THE EFFECT OF GRAZING ON LEAF DEVELOPMENT IN EIGHT GRASS SPECIES

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ABSTRACT
Grazing by herbivores affects grass species both morphologically and physiologically. A grazing study was conducted on an irrigated pasture near Outlook, Saskatchewan, Canada during the summers of 1991 and 1992 to determine morphological development of regrowth of reed canarygrass (*Phalaris arundinacea* L.), slender wheatgrass (*Elymus trachycaulus* (Link) Gould ex Shinners *subsp. trachycaulus*), intermediate wheatgrass (*Thinopyrum intermedium* (Host) Barkw. & D.R. Dewey *subsp. intermedium*), orchardgrass (*Dactylis glomerata* L.), meadow bromegrass (*Bromus beibersteinii* Roem. & Schult.), smooth *bromegrass (Bromus inermis* Leyss.), tall fescue (*Festuca arundinacea* (Schreb.) Wimm.) and timothy (*Phleum pratense* L.) in order to evaluate the suitability of these species for grazing. All eight species were mob-grazed by sheep at a stocking rate of 30 animals ha^{-1}. Physiological stage of leaf development was determined at 7, 14 and 21 d following defoliation. Smooth bromegrass and timothy consistently produced the greatest number of leaves at all regrowth stages. Tall fescue produced the least development of leaves at all time periods. Fifty-five percent of slender wheatgrass tillers and 19% of intermediate wheatgrass tillers were reproductive 21 d after defoliation. Based on leaf growth the grasses were ranked into three groups - meadow and smooth bromegrasses ranked highest, intermediate wheatgrass, reed canarygrass and orchardgrass ranked intermediate and timothy, tall fescue and slender wheatgrass ranked lowest.

KEYWORDS
Leaf, regrowth, grass

INTRODUCTION

Introduced grasses are increasingly being used for season long grazing throughout western Canada. Few studies have dealt with leaf development comparisons as leaf replacement is more favorable for species which do not elevate shoot apices during leaf elongation. Conversely, culmed species elevate vegetative growth which can expose apical meristems to removal by grazing (Hyder 1972). In 1990, differences were noted in the rate of leaf development among eight grass species. Therefore, a study was conducted to compare leaf development of eight grasses after grazing defoliation.

MATERIALS AND METHODS

In 1990, 14 ha of irrigated land near Outlook, Saskatchewan, Canada (Lat. 51.29 N; Long. 107.03 W), were seeded with reed canarygrass (*Phalaris arundinacea* L.), cv. Rival; slender wheatgrass (*Elymus trachycaulus* (Link) Gould ex Shinners *subsp. trachycaulus*), cv. Revenue; intermediate *wheatgrass (Thinopyrum intermedium* (Host) Barkw. & D.R. Dewey *subsp. intermedium*), cv. Chief; orchardgrass (*Dactylis glomerata* L.), cv. Kay; meadow bromegrass (*Bromus beibersteinii* Roem. & Schult.), cv. Paddock; smooth bromegrass (*Bromus inermis* Leyss.), cv. Magna; tall fescue (*Festuca arundinacea* (Schreb.) Wimm.), cv. Courtenay; timothy (*Phleum pratense* L.), cv. Champ. Species were seeded in replicated strips that were 4.8 m wide over the length of the study area. Strips were replicated forty times throughout the pasture.

The 14 ha area was divided into six paddocks, perpendicular to the species strips, using electric fencing and existing perimeter fences. Thus all species were replicated in all paddocks. Paddocks varied from .5 to 2.8 ha each and number of replicates within paddocks varied from 4 to 10. Paddocks were accessed from an end alley to accommodate rotational grazing.

Total precipitation from May to September in 1991 and 1992 was 358 and 254 mm, respectively. The pasture was irrigated with a Zimmatic low pressure (200 kPa) center pivot system when rainfall did not provide adequate moisture for pasture growth. Total irrigation, May to September 1991 and 1992, was 210 and 555 mm, respectively. Mean average temperatures, May to September 1991 and 1992 ranged from 4.8 to 28.7 °C and 4.1 to 22.6 °C, respectively.

Soil samples taken in 1990 indicated phosphorus levels of 18 kg ha^{-1} and available nitrogen levels of 55 kg ha^{-1}. Maintenance levels of fertilizer were applied in July 1991 (56 kg N ha^{-1}, broadcast) and August 1991 (56 kg N ha^{-1} and 15 kg P ha^{-1} by fertigation), April 1992 (115 kg N ha^{-1} and 23 kg P ha^{-1}, broadcast), and August 1992 (48 kg N ha^{-1}, fertigation).

Grazing commenced when paddock growth was at least 8 cm and lasted 114 d in 1991 (May 29 to September 13), and 120 d in 1992 (May 20 to September 15). Grazing was terminated in early fall to minimize potential winter kill of less hardy species.

Paddocks were mob grazed (Mislevy et al. 1981) by sheep at a stocking rate of 30 animals ha^{-1}. This technique allows for quick evaluation of large numbers of forage species and introduces the effects of trampling, pulling of plants and deposition of feces and urine, while reducing selectivity to a minimum. Paddocks were grazed for 4 h in the morning and evening; animals were returned to holding pens when not grazing. Animals consumed the forage to a height of approximately 4 cm in each paddock. Paddocks were grazed in four rotations in 1991, and three rotations in 1992.

In 1991, following grazing in four of six paddocks, physiological stage of leaf development, based on a modified Haun scale of development (Haun 1973), was determined 7, 14 and 21 d after defoliation on tillers of each species. Sixteen grazed tillers were randomly selected and marked from each of 2 locations within each of 4 paddocks for a total of 64 tillers. A numerical designation, subdivided into decimal fractions, is given for the number of new leaves formed on a stem (Frank 1991).

Mean Haun scores for two locations in each paddock at each observation time were calculated for statistical analyses. Only vegetative regrowth was recorded; once tillers turned reproductive they were no longer counted. In this study, tiller grazings occurred on July 2, 16, 30 and August 13.

A completely randomized design was used for estimates of leaf growth. The SAS General Linear Models procedures was used for analysis of variance (SAS Institute Inc. 1990) and Duncan's Multiple Range Test was used for mean separation.

RESULTS AND DISCUSSION

Mean Haun values after 7, 14 and 21 d of regrowth for all grasses at each observation time and species means are presented in Table 1. Differences were noted ($p<0.01$) for number of leaves produced between observation dates and combined stages of development, therefore Haun stages were not pooled across dates. It has been shown that phenological development of grasses is strongly correlated to air temperature (Higgins et al. 1964). Consequently, variability of leaf appearance at different observation times may have been due to differences in temperature during the regrowth intervals.

During the first 7 d of regrowth, smooth brome and timothy tillers produced the greatest number of new leaves. Timothy produced a greater ($p<0.05$) number of leaves than slender wheatgrass, intermediate wheatgrass, orchardgrass, meadow bromegrass or tall fescue. On July 23 and August 20, timothy had Haun scales of 1.4 leaves (Table 1). Tall fescue produced the least number of new leaves after 7 d of regrowth at all observation periods (0.7 leaves). Although meadow brome, which has good regrowth characteristics, produced fewer ($p<0.05$) leaves than timothy, the leaf area appeared much larger than leaves of other species. Slender wheatgrass was the only grass to elongate and develop seedheads 7 d after defoliation with 16 percent of tillers becoming reproductive.

After 14 d of regrowth, timothy and smooth brome produced more ($p<0.05$) new leaves than intermediate wheatgrass, meadow brome or tall fescue. Reed canarygrass and orchardgrass had Haun values significantly ($p<0.05$) greater than tall fescue at July 16 and August 13 and across all four dates. Thirty-nine percent of slender wheatgrass and 13 percent of intermediate wheatgrass tillers developed inflorescence after 14 days.

Smooth brome produced the greatest ($p<0.05$) number of new leaves (4.1) (Table 1) by July 23 after 21 d of regrowth. Smooth brome and timothy had the highest average number of leaves across all dates, 3.0 and 2.9 leaves, respectively. Tall fescue had the least ($p<0.05$) rate of development (2.0 leaves) 21 d after grazing. Fifty-six percent of slender wheatgrass culms were reproductive and 19 percent of intermediate wheatgrass tillers had developed seedheads by this time. Minimal tiller mortality was observed in orchardgrass, meadow bromegrass, smooth bromegrass and tall fescue (< 1% for each species).

Smooth brome and timothy consistently produced the greatest number of leaves at all regrowth intervals. Horrocks and Washko (1969), reported that once regrowth began in timothy, stem elongation increased, giving rise to more leaves. Reed canarygrass and orchardgrass had greater ($p<0.05$) Haun stages than tall fescue for all the regrowth intervals. After 7 d of regrowth, tall fescue showed no change between observation dates in mean Haun development and the 21 d regrowth on August 20 was equivalent to 14 d regrowth on July 16 for this species. The number of leaves produced by tall fescue at 14 d (1.2-1.7) was also equivalent to 7 d regrowth for reed canarygrass, smooth bromegrass and timothy. The time of year that observations were taken may have influenced the tendency for regrowth of this grass. Wolf et al. (1979) reported a continuous decline in crop growth rate (kg ha^{-1} d^{-1}) of tall fescue during the spring, low rates during the summer and a dramatic recovery in the fall.

The tendency for slender wheatgrass to mature rapidly after defoliation and have over 50 percent of grazed tillers reproductive 21 d after grazing demonstrates the inability of this species to remain vegetative long enough to be a productive pasture species. Inflorescence formed on 19% of the grazed tillers of intermediate wheatgrass, indicating a later maturing characteristic. Those species which remain vegetative and palatable throughout the season may be selected more readily by the grazing animal.

In this study, Haun stage of leaf development for reed canarygrass, slender wheatgrass, intermediate wheatgrass, orchardgrass, meadow bromegrass and smooth bromegrass was greater in early and mid-July than in late July or August. The number of leaves decreased at each observation date within each period for these species. Deinum (1976) demonstrated in *Lolium perenne* that successive defoliations and poor light penetration to basal buds where leaves develop were the major causes of lower production in late summer and autumn. Growth potential may have been reduced as mean daily temperatures decreased in the late summer and fall.

Orchardgrass produced more ($p<0.05$) leaves 14 and 21 d after grazing. Denison and Perry (1990) also reported that growth rates ($kg\ ha^{-1}\ d^{-1}$) of orchardgrass were generally higher in the 3rd than in the 1st week of regrowth. Early studies of orchardgrass by Davidson and Milthorpe (1966) found a positive relationship between rate of leaf expansion and total soluble carbohydrate content. Brown and Blaser (1965) indicated that carbohydrates have an important role in regrowth, winter survival and initiation of spring growth in orchardgrass. Lawrence and Warder (1979) reported a lack of winter hardiness in orchardgrass. In the present study, some winter kill of orchardgrass was noted in the spring of 1992. These findings suggest that rapid regrowth may result in low stored carbohydrate reserves and increase susceptibility to winter kill in orchardgrass.

Tall fescue had lower ($p<0.05$) development rates at all stages compared to the other 7 grasses. McKee et al. (1967) reported that faster regrowth of tall fescue was associated with decreases in stubble carbohydrate reserves. Volenec (1986) also reported decreases of 50% in carbohydrate fractions following 4 d of regrowth. Timothy had the greatest leaf development at 7, 14 and 21 d after grazing, and smooth bromegrass, meadow bromegrass and intermediate wheatgrass had good leaf development characteristics.

Based on the data from these studies, meadow bromegrass, smooth bromegrass and reed canarygrass were considered to have the best characteristics of regrowth after grazing due to moderate rates of leaf development. Intermediate wheatgrass and orchardgrass were ranked intermediate and timothy, tall fescue and slender wheatgrass are ranked lowest. Timothy was ranked low because the rapid leaf development may exhaust stored carbohydrate reserves (Lardner et al. 1997) and make this grass susceptible to winter kill. Slow development was observed for tall fescue, suggesting a poor ability to persist in pasture. Finally, slender wheatgrass was ranked lowest because of its inability to remain vegetative after defoliation.

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Table 1

Mean Haun stage after 7, 14 and 21 d of regrowth of eight grasses. (n=64)

7 d regrowth						
Observation date	July 9	July 23	August 6	August 20	MEAN	SEM [z]
Reed canarygrass	1.1*ab*	1.2*a*	1.0*b*	1.0*b*	1.1*abcde*	0.11
Slender wheatgrass	0.9*b*	1.2*a*	0.9*b*	0.7*b*	0.9*cdefg*	0.12
Intermediate wheatgrass	0.9*b*	1.1*a*	0.7*b*	0.8*b*	0.9*cde*	0.09
Orchardgrass	1.0*b*	1.0*b*	0.8*b*	0.8*b*	0.9*cdef*	0.09
Meadow bromegrass	1.1*b*	1.0*b*	1.0*b*	0.8*b*	1.0*bcd*	0.10
Smooth bromegrass	1.5*a*	1.4*a*	1.0*b*	0.9*b*	1.2*ab*	0.10
Tall fescue	0.7*c*	0.7*b*	0.7*b*	0.7*b*	0.7*fg*	0.08
Timothy	1.2*b*	1.4*a*	1.2*a*	1.4*a*	1.3*a*	0.19
14 d regrowth						
Observation date	July 16	July 30	August 13	August 27	MEAN	SEM
Reed canary grass	2.5*b*	2.0*abcdef*1.8*a*	1.6*bcd*	2.0*ab*	0.15	
Slender wheatgrass	1.9*c*	1.8*abcde* 1.7*a*	1.7*bc*	1.8*abcd*	0.23	
Intermediate wheatgrass	1.9*c*	1.7*bcde*	1.4*b*	1.3*cd*	1.6*bcd*	0.10
Orchardgrass	2.3*b*	1.9*abcd*	1.7*a*	1.8*bcdef*	1.9*abc*	0.15
Meadow bromegrass	1.9*c*	1.5*e*	1.5*b*	1.4*cdef*	1.6*bcd*	0.13
Smooth bromegrass	2.9*a*	2.2*a*	1.7*a*	1.9*ab*	2.2*a*	0.15
Tall fescue	1.7*c*	1.6*def*	1.2*b*	1.4*cde*	1.5*d*	0.10
Timothy	2.5*b*	2.1*ab*	2.0*a*	2.2*a*	2.2*a*	0.18
21 d regrowth						
Observation date		July 23	August 6 August 20	MEAN	SEM	
Reed canarygrass	3.2*bc*	2.4*abcd*	2.1*bcd*	2.6*a*	0.17	
Slender wheatgrass	2.7*cdefgh*	2.4*abc*	2.1*bcde*	2.4*a*	0.23	
Intermediate wheatgrass		2.7*def*	2.4*ab*	1.9*cdefg*	2.3*a*	0.13
Orchardgrass		3.1*bcd*	2.6*a*	2.7*ab*	2.8*a*	0.17
Meadow bromegrass		2.7*defg*	2.2*abcde*	2.0*cdef*	2.3*a*	0.17
Smooth bromegrass		4.1*a*	2.5*a*	2.5*abc*	3.0*a*	0.23
Tall fescue		2.4*fgh*	2.0*bcde*	1.7*defg*	2.0*b*	0.13
Timothy		3.4*bcde*	2.5*a*	3.0*a*	2.9*a*	0.27

[z] Standard error of the mean

a-g Means within columns with unlike letters differ ($p<0.05$)