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Spring-Clipping Response in Snake River and Thickspike Wheatgrasses

T.A. Jones* and D.C. Nielson

ABSTRACT

Grazing at the boot stage can severely damage stands of bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) A. Löve]. Snake River wheatgrass [proposed name *Elymus lanceolatus* ssp. *wawawaiensis* (Scribner & Gould) J.R. Carlson & D.R. Dewey] has recently been recognized as a taxon distinct from bluebunch wheatgrass, based on cytological data, and placed in the same species as thickspike wheatgrass [*Elymus lanceolatus* ssp. *lanceolatus* (Scribner & J.G. Smith) Gould]. Grazing tolerance of Snake River wheatgrass is unknown. This study was conducted to evaluate the effect of clipping at the boot stage on vigor of 'Secar' Snake River wheatgrass, 'Elbee' and T-21076 thickspike wheatgrass, and hybrid populations D30 (50% Snake River wheatgrass/50% thickspike wheatgrass) and D38 (75% Snake River wheatgrass/25% thickspike wheatgrass). Plots were established at North Logan, UT (mollisol) and near Stone, ID (aridisol) in 1987, clipping treatments (clipped or unclipped at the boot stage) were applied in 1988 and 1989, and treatments were compared in 1990. Regardless of spring-clipping treatment, all plants were clipped once in the summer at both locations and again in the fall at North Logan both in 1988 and 1989. Spring clipping reduced Secar dry weight 21%, spike number 27%, and plant basal area (above-ground area occupied by tillers) 17% at North Logan, while the other populations were unaffected. Spring clipping reduced dry weight 26 and 31%, spike number 37 and 36%, and plant basal area 24 and 33%, of Secar and D38, respectively, near Stone, while the other populations were unaffected. Spring clipping was more detrimental at the Stone aridisol than the North Logan mollisol site. Currently available germplasm of the rhizomatous thickspike wheatgrass appears to be more tolerant of spring clipping than that of the caespitose Snake River wheatgrass. It should be possible to make substantial genetic progress for spring-clipping tolerance in hybrid populations.

CARLSON (1986) first recognized Snake River wheatgrass as a taxon distinct from bluebunch wheatgrass. The two grasses were previously confused as they resemble one another morphologically. Snake River wheatgrass distribution is limited to the Salmon, Snake, and Columbia River drainages of the Pacific Northwest (Jones et al., 1991). It is always awned, caespitose, and allotetraploid ($4x=28$). Bluebunch wheatgrass has a much wider distribution and may be awned or awnless, caespitose or weakly rhizomatous, and diploid ($2x=14$) or autotetraploid ($4x=28$). Because their hybrids exhibit a relatively high level of fertility, both Snake River wheatgrass and thickspike wheatgrass are now considered subspecies of *E. lanceolatus*, despite their morphological dissimilarity. Unlike Snake River wheatgrass, thickspike wheatgrass is strongly rhizomatous.

Bluebunch wheatgrass, a climax species on rangelands in the Intermountain West and adjacent regions, has declined in frequency since the early 1900s (Miller et al., 1986). Properly managed, native stands can sustain defoliation by grazing animals (Miller et al., 1986). However, stands of bluebunch wheatgrass decline rapidly if grazed at the boot stage or repetitively throughout the season, especially if repeated annually. Its sensitivity to grazing has been attributed to its upright stature, elevation of meristems, high ratio of reproductive to vegetative shoots, and difficulty initiating regrowth (Mack and Thompson, 1982).

Bluebunch wheatgrass does not recover from grazing as well as the introduced crested wheatgrass [*Agropyron desertorum* (Fischer ex Link) Shultes] (Caldwell et al., 1981), in large part because it reallocates fewer resources to shoots relative to roots than crested wheatgrass after defoliation (Richards, 1984; Mueller and Richards, 1986). Richards and Caldwell (1985) determined that de novo photosynthates are more important for bluebunch wheatgrass regrowth than storage carbohydrates, which emphasizes the need for photosynthetic area after defoliation.

The phenological state when bluebunch wheatgrass is most vulnerable to defoliation is the boot stage. In northern Utah clipping at the late vegetative to early boot stage was more deleterious than earlier clipping (Stoddart, 1946). Blaisdell and Pechanec (1949) found more injury following clipping in late May and early June than in late June in eastern Idaho. Injury from fall clipping is usually not observed (Stoddart, 1946; Blaisdell and Pechanec, 1949; McLean and Wikeem, 1985b), although fall clipping sometimes increased the deleterious effect of late, but not early, spring clipping (McLean and Wikeem, 1985a).

The response of Snake River wheatgrass to grazing has not been evaluated. Because Snake River wheatgrass × thickspike wheatgrass hybrid populations have considerable breeding potential (Jones et al., 1991), we desire an understanding of the defoliation response of these grasses. Our objective was to evaluate the response of Snake River wheatgrass, thickspike wheatgrass, and two hybrid populations to spring-clipping at the boot stage in two environments representing different levels of moisture stress.

MATERIALS AND METHODS

Three-month-old seedlings were transplanted to the field at North Logan, UT on a Millville silt loam [coarse-silty, carbonatic, mesic Typic Haploxerolls (2-4% slope)] on 20 Apr. 1987 and near Stone, ID (Grandine Field, Curlew National Grassland, U.S. Forest Service) on a Hansel silt loam [fine-silty, mixed, mesic Xerollic Haplargids (0-6% slope)] on 24 Apr. 1987. The North Logan mollisol receives an approximate average annual precipitation of 440 mm, while the Stone aridisol receives an approximate average annual precipitation of 290 mm (Table 1). Each location included two replications with populations as whole plots and clipping treatments as subplots arranged in a split-plot design.

The five populations included 'Secar' Snake River wheatgrass, 'Elbee' and T-21076 thickspike wheatgrass, and two hybrid populations designated D30 and D38. Secar is a cultivar released as an unimproved population from near Lewiston, ID. Elbee is a synthetic whose parental clones were selected from collections made in Alberta and Saskatchewan. The T-21076

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Table 1. Monthly precipitation (mm) at Utah State University (for North Logan) and Snowville, Utah (for Stone).

Month	Utah State University					Snowville				
	30-yr. mean	1987	1988	1989	1990	30-yr. mean	1987	1988	1989	1990
Jan.	42.7	45.7	22.1	24.6	26.9	28.2	8.9	19.6	36.6	19.6
Feb.	39.9	38.4	4.6	35.1	35.1	22.4	35.1	4.1	0.8	8.4
Mar.	44.5	35.8	36.8	85.6	28.2	21.8	26.2	19.3	22.1	54.6
Apr.	52.3	19.6	57.9	26.7	42.9	29.0	7.4	34.0	12.2	37.1
May	43.4	124.5	40.4	47.0	40.9	37.6	88.9	30.2	32.8	53.3
June	38.9	10.4	19.3	21.6	45.2	32.0	14.0	5.6	20.6	32.0
July	11.4	45.7	0.0	0.3	5.1	13.7	47.2	0.0	1.8	2.8
Aug.	24.4	24.6	4.1	7.6	11.4	21.3	26.7	2.8	16.5	4.3
Sept.	26.9	0.8	22.4	32.3	21.3	17.8	1.3	1.5	11.7	7.4
Oct.	36.3	22.1	0.0	51.1	34.3	17.8	28.2	1.8	6.4	7.1
Nov.	38.9	33.5	82.8	28.2	44.7	25.4	55.4	66.0	10.4	9.4
Dec.	41.4	36.6	29.0	8.4	43.9	23.4	27.9	37.6	5.6	11.2
TOTAL	440.9	437.6	319.3	368.3	380.0	290.8	367.0	222.5	177.3	247.1

Table 2. Mean date for two-thirds of plants to reach spike emergence in 1988 and 1989 at North Logan, UT and Stone, ID.

Population	North Logan		Stone	
	1988	1989	1988	1989
Secar	18 May	21 May	24 May	26 May
D38	24 May	27 May	1 June	7 June
D30	18 May	26 May	27 May	3 June
Elbee	15 May	19 May	23 May	9 June
T-21076	23 May	22 May	27 May	1 June

Table 3. Dry weight of spring harvest and regrowth in summer and fall (North Logan, UT) or summer only (Stone, ID) of five populations in 1988 and 1989. Data reflect spring-clipped treatments only.

Population	1988		1989	
	Spring Harvest	Regrowth	Spring Harvest	Regrowth
	g plant^{-1}	g plant^{-1} (%†)	g plant^{-1}	g plant^{-1} (%)
		North Logan		
Secar	39.3c‡	10.5c (27)	30.8c	41.6c (135)
D38	10.2d	8.7c (86)	22.6c	29.4c (130)
D30	33.0c	10.1c (31)	17.8c	30.9c (173)
Elbee	49.2b	45.9b (93)	69.6b	115.6b (166)
T-21076	126.5a	109.7a (87)	317.2a	273.1a (86)
		Stone		
Secar	18.0c	2.6b (14)	26.3b	8.3ab (32)
D38	9.7d	2.0b (20)	11.3d	3.3c (29)
D30	16.2c	2.4b (15)	11.2d	4.9bc (44)
Elbee	29.0b	7.5a (26)	21.9c	13.4a (61)
T-21076	51.3a	11.3a (22)	45.8a	16.3a (36)

† Regrowth dry weight as a percentage of spring dry weight. Population-by-harvest interaction significant at $P \leq 0.01$, $P \leq 0.10$ at North Logan in 1988 and 1989 and at Stone in 1989, respectively, but nonsignificant ($P > 0.10$) at Stone in 1988.

‡ Populations followed by different letters within a column are significantly different (*k*-ratio = 100) according to the Bayes L.S.D.

population was collected at The Dalles, OR on stablized sand dunes and is considerably more vigorous and productive than the released cultivars Elbee or 'Critana'. Thickspike wheatgrass is most often found on sandy soils, while Snake River wheatgrass is found on medium-textured soils. D30 was derived from a cross of a single Secar plant and a single A-15 (Gillette, WY) thickspike wheatgrass plant. D38 was derived from an inadvertent cross of a K-42 (Colton, WA) Snake River wheatgrass plant with a thickspike wheatgrass plant of unknown origin backcrossed to several Snake River wheatgrass accessions. Thus, D30 and D38 are 50 and 75% Snake River wheatgrass germplasm, respectively.

Transplants were arranged on 1.5-m centers with 30 plants (six rows of five) in each whole plot. At the end of the establishment year, the North Logan and Stone locations were clipped at 5 cm on 15-19 Oct. and 6 Oct. 1987, respectively. Clipping for the remainder of the experiment was at 10 cm. Dry weight was measured after drying at 60 °C.

In 1988 two-row subplots were assigned to each of three spring-clipping treatments. These included (i) clipping when 2/3 of the plants of the population's whole plot had at least one spike emerged from the boot, (ii) clipping when the Secar whole plot had 2/3 emergence from the boot (all populations clipped on a single date), and (iii) no spring clipping. Two-thirds emergence was designated for clipping because most spikes are in the boot at this time. Spring clipping (Table 2) was followed by a summer harvest in both spring-clipped and unclipped subplots 2 to 4 July and 12 July for North Logan and Stone, respectively, in 1988, and on 5 to 10 July and 17 to 18 July, respectively, in 1989. At North Logan fall harvests were taken 13 to 18 Oct. 1988 and 16 to 18 Oct. 1989. After application of clipping treatments in 1988 and 1989, the final harvest was taken 9 to 19 July, 1990 at North Logan and 14 to 15 Aug. at Stone. In addition to dry weight, spike number per plant, plant basal area (above-ground area occupied by tillers measured with a grid with 1-cm gradations), and canopy height data were collected in 1990. The primary objective was to compare spring-clipped and unclipped treatments for each population.

A common log transformation was applied to all data to eliminate positive correlations between means and variances. Plant-to-plant variation within subplots was great and only 10 plants were included in a subplot. Therefore, transformed 1987 data were applied as a covariate to transformed data collected after clipping treatments began in 1988. Separate covariates were calculated for each population at each location. In this way, analysis of the least-squares means generated by pretreatment covariate adjustment permitted improved comparisons among treatments. Reported least-squares means were adjusted similarly, except data were not transformed. For 1988 and 1989 data, population means were separated with a Bayes L.S.D. (Smith, 1978) at each harvest at each location. In 1990, comparison of means of spring-clipped and unclipped treatments for each population was of greatest interest.

RESULTS AND DISCUSSION

Spring clipping was applied at the boot stage when bluebunch wheatgrass is more susceptible. After spring defoliation, carbon for bluebunch wheatgrass regrowth is generated primarily by de novo photosynthesis (Rich-

Table 4. Final-harvest (1990) least-squares means for dry weight, spike number, plant basal area, and canopy height of five population clipped or unclipped in the spring of 1988 and 1989 at North Logan, UT and near Stone, ID.

	N. Logan		Stone		N. Logan		Stone	
Population	Clipped	Unclipped	Clipped	Unclipped	Clipped	Unclipped	Clipped	Unclipped
	Dry Weight				Spike Number			
	g plant^{-1}				no. plant^{-1}			
Secar	208	262*	67	90*	374	511**	124	198†
D38	183	210	27	39†	291	333	47	73*
D30	156	153	33	38	360	372	88	90
Elbee	382	292	69	76	826	662	179	211*
T-21076	722	635	117	116	1085	956	203	213
	Plant Basal Area				Canopy Height			
	cm^2				mm			
Secar	320	385*	151	198*	896	933	759	814
D38	397	439	102	133**	787	789	633	656
D30	453	381†	141	134	735	741	619	611
Elbee	3004	2381	499	484	703	666	649	640
T-21076	4641	4890	480	435	1012	1013	834	842

†,*,** Clipped and unclipped treatments significantly different at $P \leq 0.10$, 0.05, and 0.01, respectively.

ards and Caldwell, 1985). Summer harvest removed leaf area a second time to exacerbate any deleterious spring-clipping effect. Late-season regrowth was sufficient for fall harvest at North Logan both years, but not at Stone either year. Again, this was designed to augment the spring-clipping effect (McLean and Wikeem, 1985b). Summer and fall clipping were applied both to plants clipped and unclipped in the spring. Based on past research, summer and fall clipping would augment damage to plants clipped at that stage while causing little damage to previously unclipped plants.

Spring-clipping dates averaged 7 and 11 d later near Stone than at North Logan in 1988 and 1989, respectively (Table 2). Earliest in spike emergence were Elbee and Secar (except in 1989 at Stone) and latest was D38 (75% Snake River wheatgrass). Regrowth dry weights for the spring-clipped treatments were considerably higher in 1989 than 1988 (Table 3). This was not only because the plants were a year older in 1989, but also because 1988 regrowth was limited by lack of precipitation at both locations (Table 1). T-21076 always produced the greatest dry weight both at spring harvest and at regrowth harvest, and was usually followed by Elbee, Secar, D30 (50% Snake River wheatgrass), and D38 (75% Snake River wheatgrass). Elbee generally exhibited the greatest regrowth dry weight relative to spring harvest (percentage). In 1988 regrowth dry weight relative to spring harvest was highest for D38 (75% Snake River wheatgrass), Elbee, and T-21076 at North Logan. The population-by-harvest interaction was not significant ($P > 0.10$) at Stone in 1988. In 1989 regrowth dry weight relative to spring harvest was highest for D30 (50% Snake River wheatgrass) and Elbee at North Logan and for Elbee at Stone.

At the final-harvest evaluation in 1990, North Logan exceeded Stone in dry weight ($P \leq 0.01$), spike number ($P \leq 0.05$), plant basal area ($P \leq 0.01$), and canopy height ($P \leq 0.05$). Likewise, populations were significantly different ($P \leq 0.01$) for all four traits. However, the significant population-by-location effect for dry weight ($P \leq 0.10$), spike number ($P \leq 0.01$), and plant basal area ($P \leq 0.01$) indicated that populations should be compared separately at each location. This interaction was not significant ($P > 0.10$) for canopy height.

Differences between the spring-clipped Treatments 1 and 2 were generally absent, so they were jointly compared with Treatment 3 (not clipped in spring) using a single-degree-of-freedom contrast. The contrast between spring-clipped and unclipped treatments was significant across the two locations in 1990 for dry weight ($P \leq 0.05$), spike number ($P \leq 0.10$), and plant basal area ($P \leq 0.10$), but not for canopy height ($P > 0.10$). Again, evidence of a treatment contrast-by-location interaction for all three traits affected by spring clipping -- dry weight ($P \leq 0.10$), spike number ($P \leq 0.10$), and plant basal area ($P = 0.13$) -- indicates that locations should be considered separately. Spring clipping was more deleterious at the aridisol (Stone) than the mollisol (North Logan) site.

When significant for a population, reductions in dry weight, spike number, and plant basal area from spring clipping occurred together and were of similar magnitude (Table 4). In contrast, Mueggler (1972) reported that spike number of bluebunch wheatgrass was more affected than herbage production in the year after spring clipping, though this difference disappeared over a 5-year rest period (Mueggler, 1975). Unlike Mueggler's study, our plots were free of competition, which may be responsible for our failure to find a greater effect of spring clipping on spike number than dry weight.

At North Logan, Secar Snake River wheatgrass was the only population adversely affected by spring clipping. Spring clipping at North Logan reduced Secar's 1990 dry weight, spike number, and plant basal area by 21, 27, and 17%, respectively. At Stone, D38 (75% Snake River wheatgrass) was affected by spring clipping as well as Secar. Spring clipping near Stone reduced dry weight, spike number, and plant basal area of Secar by 26, 37, and 24% and of D38 (75% Snake River wheatgrass) by 31, 36, and 33%, respectively. In contrast to Secar and D38 (75% Snake River wheatgrass), the populations with greater thickspike wheatgrass constitution -- T-21076, Elbee, and D30 (50% Snake River wheatgrass) -- did not show susceptibility to spring clipping at either location ($P > 0.10$).

Available germplasm of Snake River wheatgrass appears to be more susceptible to spring clipping than that of thickspike wheatgrass. Thickspike wheatgrass retains considerable leaf area below clipping height during elongation of reproductive tillers, which contributes to production of de novo photosynthates following clipping.

The contribution of thickspike wheatgrass' rhizomatous growth habit to spring-clipping tolerance may be related to its association with a high frequency of vegetative tillers. This feature is probably characteristic of a rhizomatous habit, typical of thickspike wheatgrass, as opposed to the caespitose habit of crested wheatgrass (Montero and Jones, 1992) or Snake River wheatgrass. However, plant basal area of the hybrids D30 (50% Snake River wheatgrass) and D38 (75% Snake River wheatgrass) is much more similar to Snake River wheatgrass than to thickspike wheatgrass (Table 4), suggesting their greater spring-clipping tolerance relative to Secar is not strictly dependent on rhizomatous spreading.

Hybrid Snake River wheatgrass × thickspike wheatgrass populations should be selected for spring-clipping tolerance contributed by the thickspike wheatgrass parent. The effect of our 1988 and 1989 spring-clipping treatments was relatively mild. We had anticipated more drastic spring-clipping effects, but apparently these were reduced by the lack of competition in the spaced-plant nursery. Mueggler (1972) reported that the deleterious effects of spring clipping of bluebunch wheatgrass at native sites could be compensated for by eliminating competition by removal of adjacent native vegetation within a 90-cm radius. To increase susceptibility in a selection program, defoliation should be applied in multiple treatments, conducted in a more competitive, densely spaced nursery, or evaluated in a more moisture-stressed environment.

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