# Response of *Bouteloua eriopoda* (Torr.) Torr. and *Sporobolus flexuosus* (Thurb.) Rybd. to Season of Defoliation

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## Abstract

**Production, total nonstructural carbohydrates, and crown diameters were measured to evaluate the effects of season of clipping on black grama and mesa dropseed. Vegetative reproduction was also monitored for black grama. Early defoliation of both black grama and mesa dropseed had less impact on plant vigor than continuous defoliation or defoliation during the last half of the growing season. Black grama plants clipped during or after flowering, or continuously through the growing season, produced less herbage in the following year than those plants clipped during the vegetative stage. Removal of 65% of the current year's growth any time during the growing season significantly reduced stolon numbers on black grama. Mesa dropseed clipped during maturity, during flowering, or clipped continuously throughout the growing season was negatively affected on one or more of the plant parameters measured. Clipping during the vegetative state had little apparent effect on plant vigor.**

Knowledge of plant responses to defoliation during various seasons, frequencies, and intensities is essential for proper management on rangelands. Limited data exist on season, frequency, and intensity of use on native plants occurring on Southwestern rangelands. Nelson (1934) and Canfield (1939) concluded that persistent heavy grazing significantly reduced the vigor of black grama (*Bouteloua eriopoda* (Torr.) Torr.), an ecological dominant of much of the Southwest. Valentine (1970) found the number and length of stolons per black grama plant were closely correlated with intensity of winter grazing. Paulsen and Ares (1962) reported cyclic changes in black grama basal area were closely correlated with precipitation during the growing season.

Paulsen and Ares (1962) reported that temperature requirements for mesa dropseed (*Sporobolus flexuosus* (Thurb.) Rybd.), another important Southwestern range plant, were less limiting than for black grama. Mesa dropseed seedlings establish well on open areas (Nelson 1934), especially during the first favorable growing season following drought (Dittberner 1971).

While ecological relationships and limited information on grazing tolerance are available, the impact of defoliation at different stages of phenological development on physiological and morphologcal characteristics have not been established for this area. Similarly, time necessary for recovery of vigor of important range plants in the Southwest has not been defined. The purpose of this study was to measure the effect of six defoliation patterns over a 3-year period on forage harvested, total nonstructural carbohydrates (TNC), and crown diameter for black grama and mesa dropseed and vegetative reproduction of black grama. Such information is an integral portion of grazing strategies.

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## Study Area

The study area was located on the New Mexico State University College Ranch, located 32 km north of Las Cruces in Dona Ana County. Average annual rainfall is 22 cm. Of this total, 55% occurs during the growing season of July, August, and September (Agr. Res. Serv. 1975). Precipitation during the growing season was 107% above the mean in 1974, 26% above the mean in 1975, and 28% below the mean in 1976. Most summer rainfall comes from high intensity convectional thunderstorms (Paulsen and Areas 1962). Annual rainfall is highly variable, and drought is common throughout these desert ranges. The frost-free period is approximately 200 days, with the growing season ranging between 90 to 100 days, depending on rainfall distribution.

Soils ranged from sandy loams to light loamy sands on the black grama and mesa dropseed study areas (Valentine 1970). Soil depth varied between 15 to 90 cm to a highly fractured calcium carbonate hardpan. Vegetation associated with these two sites consisted of fluffgrass (*Erioneuron puchellum* (H.B.K.) Takeoka), three awn (*Aristida* sp.), broom snakeweed (*Xanthocephalum sarothrae* (Pursh.) Shinners), soaptree yucca (*Yucca elata* Englm.) and honey mesquite (*Prosopis juliflora* (Sw.) D.C.). The two study areas have been protected from cattle grazing since 1965.

## Methods

Criteria used in measuring plant response to defoliation were levels of TNC, forage harvested, and plant growth characteristics. The six clipping treatments were (1) *vegetative*, plants clipped only in the vegetative stage once each year during the 3-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 stage 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 the vegetative, flowering, leaf senescence, and quiescence stages during each of the 3 years; and (6) *control*, nondefoliated plants. The four phenological stages designating the period of defoliation were the third to fouth 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 65% on a weight basis of the current annual growth.

Plants were excavated from each of the three replications 7 days after defoliation, placed on ice in the field, and brought into the

Table 1. Percent TNC between defoliation treatments for black grama roots and mesa dropseed roots collected during quiescence, 1976.

| | | Stage of defoliation | | | | | |
|---|---|---|---|---|---|---|---|
| | 1974 | Control | Vegetative | Vegetative | Vegetative | Maturity | Continuous |
| | 1975 | Control | Vegetative | Flowering | Senescence | Maturity | Continuous |
| Species | 1976 | Control | Vegetative | Senescence | Vegetative | Maturity | Continuous |
| Black grama | | | | | | | |
| Black grama | | 16.0[a1] | 15.2[a] | 15.3[a] | 15.8[a] | 15.2[a] | 14.9[a] |
| Mesa dropseed | | 18.8[a] | 16.6[ab] | 17.3[ab] | 18.4[a] | 14.6[b] | 14.8[b] |

[1] Data in rows followed by a different letter are significantly different at the 95% level by Tukey's *w*-procedure.

laboratory, where they were dried at 68°C for 48 hours. Total available carbohydrates were extracted from a 0.5-g root sample in 0.8 N $H_2SO_4$ (Smith et al. 1964). All samples were refluxed on a crude fiber apparatus. An extension of Forsee's photocolorimetric ferricyanide method was used for determining TNC levels (Morrell 1941).

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 black grama and mesa dropseed. The number of stoloniferous culms on black grama were counted in 1976 prior to defoliation in the vegetative stage and at the end of the growing season. Precipitation data were recorded on each site from U.S. Weather Bureau standard rain gauges.

Analysis of variance, Turkey'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

### Black Grama

At completion of the 3-year study, no significant differences occurred in percent TNC for black grama among the six defoliation treatments (Table 1). This indicated that season of clipping had no effect on black grama food storage reserves. However, concentrations of TNC in black grama were highly variable between plants within the same treatment and phenological stage. If defoliation did affect TNC levels, this response was obscured by variation in food storage levels among plants. Variability in TNC levels among plants within the same treatment and the apparent lack of response in TNC levels to defoliation were similar to data on blue grama (*Bouteloua gracilis* (H.B.K. Lag.) in Colorado (Menke and Trlica 1972), *Dupontia fisheri* R. Br. in Alaska (Mattheis et al. 1972), and western wheatgrass (*Agropyron smithii* Rydb.) in a hydroponic solution (Bokari and Singh 1974).

Season of clipping black grama did not significantly affect the percent root TNC (Table 1) or crown diameter (Table 2). The smallest crown diameter increases were measured from plants clipped continuously through the growing season or in maturity. These trends were consistent with available forage trends. Season of clipping did significantly affect the amount of forage being harvested during the current growing season, the following year's forage production and the vegetative reproduction potential. When 65% of the current year's growth was clipped in the first year (1974), 50% less forage was harvested on plants defoliated during the vegetative stage (3.9 g/plant) as compared to either the continuous or mature treatments (7.2 and 7.9 g/plant, respectively). However, both continuous and late defoliation decreased forage harvested in the following growing season (Table 3). Plants clipped in the 1974 growing season during the vegetative stage produced significantly more forage during the vegetative, flowering, and leaf senescent stage in 1975 than either the continuous or defoliation at maturity treatments. Plants clipped only once during the vegetative stage in 1974 produced more forage during this same stage in 1975 than did plants that had been clipped in the continuous or mature treatments.

In 1976, plants defoliated only in the vegetative stage for two consecutive years had significantly more forage during the initial third and fourth leaf stage of growth than either the VSV or continuous treatments (Table 3). Little additional growth occurred in August and September, probably because of low rainfall. Forage harvested from the VFS, maturity and continuous defoliation treatments during senescence in 1976 were not significantly different. It appeared that clipping black grama during flowering in 1975 reduced forage production potential (1.1 g/plant) for the following year. Low rainfall on the black grama sites during the 1976 growing season (34% below average) may have obscured treatment effects on production between VFS, maturity, and continuous treatments.

One of the more detrimental effects of clipping black grama was the reduction of stolon numbers. Vegetative reproduction is very important for increasing black grama stands since this plant produces few viable seed (Valentine 1970). Black grama

Table 2. Mean change in crown diameter (cm) for black grama and mesa dropseed plants during the 1975 and 1976 growing seasons.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1974 | Control | Vegetative | Vegetative | Vegetative | Maturity | Continuous |
| | 1975 | Control | Vegetative | Flowering | Senescence | Maturity | Continuous |
| Species and date | 1976 | Control | Vegetative | Senescence | Vegetative | Maturity | Continuous |
| Black grama | | | | | | | |
| 1975 | | 1.4[a1] | 2.1[a] | 2.1[a] | 2.0[a] | 0.4[a] | 1.3[a] |
| 1976 | | −0.6[a] | 0.0[a] | −1.0[a] | −1.2[a] | −1.3[a] | −2.8[a] |
| Mesa dropseed | | | | | | | |
| 1975 | | 1.4[a] | −1.1[ab] | 0.2[ab] | 0.7[ab] | −4.7[c] | −2.0[bc] |
| 1976 | | 0.7[ab] | 1.4[a] | −1.1[ab] | 0.1[ab] | −5.7[c] | −3.2[bc] |

[1] Data in rows followed by a different letter are significantly different at the 95% level by Tukey's *w*-procedure.

**Table 3. Mean dry weight (g) of forage harvested per plant of black grama and mesa dropseed from five defoliation treatments during 1974, 1975, and 1976. Data are accumulative within years across phenology stages.**

| Species and treatment | Phenology at time of harvest | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1974 | | | | 1975 | | | | 1976 | | | |
| | Veg[1] | Flow | Sen | Quies | Veg | Flow | Sen | Quies | Veg | Flow | Sen | Quies |
| Black grama | | | | | | | | | | | | |
| Veg[1] | 3.9$^{a}$[2] | | | | 4.3$^{a}$ | | | | 3.6$^{a}$ | | | |
| VFS | 4.2$^{a}$ | | | | | 5.1$^{a}$ | | | | | 1.1$^{a}$ | |
| VSV | 3.6$^{a}$ | | | | | | 7.2$^{a}$ | | 1.2.$^{b}$ | | | |
| Sen & Quies | | | 5.3$^{a}$ | 7.9$^{a}$ | | | 3.2$^{b}$ | 3.2$^{a}$ | | | 1.0$^{a}$ | 1.0$^{a}$ |
| Continuous | 3.2$^{a}$ | 4.3 | 5.9$^{a}$ | 7.2$^{a}$ | 1.2$^{a}$ | 2.7$^{b}$ | 3.4$^{b}$ | 3.4$^{a}$ | 0.5$^{b}$ | 1.0 | 1.1$^{a}$ | 1.1$^{a}$ |
| Mesa Dropseed | | | | | | | | | | | | |
| Veg | 4.1$^{a}$ | | | | 4.3$^{a}$ | | | | 2.7$^{a}$ | | | |
| VFS | 4.8$^{a}$ | | | | | 7.0$^{a}$ | | | | | 3.0$^{a}$ | |
| VSV | 4.9$^{a}$ | | | | | | 10.1$^{a}$ | | 2.0$^{ab}$ | | | |
| Sen & Quies | | | 7.7$^{a}$ | 16.5$^{a}$ | | | 10.4$^{a}$ | 13.4$^{a}$ | | 5.3$^{a}$ | 5.3$^{a}$ | 5.3$^{a}$ |
| Continuous | 3.7$^{a}$ | 5.7 | 8.5$^{a}$ | 13.3$^{a}$ | 1.2$^{b}$ | 3.6$^{b}$ | 3.6$^{b}$ | 4.0$^{b}$ | 1.0$^{b}$ | 2.1 | 2.9$^{b}$ | 2.9$^{b}$ |

[1] The abbreviations are: Veg = Vegetative, Flow = Flowering, Sen = Senescence, Quies = Quiescence. These treatments reflect period of defoliation for 1974, 1975, and 1976, respectively.

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

produces a true stolon, which is generally located toward the outer portion of the plant base. Occasionally, the true stolons may develop and form sets within the same year, when precipitation and length of growing season are adequate (Nelson 1934). The true stolon, usually prostrate, may be elevated a few centimeters from the soil surface. When the stolon set is formed and nodal roots develop, the set is generally in contact with, or in close proximity to, the soil surface.

A second type of stolon activity was observed from flowering culms and identified as a stoloniferous culm. This form of stolon generally develops from the interior portion of the plant over a 2-year period. Inflorescence-bearing reproductive culms developed during the first year. Simultaneously, culms began elongating with development, depending upon growing conditions during and after flowering. During the winter the meristematic tissue in the stolon culms persisted in a quiescent stage. It was observed that this material constituted a large percentage of the palatable stem bases that remained green throughout the winter. Under favorable conditions the following growing season, these stems all quickly elongated during the initial stages of growth and developed axillary vegetative branching and nodal roots, giving the same appearance of a stolon set. At this stage of development, inflorescences formed in the previous year could be found at the tip of the culm. These stoloniferous culms generally remained several centimeters above the ground and were thus readily exposed to defoliation. The nodal roots seldom appeared to make contact with the soil surface in the second year, thus limiting the capability of vegetative reproduction in the second year.

Defoliation during or after flowering significantly decreased the vegetative reproduction potential of these plants in the following growing season primarily through removal of stoloniferous culms (Table 4). Because of the vulnerability of these elevated stolons to defoliation, reduction of these vegetative reproductive parts was simply caused by physical removal. Plants defoliated in the vegetative stage in 1974 and 1975 had significantly more stolons in the initial stages of growth in 1976 than did plants in any other defoliation treatment (Table 4). Stolon potential on plants defoliated in the vegetative stage during the previous two growing seasons was similar to that of nondefoliated plants. However, the current year's potential for stolon development for those plants defoliated in the vegetative stage during the two previous growing seasons was removed when the plants were clipped in the vegetative state in 1976 (Table 4). The still-elevated stolons, developed during the previous growing season, were easily removed by clipping in the second year of formation during the vegetative stage, which significantly reduced the reproductive potential. Few stoloniferous culms were present at the end of the 1976 growing season for the five treatments in which clipping occurred. Low rainfall promoted little development of new stoloniferous culms. Although the nondefoliated plants had significantly more stolons than any of the defoliated plants, most of these had been produced during the 1975 growing season.

### Mesa Dropseed

After 3 years of defoliation, season of forage removal had a significant affect on TNC, amount of forage being harvested

**Table 4. Mean change in stolon numbers of black grama plants during the vegetative stage prior to clipping and during quiescence in 1976.**

| Treatment | | Stage of defoliation | | | | | |
|---|---|---|---|---|---|---|---|
| | 1974 | Control | Vegetative | Vegetative | Vegetative | Maturity | Continuous |
| | 1975 | Control | Vegetative | Flowering | Senescence | Maturity | Continuous |
| | 1976 | Control | Vegetative | Senescence | Vegetative | Maturity | Continuous |
| Vegetative | | 8.3$^{a}$[1] | 11.3$^{a}$ | 1.3$^{b}$ | 0.0$^{b}$ | 0.0$^{b}$ | 0.0$^{b}$ |
| Quiescence | | 8.0$^{a}$ | 1.9$^{a}$ | 0.4$^{b}$ | 2.4$^{b}$ | 2.4$^{b}$ | 0.3$^{b}$ |

[1] Data in rows followed by a different letter are significantly different at the 95% level by Tuckey's *w*-procedure.

during the current growing season, the following year's forage production, and crown diameters of mesa dropseed.

Concentrations of TNC were not highly sensitive to defoliation. Variability of food reserves between plants was generally greater than that caused by herbage removal. However, after three consecutive years of clipping, TNC levels in plants defoliated continuously or during maturity were significantly less than levels present in nondefoliated plants (Table 1).

Defoliating plants before or after flowering did not affect production of forage harvested (Table 3). However, defoliating plants during flowering or continuously throughout the growing season significantly reduced production the following growing season. Removal of 65% of the current annual production present during the vegetative stage in 1974 resulted in about 70% less forage being harvested than if plants were clipped continuously or during maturity at the same intensity. Clipping 65% of the current annual growth on mesa dropseed during the 3 to 4 leaf stage harvested approximately 19 to 20% of the annual forage available.

During the 1975 growing season, plants that had been clipped in the vegetative stage in 1974 yielded significantly more forage in the vegetative stage, flowering stage, and senescence stage than plants that had been continuously defoliated (Table 3). Plants clipped at maturity during 1974 and 1975 also produced significantly more forage during the 1975 growing season than did continuously clipped plants.

In 1976 continuously defoliated plants produced significantly less during the vegetative stage than did plants defoliated at the vegetative stage (Table 3). During leaf senescence in 1976, plants that had been clipped continuously or during flowering in 1975 produced significantly less than plants clipped during maturity in 1976.

Low yields for plants from the VFS treatment indicated defoliation during flowering was detrimental to the following year's forage production. However, this was based on 1 year of data, in which growing season rainfall was 28% below average on the mesa dropseed study area. No measurable amount of forage was produced during the latter part of senescence, probably because of lack of precipitation and cool temperatures.

Crown diameters for control plants were significantly larger than diameters of plants clipped continuously or at maturity during the 1975 and 1976 growing seasons (Table 2). Although this was not totally consistent with production data, it did correlate with TNC data in the last year. As crown diameters decreased, TNC levels decreased during the quiescence stage in 1976.

## Conclusions

Total available carbohydrates and crown diameters of black grama showed little response to season of clipping. However, the amount of forage harvested was sensitive to season of clipping. Black grama plants continuously defoliated throughout the growing season, or during senescence and quiescence, during flowering, or during senescence, produced less forage in the following year than did those plants clipped only during the vegetative stage. Early clipping allowed for substantial regrowth, probably enabling plants to adequately complete normal growth requirements. In 1974 less than half of the total forage yield was present during the three to four leaf stage. Defoliation at a level of 65% during this period removed only 30% of the plant total. This was consistent with levels of winter use required to maintain or improve stands of black grama reported by Campbell and Crafts (1939) and Valentine (1970). However, removing 65% of the current year's growth during the vegetative stage significantly reduced the number of stolons produced during the following growing season. Later use at this intensity removed the current year's production of stolons. Due to the vulnerability of stolons, 65% removal of the current year's production any time during the growing season will impair the ability of black grama to increase vegetatively, thus greatly decreasing its competitive ability. Probably a more effective scheme for managing black grama would be to harvest 30 to 35% of the total annual production throughout the growing season. This should decrease grazing pressure on stoloniferous culms.

The responses of TNC, production, and crown diameter in mesa dropseed to season of clipping were not consistent. Continuous defoliationg at 65% intensity significantly reduced TNC levels and crown diameter below that of the control plants, and significantly reduced production below the level of plants clipped in the vegetative stage. Crown diameters and TNC levels were also significantly reduced in plants clipped during senescence and quiescence although productivity was not affected. Clipping during flowering significantly reduced productivity in the following year but had no effect on crown diameters and TNC levels. Of the five clipping treatments, both the vegetative and VSV treatments had no apparent effect on plant vigor. As with black grama, less than half the total annual yield was present during the three to four leaf stage. Removing 65% of the vegetative growth during this period harvested 19% of the total.

Since mesa dropseed becomes unpalatable and low in nutrients when it matures (Paulsen and Ares 1962), it would benefit beef production to graze this plant during the growing season. If plants are to be continuously grazed during active growth or grazed during or after flowering, utilization should be less than 65%. In summary, these plants can withstand heavier use prior to flowering than during the remainder of the growing season.

Early use of both black grama and mesa dropseed had less impact on plant vigor than late season or continuous defoliation. Several factors are possibly involved. Early defoliation occurs during a time when environmental parameters (mainly soil moisture and air temperature) are adequate to allow for quick regrowth. As plants mature, these conditions become less optimal and plants have less time to complete important growth functions. Besides environmental factors affecting regrowth, the elapse of time for chemical processes to attain peak rates with defoliation increases with leaf age (Hodgkinson 1974).

Both species were unable to tolerate continuous clipping at 65% herbage removal. However, care must be taken in the interpretation of continuous clipping. Continuous clipping and continuous grazing may be two different things. Continuous grazing would decrease plant vigor under the assumption that herbivores will continually remove plant material from these plants during the growing season. However, cattle do not consistently graze one species or the same plant unit of a given species during the entire growing season under desert conditions. Also, lighter use would be made during the growing season under a continuous year-long grazing system.

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