variation (Pittman and Andrews, 1961). The recommended window for seeding winter cereals in the Parkland of Alberta is 21 August to 7 September (Salmon and McLelland, 1996). Winter hardiness is reduced if plants are either too large (because disease incidence is greater [Slykuis et al., 1957; Fowler, 1982]) or too small (because root reserves and vigor are low [Thill et al., 1978]) before winter dormancy. When seeding occurs in late September vs. late August, heading date can be delayed 2 to 4 d and forage yield at the dough stage reduced by 30% (Corns, 1959). Winter wheat seeded from late August to early September in Washington, produced greater tiller and spike densities, headed 2 to 3 d earlier, and had higher shoot weights than wheat planted a month later (Thill et al., 1978).

The feasibility of extending the fall grazing season by seeding fall rye, winter wheat, and winter triticale in early May has been demonstrated. Generally fall rye and winter triticale have been superior to winter wheat for fall pasture (Baron et al., 1993) and also for subsequent grain production the following season (Salmon et al., 1993). Fall rye has been suggested as an alternative spring pasture to perennial grasses in northern areas (Klebesadel, 1969; Kilcher and Lawrence, 1979; Kilcher, 1982). Perennial bromegrass species are usually ready for grazing the third week of May while early grazing on crested wheatgrass (*Agropyron cristatum* L.) can occur the first 2 wk of May. To provide early-season grazing, cereals would have to produce sufficient forage for grazing before mid-May.

Spring growth does not usually begin until mid-April and stem elongation may begin by mid-May in the Parkland regions of western Canada. Given that a period of time is

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Abbreviations: GDD, growing degree days; S, species; SD, seeding date.

required to accumulate sufficient growth for grazing, there is a limited period for grazing before stem elongation moves the floral apex into the grazing zone where its removal may reduce grain yield. Hunt and Chapleau (1986) observed that aspects of floral development in winter cereals are variable. They ranked the interval between double ridges and terminal floret development as fall rye > winter triticale > winter wheat. Whether the same relationship among species exists between double ridges and elevation of the floral apices (growing points) is unknown.

It can be hypothesized that early fall planting may increase the size of a winter cereal plant going into winter, so that when growth resumes in the spring, herbage masses suitable for grazing may occur relatively early. As a result of this early dry matter production, a longer period between green up in the spring and stem elongation may occur, thereby increasing grazing days. Winter cereal genotypes that respond to an early seeding date in this manner may provide earlier spring grazing. The objective of this study was to determine the effect of fall planting date on the size and earliness of spring forage yield, and the stage of development and position of the floral apices in relation to clipping height among fall rye, winter wheat, and winter triticale.

MATERIALS AND METHODS

Experiments were conducted during 1993 and 1994 at Lacombe, Alberta, on plots that were seeded the previous fall on fallowed Penhold silt loam (coarse loamy, mixed, frigid, Typic Haplustall) soil. Prior to seeding, 55 lb P_2O_5/acre and 55 lb K_2O/acre were applied and incorporated. Nitrogen was broadcast at 45 lb/acre in the fall prior to freeze up and an additional 22 lb N/acre was broadcast in late May. 'Muskateer' fall rye, 'Pika' winter triticale, and 'Norstar' winter wheat were included in the tests and seeded in plots consisting of six rows with 10 in. spacing and 11.2 ft in length with a seeding density of 19 seeds/sq ft. Three seeding dates, 15 August (SD1), 1 September (SD2), and 15 September (SD3) were used each year. Emergence date was noted for each plot and leaf, tiller, and plant counts were recorded after 15 October. Two complete sets of plots were maintained so that the continuing development of the crop could be observed after clippings were taken.

Survival was rated visually in the spring. The first set of plots was clipped when canopy height, as measured with a weighted disk (Bransby et al., 1977), was about 2 in. This height was chosen because experience indicated that there was sufficient above ground herbage for grazing, but plants would still be in the pre-early-joint stage according to Dunphy et al. (1982). The intent was to harvest all plots at approximately the same herbage mass or height suitable for grazing; therefore different treatments were not harvested at the same date. However, all replications for one treatment were clipped the same day. Measurements and observations recorded prior to clipping included canopy height measured with a disk height meter (Bransby et al., 1977) and phenological stage of main tillers according to Tottman and Makepeace (1979). Position of the growing point was determined by dissection of five tillers chosen at random from the guard rows of each plot (Dunphy et al., 1982). All herbage was removed from the four inside rows of the plots to a height of 2 in. using a rotary lawn mower equipped with a bagger, collected and weighed. A 0.55 lb subsample was removed and dried at 175°F to determine percentage dry matter from which dry matter herbage yield was calculated. The second set of plots was clipped approximately 1 wk later than the first following identical procedures. The primary purpose of this clipping was to observe changes in growing point position and stage of development.

Table 1. Mean monthly temperatures and precipitation for fall and spring measurement periods and 86-yr means at Lacombe, AB.

Month	Mean monthly temperature, °F			Mean monthly precipitation, in.		
	1992–1993†	1993–1994	86-yr mean	1992–1993	1993–1994	86-yr mean
Aug	56.5	56.5	58.6	0.72	1.87	2.49
Sept	47.5	49.5	49.6	2.33	1.14	1.64
Oct	39.6	40.6	40.3	0.69	0.33	0.76
Apr	41.0	42.3	38.7	0.90	0.18	1.09
May	52.9	51.6	49.6	1.73	2.29	1.98
June	55.4	57.0	56.5	3.34	2.76	3.22

†Fall of 1992 and spring of 1993.

Meteorological measurements were recorded within 0.5 mi of the field site. Growing degree days >32°F were calculated and accumulated from date of seeding in the fall and from 1 April in the spring.

The experiment was designed as a 3 × 3 factorial in a split-plot arrangement in each year. Seeding dates (SD) were the main plots randomized in each of 3 replicates and species (S) were subplots randomized within each SD. The significance of SD, S, and replicate effects were tested for each year separately using SAS Proc GLM (SAS Institute, 1989). Years were tested for homogeneity of error variances and were found to be heterogeneous. Therefore, results are reported for each year separately. Means separation was achieved with LSD calculated from appropriate error terms for comparisons in a split-plot arrangement (Gomez and Gomez, 1984). The LSD between means was considered only if a significant ($P \leq 0.05$) F ratio resulted from the ANOVA. Correlations among spring harvest date, fall leaf and tiller growth, GDD, stage of development, position of the growing point, and yield of the two clippings were determined using means for each S × SD × yr combination ($n = 18$).

RESULTS

Climate

Total precipitation for fall and spring was quite similar in both years, although October 1993 and April 1994 had lower than average monthly precipitation (Table 1). Generally, mean temperatures were lower in fall 1992 than fall 1993, which was closer to the long-term average. The difference in mean temperatures between the two fall periods resulted in about one-third more fall GDD from planting in 1993 than 1992 (Table 2). Growing degree days available for fall growth declined by 200 to 300 for each 2-wk delay in seeding date (Table 2).

Cutting (Grazing) Time

Distinct qualitative trends were evident for the first clipping time. The range in first harvest date was from 5 May to

Table 2. Growing degree days after seeding in the fall and before harvest in the spring for three winter cereal species at Lacombe, AB, during 1992–1993 and 1993–1994.

	Fall degree days†							
	1992–1993				1993–1994			
	SD1‡	SD2	SD3		SD1	SD2	SD3	
	828	565	376		1089	774	511	
Species§	Spring degree days¶							
Fall rye	167	261	389		138	185	196	
Winter triticale	448	533	828		196	242	329	
Winter wheat	448	533	828		196	329	329	
	Accumulated degree days							
Fall rye	995	826	765		1227	959	707	
Winter triticale	1276	1098	1204		1284	1016	840	
Winter wheat	1276	1098	1204		1284	1103	840	
	Date of first forage harvest							
				Mean				Mean
Fall rye	5 May	19 May	22 May	15 May	1 May	8 May	9 May	6 May
Winter triticale	24 May	1 June	2 June	30 May	9 May	18 May	28 May	18 May
Winter wheat	24 May	1 June	2 June	30 May	9 May	28 May	28 May	22 May
Mean	18 May	28 May	29 May	25 May	6 May	18 May	22 May	15 May

† Degree days above 32°F accumulated from seeding to 18 October each year.
‡ Seeding dates: SD1 was 15 August, SD2 was 1 September, and SD3 was 15 September in each year.
§ Cultivars were Muskateer fall rye, Pika winter triticale, and Norstar winter wheat.
¶ Spring degree days above 32°F were accumulated from 1 April until first forage harvest for each species.

Table 3. Number of leaves per tiller and tillers per plant produced prior to winter dormancy by three winter cereal species with three planting dates in 2 yr at Lacombe, AB.

	1992–1993				1993–1994			
Species†	SD1‡	SD2	SD3	Mean	SD1	SD2	SD3	Mean
	Leaves/tiller							
Fall rye	5.5	4.2	2.3	4.0	5.6	5.0	2.9	4.5
Winter triticale	5.3	3.7	2.2	3.7	5.2	4.8	2.8	4.3
Winter wheat	5.1	4.1	2.4	3.9	5.5	5.0	3.0	4.5
Mean	5.3	4.0	2.3	3.9	5.4	4.9	2.9	4.4
LSD1§		0.9				0.9		
LSD2		0.2				ns		
LSD3		0.8				0.8		
LSD4		ns				0.4		
	Tillers/plant							
Fall rye	9.0	2.8	1.0	4.3	18.9	5.1	1.0	8.3
Winter triticale	7.3	2.1	1.0	3.5	17.7	4.9	1.0	7.9
Winter wheat	7.1	3.9	1.0	4.0	15.5	4.2	1.0	6.9
Mean	8.5	2.9	1.0	3.9	17.4	4.7	1.0	7.7
LSD1		1.8				ns		
LSD2		3.1				1.8		
LSD3		2.7				2.6		
LSD4		ns				ns		

† Cultivars were Muskateer fall rye, Pika winter triticale, and Norstar winter wheat.
‡ Seeding dates: SD1 was 15 August, SD2 was 1 September, and SD3 was 15 September in each year.
§ LSD1 is for difference between species at the same seeding date; LSD2 is for difference between seeding dates for the same species; LSD3 is difference between seeding dates averaged across species; LSD4 is difference between species averaged across seeding dates.

2 June (28 d) during 1992–1993 and from 1 May to 28 May (27 d) during 1993–1994 (Table 2). In both years earlier seeding was associated with earlier forage availability. Early seeding (SD1) provided pasture 10 d earlier than SD2, and 11 d earlier than SD3 in 1992–1993 (Table 2). In 1993–1994, SD1 was 12 d earlier than SD2, 16 d earlier than SD3. Fall rye was ready to graze 11 to 19 d earlier than winter wheat or triticale in 1992–1993. In 1993–1994, the response of species to SD was more variable, but rye was at least 8 to 19 d earlier than the other two species for all SD. With a rare exception, harvest date for wheat and triticale for SD2 in 1993–1994 were similar for SD within years.

In 1993–1994, the time and GDD between SD1 and SD2 were less than in 1992–1993. Generally, more GDD in spring were required to reach harvest in 1992–1993 than 1993–1994, perhaps partially compensating for a lack of GDD during the former fall. Although there was an inverse relationship between fall GDD and spring GDD to harvest ($r = -0.63$, $P \leq 0.05$), total accumulated GDD were not equivalent for all season, S, and planting date combinations (Table 2).

Fall Growth

Size of plants in the fall was assessed by leaf number per tiller and tillers per plant. In both years, leaf number decreased as planting date was delayed, but the difference between SD1 and SD2 was larger in 1992–1993 than in 1993–1994 (Table 3). In 1992–1993, fall rye had significantly more leaves than winter triticale, averaged over all SD, but the difference was not significant at the $P \leq 0.05$ level; there were no significant differences among S the following year. Generally tiller number for rye > triticale > wheat. Only 1 tiller/plant was evident for all species for SD3 in both years. In 1993–1994, SD1 and SD2 produced approximately twice as many tillers per plant as in 1992–1993, with an exception for winter wheat for SD2. Leaf and tiller number was highly correlated with fall GDD ($r = 0.92$ and $r = 0.93$, respectively, $P < 0.01$) including all S and year.

Stage and Growing Point Position

At the first clipping, growing points for fall rye were below clipping height in both years, across all SD and years (Table 4). Growing points for the other species were at or above the clipping level for SD3 and SD2 in 1992–1993 and 1993–1994, respectively at the first clipping, when they first appeared to have enough forage for grazing. A week later, at the second clipping, the only SD × S combination that consistently had growing points below clipping height was rye seeded at SD1. Averaged across S, the growing points for SD1 were lower than for SD2 or SD3 in 1993–1994.

Average stage of development (Tottmann and Makepeace, 1979) was comparable between years for each clipping (Table 5). In 1993–1994, first-clip stage among treatments was similar to the position of the growing point (Table 4), with elongation just beginning at all SD for rye, and two or more palpable nodes detectable above ground for winter triticale and wheat at SD2 and SD3. By the second clipping, winter triticale and wheat were at a more advanced stage than rye (Table 4). In effect, rye was phenologically less advanced than the other S, while producing similar or greater forage yields. (Table 5, 6).

Yield

Averaged across SD, 1993–1994 forage yields were approximately double 1992–1993 yields at both clippings (Table 6). At the first clipping, no general trends were evi-

Table 4. Position of growing point† at time of first and second spring forage harvests for three winter cereal species in two yr at Lacombe, AB.

	1992–1993				1993–1994			
Species‡	SD1§	SD2	SD3	Mean	SD1	SD2	SD3	Mean
				First clipping				
Fall rye	0.0	0.7	1.0	0.6	1.0	1.0	1.0	1.0
Winter triticale	0.7	0.0	1.8	0.8	1.0	2.0	3.0	2.0
Winter wheat	0.3	0.3	2.7	1.1	1.0	3.0	3.0	2.3
Mean	0.3	0.3	1.8	0.8	1.0	2.0	2.3	1.8
LSD1¶		3.2				2.9		
LSD2		1.2				1.0		
LSD3		2.5				2.2		
LSD4		1.7				1.5		
				Second clipping				
Fall rye	1.3	2.0	2.0	1.8	1.0	3.0	3.0	2.3
Winter triticale	3.0	2.0	2.0	2.1	2.3	3.0	3.0	2.8
Winter wheat	1.3	1.3	2.0	1.5	2.0	3.0	3.0	2.7
Mean	1.9	1.8	2.0	1.8	1.8	3.0	3.0	2.6
LSD1		1.2				0.4		
LSD2		0.4				0.1		
LSD3		0.9				0.2		
LSD4		0.6				0.2		

† Growing point position was on a scale of 0 to 3 where 0 was below ground, 1 was at ground level, 2 was above ground but below clipping height, and 3 was above clipping height.
‡ Cultivars were Muskateer fall rye, Pika winter triticale, and Norstar winter wheat.
§ Seeding dates: SD1 was 15 August, SD2 was 1 September, and SD3 was 15 September in each year.
¶ LSD1 is for difference between species at the same seeding date; LSD2 is for difference between seeding dates for the same species; LSD3 is difference between seeding dates averaged across species; LSD4 is difference between species averaged across seeding dates.

Table 5. Growth stage† at first and second spring forage harvests for three winter cereal species with three seeding dates in 2 yr at Lacombe, AB.

	1992–1993				1993–1994			
Species‡	SD1§	SD2	SD3	Mean	SD1	SD2	SD3	Mean
				First clipping				
Fall rye	30.0	30.0	30.3	30.1	29.0	30.7	30.7	30.1
Winter triticale	30.3	32.6	37.0	33.2	30.0	32.0	33.0	31.7
Winter wheat	30.0	30.0	32.0	30.7	30.0	33.0	33.0	32.0
Mean	30.1	30.9	33.1		29.7	31.9	32.2	
LSD1¶		ns				0.6		
LSD2		ns				0.2		
LSD3		ns				0.3		
LSD4		ns				0.3		
				Second clipping				
Fall rye	31.0	31.3	32.0	31.4	31.3	33.0	33.0	31.4
Winter triticale	32.0	31.7	46.3	36.7	32.3	34.0	38.0	34.8
Winter wheat	35.0	31.0	45.7	37.2	32.0	40.0	37.0	36.3
Mean	32.7	31.3	41.3	35.1	31.2	35.7	36.0	34.2
LSD1¶		4.8				0.6		
LSD2		1.5				0.2		
LSD3		3.0				0.2		
LSD4		2.5				0.3		

† Growth stages according to Tottman and Makepeace (1979). Stage 30 occurs when the pseudostem is erect; 33 is third node detectable; 37 is flag leaf just visible.
‡ Cultivars were Muskateer fall rye, Pika winter triticale, and Norstar winter wheat.
§ Seeding dates: SD1 was 15 August, SD2 was 1 September, and SD3 was 15 September in each year.
¶ LSD1 is for difference between species at the same seeding date; LSD2 is for difference between seeding dates for the same species; LSD3 is difference between seeding dates averaged across species; LSD4 is difference between species averaged across seeding dates.

dent among S and SD in 1992–1993. In 1993–1994, later seeding resulted in lower yields. In 1993–1994, fall rye yielded more than the other species at SD1 and SD2 at both clippings, although yield for rye tended to decrease from SD1 to SD3. At the second clip, rye yielded more than the other S, averaged over SD, although no trends among S and SD were observed. In 1993–1994, there was a general decrease in yield with SD, and rye yielded more than the other species at SD1 and SD2 at both clips.

Including both species and years, there was a high correlation between first clipping yield and fall GDD ($r = 0.73$, $P < 0.01$) and between yield and fall tiller number ($r = 0.75$, $P < 0.01$). The correlation between first clipping yield and fall leaf number was 0.53 ($P < 0.05$).

Discussion

Experience indicated sufficient available forage for the commencement of grazing when the canopy disk height was about 2 in. First clip yields taken at this time ranged from 0.28 to 1.48 tons/acre. Previous research by Sneva (1977) with crested wheatgrass in Oregon concluded that about 0.10 to 0.15 tons/acre was suitable for early spring grazing. On the other hand, New Zealand researchers (Nichol and Nicholl, 1987) recommend that at least 1 ton/acre of forage be available for efficient grazing. Because the spring grazing season is so short, initiating grazing on the lower side of the range may be essential, with stocking rates set accordingly.

Time of forage availability was closely related to accumulated GDD from planting until freeze-up in the fall, but there was no relationship with accumulated or total and spring GDD. This implies that late-planted cereals (15 September) are unlikely to produce sufficient dry matter for early grazing the next spring. In a year of average fall temperatures (e.g., 1993–1994), planting would have to occur as early as 15 August, so that all species could be grazed during the first week of May, and in a year with below average

Table 6. Dry matter yield† at first and second spring forage harvests for three winter cereal species with three seeding dates in 2 yr at Lacombe, AB.

	1992–1993				1993–1994			
Species‡	SD1§	SD2	SD3	Mean	SD1	SD2	SD3	Mean
				First clipping				
Fall rye	0.49	0.41	0.28	0.39	1.48	1.04	0.59	1.04
Winter triticale	0.54	0.37	0.52	0.48	1.08	0.69	0.63	0.79
Winter wheat	0.41	0.34	0.52	0.42	0.92	0.78	0.53	0.74
Mean	0.48	0.37	0.44	0.43	1.16	0.84	0.58	0.86
LSD1		ns				0.23		
LSD2		ns				0.08		
LSD3		ns				0.18		
LSD4		ns				0.12		
				Second clipping				
Fall rye	0.67	0.69	0.98	0.78	1.96	2.16	0.92	1.68
Winter triticale	0.86	0.34	0.60	0.60	1.15	1.11	1.43	1.23
Winter wheat	0.82	0.39	0.72	0.64	1.05	1.74	1.55	1.45
Mean	0.78	0.47	0.77	0.67	1.39	1.67	1.30	1.45
LSD1		0.25				0.8		
LSD2		0.08				0.2		
LSD3		0.18				0.4		
LSD4		0.13				0.4		

† Dry matter yield (tons/acre).
‡ Cultivars were Muskateer fall rye, Pika winter triticale, and Norstar winter wheat.
§ Seeding dates: SD1 was 15 August, SD2 was 1 September, and SD3 was 15 September in each year.
¶ LSD1 is for difference between species at the same seeding date; LSD2 is for difference between seeding dates for the same species; LSD3 is difference between seeding dates averaged across species; LSD4 is difference between species averaged across seeding dates.

temperatures only fall rye could be grazed that early and only if planted by 15 August. This study did not determine the effect of grazing or clipping in the fall on time of spring grazing.

Generally, time of grazing was related to plant size in the fall. There was a close relationship between fall GDD and leaf and tiller number. A linear relationship between leaf appearance and GDD has been established (Klepper et al., 1988). Time of first clip yield was inversely related to both leaf and tiller number. First clip yield however, was positively correlated to tiller number. More leaves per tiller provide more potential tiller sites and potentially denser swards (Robson et al., 1988). The extent to which leaf and tiller development occurred in the fall influenced vegetative crop growth in the spring. In effect, more growing points were ready to continue growth in the spring.

Fall rye responded to planting date for early grazing and was much more reliable in providing early spring grazing than the other S. The ability of rye to produce tillers and leaves under cool fall, and perhaps spring, conditions may be partially responsible for its early spring superiority. Generally, fall rye had more tillers per plant late in the fall than the other S. Past research has shown fall rye to have higher shoot and root dry matter accumulation than winter wheat and triticale when grown under cool (50–45°F) temperatures. This was attributed to superior tiller production at these temperatures (Winzeler et al., 1989). Fall rye may have been able to continue growth later in the fall and resume growth under cool temperatures of early spring better than winter wheat and triticale. Estimation of potential duration of grazing was not precise, because the duration over which grazing might continue without damage to subsequent grain yield was not assessed. Most of the criteria used and developed for movement of cattle on and off cereal pastures has been developed in a vastly different climate (Texas and Oklahoma) and with winter cereal germplasm different from that used in the current study. There is little consensus in the literature as to when spring grazing should be terminated to avoid yield loss in the subsequent grain harvest (Redmon et al., 1996). A number of factors appear to affect grazing termination date including environment, S, and genotype. Kilcher (1982) recommended grazing fall rye during the spring for only 2 to 3 wk during May in the semiarid region of Saskatchewan, based on losses in grain yield. This is the climate most similar to the present study. In Texas, Dunphy et al. (1982) concluded that grain yield of winter wheat was significantly reduced when grazed at "late joint," a stage defined as when first tillers are observed with apices above a clipping height of 3 in., representing the stubble (lower) height of the grazing zone. However, they noted that time of jointing of winter wheat in that environment was highly variable. In Oklahoma, time of "first hollow stem" was found to be a suitable criterion to use to determine the termination time for grazing semi-dwarf winter wheat (Redmon et al., 1996). The first hollow stem stage is estimated to be earlier than the late joint stage described by Dunphy et al. (1982). Generally, stages of development recommended as times of livestock removal from wheat pastures in the southern USA would limit grazing to such short periods if used in Western Canada that grazing winter cereals in spring would be impractical.

The growing point of fall rye was almost always below clipping height at the first clip, but the growing point only remained below clipping height over both clips when planted as early as 15 August in a year of average fall temperatures (1993–1994). At later SD, all cereals were left with very few tillers at freeze-up with which to resume growth the following spring. At the same time, increasing daylength and temperatures in the spring drove floral development forward in spite of low biomass accumulation. Therefore, given that grazing initiation in the spring was based on disk height or yield, a shorter window between grazing initiation and jointing occurred. This particularly limits the potential for grazing winter wheat and triticale in the spring. The explanation is borne out partially where first and second clip yield of fall rye, in particular, tended to decrease (or remain the same at second clipping) with delayed seeding, especially in 1993–1994. Increasing daylength and temperature reduce days to flowering, and tillering is limited by ear development (Evans et al., 1978). This study did not indicate that the growing point of fall rye remained below clipping height longer than winter wheat and triticale because exact times of passage from soil surface to the clipping height were not monitored. However, it is apparent that fall rye was capable of reaching an available yield suitable for spring grazing sooner than the other species and this was probably the operative factor in rye having a potentially larger window for spring grazing than the other S. While only one cultivar of each species was used in the study, they were representative of the limited winter hardy, adapted, material available for the region (Salmon et al., 1996).

There are several important conclusions from this research. Seeding winter cereals earlier than recommended for grain resulted in earlier pasture the following spring. Fall rye appeared more responsive to earlier seeding for early spring pasture than winter triticale and wheat; the growing point of fall rye appeared to remain below clipping height across an array of seeding times. In this context, fall rye did not necessarily have higher yields, but at least had similar yields, earlier, than the other S. Earliness was associated with fall GDD from planting until feeze-up. During a year with below average mean temperatures, early planting had more impact on "earliness" for spring grazing than during a year with average mean temperatures. There was a positive relationship between tiller number or leaf number in the fall and first clip yield the following spring.

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