Response of *Muhlenbergia porteri* Scribn. to Season of Defoliation

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Abstract

Removing 65% of the leaf area of bush muhly in three consecutive years during the growing season reduced plant vigor regardless of season of clipping. Late or continuous season defoliation had the greatest impact on food reserves, production, crown diameter and number of stem internodes. Defoliation during the vegetative stage had the least effect of the clipping treatments.

Bush muhly (*Muhlenbergia porteri*) is a perennial grass characterized by numerous wiry, much-branched culms, growing on dry mesas and rocky slopes throughout the Southwest (Gould 1951). Historically forming extensive stands in parts of its range, bush muhly now is generally restricted to growing under the protection of shrubs and sub-shrubs. This grass species has been reported as being highly palatable (Gardner 1951). However, Welsh and Beck (1976) observed that the palatability of the species was only average and that it was sensitive to grazing because of its branching and nodal disarticulation characteristics.

Bush muhly can become established in badly deteriorated sites occupied primarily by creosotebush (*Larrea tridentata*) where their geographic ranges overlap. As bush muhly gains in stature, it can outcompete creosotebush, leading to a decrease in shrub vigor and, in numerous instances, mortality (Welsh and Beck 1976). The ability of bush muhly to revegetate these areas naturally makes it a highly desirable plant to maintain or increase in abundance. We need more information on the growth characteristics of this species

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This was submitted as Journal Article 747, New Mexico Agricultural Experiment Station, Las Cruces, New Mexico, 88003. It reports on work supported in part by Bureau of Land Management Contract YA-512-CT6-205.

Manuscript received November 11, 1979.

if effective management is to be implemented.

The purpose of this study was to evaluate the effect of season of defoliation on (1) total nonstructural carbohydrates, (2) number of elongated internodes, (3) production and (4) crown diameter.

Study Area

The study area was located on the New Mexico State University College Ranch, 32 km north of Las Cruces in Dona Ana County, New Mexico. The arid climate is characterized by low precipitation, low humidity, high temperatures, high evaporation potential, and periodic strong winds. Average annual rainfall is 22 cm. Approximately 55% of the annual precipitation falls during the growing season from July through September (Agr. Res. Serv. 1975). Most summer precipitation comes from high intensity convective thunderstorms (Paulsen and Ares 1962). Annual rainfall is highly variable with drought commonly occurring throughout the desert grasslands. Drought (75% or less of average rainfall) occurs 20 to 40% of the time (Campbell and Crafts 1939). Potential annual evaporation rate averages 229 cm (Herbel et al. 1974). The frost-free period lasts approximately 200 days with maximum air temperatures reaching 36° C in June.

The growing season generally ranges between 90 and 100 days depending primarily on rainfall distribution. Mean air temperatures range from 16° C to 33° C during this period with approximately 4 cm of rain falling per month.

Precipitation during the growing season was 207% of the mean in 1974, 126% of the mean in 1975 and 72% of the mean in 1976 (Fig. 1). Production during the 1974 growing season was lush. However, in 1975 over half of the rainfall came at the end of the growing season, losing much of its effectiveness.

The study site was located within a 5.6-ha cattle enclosure at an

● Monthly precipitation
■ 59-Year average precipitation

Fig. 1. Monthly precipitation during the growing seasons of 1974, 1975, 1976 and a 59-year average.

elevation of 1,400 m. The site has been protected from cattle grazing since 1965. Prior to 1960 very little bush muhly was present (Welsh 1972). In 1960 bush muhly began to establish rapidly at the base of individual creosotebush plants. Soils were gravelly sandy loam varying from zero to 92+ cm in depth. Soil depth was restricted by a fractured calcium carbonate hardpan. Common subordinate plants are fluffgrass (*Erioneuron puchellum*), loco-weed (*Astragalus* sp.), broom snakeweed (*Xanthocephalum sarothrae*), honey mesquite (*Prosopis juliflora*), and tarbush (*Flourensia cernua*).

Methods

The effects of six different clipping treatments were evaluated during 1974, 1975, and 1976. The six treatments involved clipping at different phenological stages during the three-year period. The specific treatments were (1) *vegetative*, plants clipped only in the vegetative stage once each year during the three-year period; (2) *VFS*, plants clipped once in the vegetative stage in 1974, once during flowering in 1975, and once during leaf senescence in 1976; (3) *VSV*, plants clipped once in the vegetative state in 1974, once in leaf senescence in 1975, and once in the vegetative stage in 1976; (4) *maturity*, plants clipped once in leaf senescence and once during quiescence in 1974, 1975, and 1976; (5) *continuous*, plants clipped once in each of the vegetative, flowering, leaf senescence, and quiescence stages during each of the three years; and (6) *control*, nondefoliated plants. The four phenological stages designating the period of defoliation were the third to fourth leaf stage for vegetative, dough stage for flowering, after seed ripening for leaf senescence, and chlorophyll absent from about 90% of the leaf tissue for quiescence. Defoliation for all treatments was accomplished by clipping approximately 65% on a weight basis of the current annual growth.

Phenological data were collected on 24 bush muhly plants per treatment during each defoliation period throughout the study. Phenological measurements were recorded on the same plants during the three-year period.

Six plants were excavated in each treatment during each of the four phenological stages seven days after defoliation, placed on ice in the field and brought into the laboratory, where they were dried at 68° C for 48 hours. Total nonstructural carbohydrates were extracted from 0.5 g root sample in 0.8 N H₂SO₄ (Smith et al.

1964). All samples were refluxed on a crude fiber apparatus. An extension of Forsee's photocolormetric ferricyanide method was used for determining TNC levels (Morrell 1941).

Elongated internodes were counted on ten randomly selected culms per plant in each treatment prior to defoliation in 1975 and 1976. Eight observations were made per treatment each year.

Clipped material was collected and bagged for each plant during defoliation for dry matter yield determinations. Crown diameters were measured at the end of each growing season for all six treatments on bush muhly.

Analysis of variance, Tukey's *w*-procedure and the pooled-*t* test were used to analyze data at the 95% confidence level (Steel and Torrie 1960).

Results and Discussion

Bush muhly initiated primary leaf growth during mid to late July in all three growing seasons, dependent upon rainfall (Table 1). In late May and early June of 1975 and 1976, limited moisture initiated leaf growth. However, bush muhly returned to a quiescent state in mid-June due to an absence of available soil water. Flowering occurred 34 and 29 days earlier in 1974 than in 1975 and 1976, respectively. This was due to limited rainfall during August in 1975 and 1976 (Fig. 1). Senescence was delayed in 1974 due to available moisture in October and November. In 1976 cold temperatures in September terminated seasonal growth. Soil moisture and air temperature determined the time of quiescence.

Table 1. Dates of phenological stages and range of their occurrence in 1974, 1975, and 1976 for bush muhly.

Phenology	Dates			Range (Days)
	1974	1975	1976	
Vegetative	7/16	7/28	7/20	12
Flowering	8/14	9/17	9/12	34
Senescence	11/20	10/22	9/29	52
Quiescence	12/15	11/6	10/12	63

Three years of clipping bush muhly did not significantly influence TNC levels until the close of the 1976 growing season. Defoliating bush muhly continuously through the growing season or during maturity significantly reduced TNC levels below that found in nondefoliated plants or plants only clipped during the vegetative stage for three years (Table 2). Prior to the end of the third year, concentration of TNC did not respond to defoliation. VFS and VSV treatments had less effect on TNC levels than did the other four treatments. Although the VFS and VSV treatments included defoliation during maturity, earlier defoliation periods two years in three appeared to nullify this late clipping effect.

Bush muhly elongates the internodes on all culms very early during the vegetative stage. This morphological characteristic allows easy accessibility of apical meristems and axillary buds to grazing. The number of elongated internodes produced per culm was very sensitive to the previous year's clipping treatment (Table 3).

During vegetative growth in 1975 bush muhly plants produced significantly more internodes per culm on nondefoliated plants and plants defoliated during the vegetative stage in 1974 (including the vegetative, VFS and VSV treatments) than plants defoliated continuously or during maturity in 1976. There was no significant difference in internode numbers per culm in 1975 between plants

Table 2. TNC concentration (%) of bush muhly roots during quiescence 1976 from plants subjected to different clipping treatments.

	Phenological stage of clipping					
	Control	Vegetative	Vegetative	Vegetative	Maturity	Continuous
1974	Control	Vegetative	Vegetative	Vegetative	Maturity	Continuous
1975	Control	Vegetative	Flowering	Senescence	Maturity	Continuous
1976	Control	Vegetative	Senescence	Vegetative	Maturity	Continuous
% TNC	18.5 ^{a1}	18.7 ^a	15.5 ^{ab}	16.7 ^{ab}	14.5 ^b	14.2 ^b

¹Data followed by a different letter are significantly different at the 95% level, by Tukeys *w*-procedure.

Table 3. Mean number of elongated stem internodes on bush muhly prior to defoliation in 1975 and 1976 during the vegetative stage.

Defoliation treatment	Number of internodes during vegetative stage	
	1975	1976
Control 1974 and 1975	11.1 ^{a1}	11.8 ^a
Vegetative 1974 and 1975	9.0 ^a	9.1 ^b
Vegetative 1974		
Flowering 1975	9.9 ^a	8.4 ^b
Vegetative 1974		
Senescence 1975	10.6 ^a	5.4 ^c
Maturity 1974 and 1975	5.1 ^b	4.9 ^c
Continuous 1974 and 1975	4.7 ^b	4.1 ^c

¹Data in columns followed by a different letter are significantly different at the 95% level, by Tukey's w-procedure.

defoliated in the vegetative stage in 1976 and non-defoliation plants.

Following two years of defoliation all clipped plants showed a decrease in the number of elongated internodes per culm in 1976 regardless of season of defoliation. However, plants defoliated after the flowering stage showed a significantly greater detrimental effect than plants defoliated prior to or during flowering. The data indicate that removing 65% of the current year's growth in two consecutive years during the vegetative stage is detrimental to the number of elongated internodes produced per culm. However, if defoliation occurs after flowering for only one growing season, the number of elongated internodes produced per culm will be only 50% of that produced by non-defoliated plants.

Removing 65% of the leaf area during the vegetative stage accounted for approximately 30% of the total annual growth in 1974 (Table 4). This was about 50% less than the amount of forage obtained from the mature or continuous treatments.

In 1975, the second year of clipping, production sharply decreased from that produced in 1974. Although it was impossible to compare the clipping effect across years due to climatic variation, production of four other species studied in the area did not decrease as drastically (Miller 1976). Plants defoliated early in the

growing season in 1974 produced significantly more herbage than those clipped continuously or at maturity throughout the vegetative flowering and senescence stages in 1975 (Table 4). Clipping during maturity was as detrimental to forage production as continuous defoliation.

In 1976, the third year of defoliation, production appeared to continue to decline. Again climatic variation must be taken into account. Bush muhly clipped in the vegetative stage for two consecutive years produced significantly more forage during this phenological stage than plants subjected to the continuous or VSV treatments during 1976 (Table 4). This response was similar to internode response.

Crown diameter was significantly larger in non-defoliated plants than in defoliated plants during the 1975 growing season (Table 5). Following the 1976 growing season crown diameters in plants continuously defoliated for a three-year period, continued to decrease significantly as compared to non-defoliated plants. The control plants showed no change in size while continuously defoliated plants decreased in diameter by 4 cm.

Conclusions

The decrease in TNC levels, internode numbers, yield, and crown diameter in 1976 indicated continuous or late defoliation of bush muhly had a greater detrimental impact than any of the remaining clipping treatments. Further, the average number of internodes and plant material harvested during the vegetative stage in 1976 indicated that the seed ripening stage may have been the plants' most vulnerable stage to harvesting. Clipping in the vegetative stage in three consecutive years had the least detrimental effect of the five clipping treatments. Yield and TNC levels were optimal with defoliation practices during vegetative growth. However, removing 65% of the leaf area on bush muhly during any of the four growth stages reduced plant vigor as observed by yield and number of internodes present. Only the continuous and maturity defoliations resulted in a significant decrease in TNC levels. The vegetative treatment may have had less impact on the plants since only 30% of the total season's growth was harvested. The decrease in production from 1974 through 1976 on the five clipping treatments appeared to be caused by more than climate alone. The reduction in both crown diameters and elongated internodes due to clipping suggested defoliation to be part of the cause for the sharp decrease

Table 4. Mean dry weight of forage harvested per bush muhly plant from five defoliation treatments during 1974, 1975 and 1976. Data are accumulative within years across phenology.

Treatment	Phenological stage at time of clipping											
	1974				1975				1976			
	Veg ¹	Flow	Sen	Qui	Veg	Flow	Sen	Qui	Veg	Flow	Sen	Qui
Vegetative	34.5 ^{a2}				11.9 ^a				4.5 ^a			
VFS	34.8 ^a					12.3 ^a					2.3 ^a	
VSV	46.8 ^a						20.7 ^a		0.9 ^b			
Maturity			60.4 ^a	72.9 ^a			5.7 ^b	7.1 ^a			0.5 ^b	0.5 ^b
Continuous	36.1 ^a	45.3	55.1 ^a	60.3 ^a	1.1 ^b	2.3 ^b	7.2 ^b	9.4 ^a	0.6 ^b	0.7	2.0 ^a	2.0 ^a

¹Abbreviations are: Veg = Vegetative, Flow = Flowering, Sen = Senescence, Qui = Quiescence. These treatments reflect the period of defoliation for 1974, 1975 and 1976 respectively.

²Data in columns followed by a different letter are significantly different at the 95% level by Tukey's w-procedure.

Table 5. Mean annual change in crown diameter (cm) per bush muhly plant during the 1975 and 1976 growing seasons.

	Phenological stage at time of clipping					
	Control	Vegetative	Vegetative	Vegetative	Maturity	Continuous
1974	Control	Vegetative	Flowering	Senescence	Maturity	Continuous
1975	Control	Vegetative	Flowering	Senescence	Maturity	Continuous
1976	Control	Vegetative	Senescence	Vegetative	Maturity	Continuous
1975	6.4 ^a	2.0 ^{b1}	1.0 ^b	-0.5 ^b	-0.7 ^b	-2.0 ^b
1976	0.0 ^a	-0.5 ^{ab}	-2.3 ^{ab}	-1.6 ^{ab}	-0.7 ^{ab}	-4.0 ^b

¹Data in rows followed by different letters are significantly different at the 95% level by Tukey's w-procedure.

in production.

Past authors probably attributed the decrease of bush muhly throughout its range to high palatability. However, it was observed in this study and others (Welsh and Beck 1976) that livestock did not graze bush muhly until late in the growing season and during quiescence. This was due to a decrease in the availability of more desirable forages. The extensive decrease in bush muhly is more likely a result of its low resistance to grazing. The morphological characteristics of this plant do not appear to be well adapted for grazing. Elevated apical meristems and axillary buds make the growing points accessible to removal. As a result of the high proportion of elevated meristematic tissue, it is likely that a considerable amount of food reserves are stored in the culms well above the crown. Unlike most other grasses that tiller from non-elongated internodes near the crown, culms on bush muhly commonly branch, forming new culms well above the ground. It was also observed that the culms were easily broken off at the crown by grazing animals, which would be more damaging than the defoliation treatments described. In a study on the effects of defoliation on four common range grasses in the Southwest, it was concluded that bush muhly was the least resistant to grazing (Miller 1976).

To maintain stands of bush muhly, utilization must be below 65%, especially if grazing is occurring after flowering. This species is not a highly desirable plant to manage for livestock feed due both to its low palatability and its low resistance to grazing. However, in many deteriorated ranges invaded by creosotebush it may be our best alternative.

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