THE EFFECT OF GRAZING ON ETIOLATED REGROWTH 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 etiolated regrowth after grazing 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}. Carbohydrate reserves were estimated by determination of etiolated regrowth. Meadow bromegrass produced the greatest etiolated regrowth and timothy the least. Based on production of etiolated regrowth the grasses were ranked into three groups - meadow bromegrass and intermediate wheatgrass ranked highest, smooth bromegrass, reed canarygrass, slender wheatgrass and orchardgrass ranked intermediate and timothy and tall fescue ranked lowest.

KEYWORDS

grazing, etiolated regrowth, carbohydrate reserves, grass

INTRODUCTION

Production of perennial grass herbage is considered to be strongly influenced by the amount of organic reserve material that is developed during the previous growing season. These reserves are predominantly non-structural carbohydrates that accumulate in the roots and crowns of plants. Ward and Blaser (1961) indicated that tiller regrowth of orchardgrass was affected by both carbohydrate reserves and leaf area. Etiolated regrowth measured in the field can be used as a quantitative index of stored carbohydrate reserves of plants prior to spring growth (McKendrick and Sharp, 1970). Total non-structural carbohydrates (TNC) are a measure of the pool of energy available for growth in the spring, for regrowth after defoliation, or for the active metabolic processes associated with hardening and maintaining plants during the winter. Analysis of TNC can be laborious and expensive and provides an erroneous measure of the organic reserve level (McKendrick and Sharp, 1970). Consequently, a method has been developed to evaluate this reserve by measuring etiolated regrowth that a plant undergoes before its reserves are exhausted. This method is based on the assumption that the ‘potential vigor’ of grass plants can be estimated from the weight of the aerial regrowth in darkness (Edwards, 1964). Therefore, a study was conducted to compare the amount of stored reserve material of eight grasses, as indicated by etiolated growth under light-tight pots, measured in the spring.

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 ^{o}C and 4.1 to 22.6 ^{o}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. Carbohydrate reserves of each grass following the 1991 grazing season were estimated for all six paddocks in early 1992 using the etiolated growth technique (Matches, 1969). Six replicates of each grass were randomly selected and clipped to 3 cm height and covered on April 4 with metal cans (13.5 cm diameter, 25 cm height). Richards and Caldwell (1985), reported no significant effects of moisture or heat stress in covered plants. As plants were covered, tuft basal circumference was measured using meter tape and weights adjusted by covariance for differences in circumference. Etiolated growth was measured from April 4 to June 22, 1992. First clip of etiolated growth occurred 20 d after covering tufts and every 7 d thereafter until no further regrowth occurred. Clipped etiolated growth of each plant was dried at 60°C for 48 h and weighed. Estimated carbohydrate reserves were expressed as mean etiolated growth for each species. A completely randomized design was used for estimates of etiolation. 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

There were significant differences in total etiolated regrowth between the eight grass species (Table 1). Meadow bromegrass produced the greatest ($p<0.05$) total etiolated regrowth over the 80 d that plants were clipped. Timothy had the least ($p<0.05$) amount of etiolated regrowth for five of the six cutting dates where there was regrowth. For the first two cuts etiolated regrowth was greater ($p<0.05$) for meadow brome than for reed canarygrass, orchardgrass, smooth brome, tall fescue and timothy. This suggests that meadow brome, which has rapid regrowth characteristics (Fairbourn, 1983; Lardner et al., 1997), also has the greatest potential for early spring production relative to the grasses tested. Timothy did not produce etiolated regrowth beyond June 1, 3 wk before the study ended. This suggested that timothy exhausted its reserves rapidly, possibly as a result of rapid leaf development rates and successive defoliations from the previous year (Lardner et al., 1997) preventing it from storing sufficient carbohydrate reserves for competitive growth the following spring. Colby et al. (1974) also reported low reserve levels in Phleum pratense after periods of high growth rates. Orchardgrass had a total etiolated growth of 3.75 g. Denison and Perry (1990) 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 of the grass. The amount of etiolated regrowth produced by orchardgrass was relatively low compared to other species. This may have been a consequence of the high production during late August of the previous grazing year. 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 (Lardner et al., 1997) may result in low stored carbohydrate reserves and increase susceptibility to winter in orchardgrass. McKee et al. (1967) reported that fast regrowth of tall fescue was associated with decreased stubble carbohydrate reserves. Volenec (1986) also reported decreases of 50% in carbohydrate fractions following 4 d of regrowth. Our findings (Lardner et al., 1997) suggested that, tall fescue had high development rates in 1991 and carbohydrate reserves were reduced significantly during regrowth and this was reflected in poor production of etiolated regrowth the following spring. Smith (1969) reported that concentrations of stored carbohydrate reserves were greatest in the internode, leaf blade and sheath of smooth bromegrass and timothy. Plants that maintain storage reserves while producing new top growth may have an advantage in the next grazing season. If defoliations are frequent and severe, regrowth and carbohydrate reserves may be reduced and the time intervals for recovery may be too short to allow for TNC buildup. Reserves are exhausted in producing new leaf growth which is being grazed off and a sufficient recovery time does not allow carbohydrate stores to be replenished. Thus, grazing of these plants should be regulated to avoid severe defoliation for those species which exhaust their reserves rapidly, and to allow sufficient leaf area to be maintained throughout the growing season. Richards and Caldwell (1985) reported no significant correlations between leaf development and etiolated regrowth the following year. This suggests that rate of regrowth following grazing and energy reserves for growth the next spring are independent traits for grass species. In the present study timothy, which had the greatest leaf development rate after grazing (Lardner et al., 1997), had the lowest etiolated regrowth in this study while tall fescue, which had the lowest leaf development after grazing (Lardner et al., 1997) also had a low etiolated regrowth. Smooth bromegrass, meadow bromegrass and intermediate wheatgrass which had moderate leaf development following grazing (Lardner et al., 1997) had good etiolated regrowth characteristics. Grasses such as timothy and orchardgrass which produced consistently high regrowth the previous grazing season produced low to moderate amounts of etiolated regrowth. Based on the data from this study, meadow bromegrass, smooth bromegrass and reed canarygrass could expect to have a high degree of long term productivity in a grazed pasture due to moderate to high etiolated regrowth which reflects the stored carbohydrate reserves of these species. Intermediate wheatgrass and orchardgrass are ranked intermediate and timothy, tall fescue and slender wheatgrass are ranked lowest. Timothy ranked low in long term productivity; the rapid development observed for this species (Lardner et al., 1997) may have exhausted stored carbohydrate reserves, reflected in low etiolated regrowth. Slow development (Lardner et al., 1997) and low etiolated yield, were observed for tall fescue, suggesting a poor ability to persist in pasture. Finally, slender wheatgrass was ranked lowest, even though its etiolated regrowth was third highest among the 8 grasses, because of its inability to remain vegetative after defoliation (Lardner et al., 1997).

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Table 1
Total etiolated regrowth for eight grass species (g).

Species	April 24[Z]	May 4	May 11	May 18	May 25	June 1	June 8	June 15	June 22	TOTAL	SEM [Y]
Reed canarygrass	0.28*e*	1.31*b*	0.81*a*	0.7*a*	0.57*a*	0.38*abc*	0.16*a*	0.15*a*	0.04*a*	4.40*bcde*	0.10
Slender wheatgrass	1.26*b*	1.92*ab*	0.72*a*	0.52*abcde*	0.43*abc*	0.16*bcdef*	0.12*a*	0.04*a*	-	5.17*cd*	0.12
Intermediate wheatgrass	1.15*bc*	*1.95ab*	*0.82a*	*0.77a*	*0.74a*	*0.48a*	*0.21a*	*0.41a*	*0.02a*	*6.55abc*	*0.12*
Orchardgrass	*0.27e*	*1.80b*	*0.72a*	*0.58abcd*	*0.21bcd*	*0.12bcdefg*	*0.05a*	-	-	*3.75de*	*0.11*
Meadow bromegrass	*1.61a*	*2.74a*	*0.96a*	*0.78a*	*0.68a*	*0.40ab*	*0.19a*	*0.15a*	*0.02a*	*7.53a*	*0.10*
Smooth bromegrass	*0.84cd*	*1.73b*	*0.73a*	*0.58abc*	*0.53ab*	*0.37abcd*	*0.14a*	-	-	*4.92bcd*	*0.12*
Tall fescue	*0.32e*	*1.35b*	*0.80a*	*0.63ab*	*0.39abcd*	*0.17bcde*	*0.08a*	-	-	*3.74de*	*0.09*
Timothy	*0.78d*	*1.19b*	*0.24b*	*0.26bcde*	*0.06cd*	*0.03efg*	-	-	-	*2.56e*	*0.06*

[Z] *Cutting date*
[Y] *Standard error of the mean*
a-g Means within columns with unlike letters differ (p<0.05)