Some Factors Affecting Twig Growth in Blackbrush

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Abstract

Domestic goat browsing was used to stimulate twig production by blackbrush. Precipitation, soil depth and stoniness, branch location, and the number of years of browsing and rest from browsing affected twig production ($P<0.05$). As precipitation doubled, production increased by a factor of 1.9. Twig production by plants growing on deep soils (71 cm) was 1.9 times that by plants growing on shallow soils (39 cm). Older branches growing on the outer edges of blackbrush plants (terminal branches) produced 4.6 times more current season's twigs than sprouts and young branches (basal branches) growing within the shrub canopy. Heavily browsed plants increased twig production by a factor of 3.6 relative to control plants, and production remained at this level, even after 4 consecutive years of browsing. Annual twig production declined with rest from browsing. However, plants that were browsed and subsequently rested for 2 years yielded an aggregate 1.6 times more available forage than plants that were browsed on a yearly basis. This was due to an accumulation of twigs ranging in age from 1 to 3 years.

Blackbrush *(Coleogyne ramosissima)* is a densely branched shrub that occurs on several million hectares of rangeland in the southwestern United States. The terminal twigs of blackbrush branches tend to die back for several centimeters from the tip resulting in a compact, spinescent growth form (Bowns 1973). This growth form limits the accessibility to and palatability of blackbrush twigs for most ungulates and this species is generally considered poor forage.

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Domestic goats were used to modify the growth form of blackbrush in southwestern Utah in an attempt to improve these rangelands for cattle (Provenza et al. 1983). Winter removal of spinescent twigs by goat browsing stimulated spring sprouting from basal and axillary buds, which resulted in increased twig production. The purpose of this paper is to describe some factors affecting twig production by blackbrush.

Methods

The experiment was conducted on Bureau of Land Management administered land in the extreme southwestern corner of Utah near Gunlock. The study area was an elevation of 1,280 m and consisted floristically of blackbrush associated with juniper *(Juniperus osteosperma)*. The soil series of the site was a Pastura Loam with an A-C horizon sequence underlaid by a petrocalcic (caliche) horizon (Bowns 1973). A Bureau of Land Management rain gauge, located approximately 2 km west of the study area, showed an average of 165 mm of precipitation from December through June from 1965 to 1976. An average of 302 mm of precipitation was recorded for the same period during this study, 1977 to 1980.

The effects of soil depth, browsing and rest, branch location, and precipitation on current season's twig growth (CSG) were examined. To assess the effects of soil depth and stoniness on production of CSG, 36 plants were selected on both deep and shallow soils. The average depth to the impervious petrocalcic horizon for deep and shallow soils was 71 and 39 cm, respectively, and shallow soils contained surface and subsurface stones.

Table 1. Years in which blackbrush plants growing on deep and shallow soils were browsed and rested from browsing.

Treatment symbol ("years")[1]	Number of plants	Year	
		Browsed	Rested
B0 R4	6	——	1977, 1978, 1979, 1980
B1 R3	6	1977	1978, 1979, 1980
B2 R2	6	1977, 1978	1979, 1980
B3 R1	6	1977, 1978, 1979	1980
B4 R0	6	1977, 1978, 1979, 1980	——
B1 R0	6	1980	——

[1]B and R represent browsed and rested from browsing and the numbers represent years.

Within each soil depth, the effects of heavy use followed by rest were investigated (Table 1). Heavy use in the initial year (1977) was removal of twigs from all of the terminal branches. Subsequently, heavy use was greater than 95 percent removal of current season's twigs from terminal and basal branches. *Terminal branches* were older branches growing on the outer edges of the plant canopy, while *basal branches* were sprouts and young branches arising from within the terminal branch canopy.

Three terminal and three basal branches were randomly selected and measured on all plants except control. One terminal and one basal branch were measured on control plants in 1977, 1978, and 1979. Total length of seasonal twig growth was measured in December of 1977 and September of 1978, 1979, and 1980, after blackbrush growth had ceased (Bowns 1973). The relationship between precipitation, from December through June, and twig production for these years was assessed. The statistical design of the experiment was a factorial with repeated measurements on the plants. Soil depth and "years" were the main effects, and branch location within plants was treated as a subplot in the analysis.

Results and Discussion

Precipitation influenced the amount of CSG produced. A linear relationship was found between current season's twig production by unbrowsed plants and the amount of precipitation received between December and June (Fig. 1). A similar relationship (r^2=0.95) was found for heavily browsed plants; however, twig production was greater. Moisture received from December to mid-March recharged the soil profile prior to the initiation of plant growth, while precipitation received from mid-March to mid-June was used during the period of active plant growth. When precipitation was sufficient to wet the soil profile to the 20 cm depth, the zone of most abundant root biomass (Bowns 1973), increased production resulted.

Data obtained from heavily browsed blackbrush plants selected for intensive studies indicated that production of CSG was affected by soil depth and stoniness, and branch location on the plant (Table 2). Blackbrush plants growing on deep soils with little surface stone produced more CSG than plants growing on shallow soils with much surface stone. An interaction between branch location and soil depth resulted from basal branches producing similar quantities of current season's twigs on deep and shallow soils, while the terminal branches of plants growing on deep soils outproduced those of plants growing on shallow soils.

Enhanced soil moisture relations were probably responsible for the increased twig production by plants growing deep soils. Medin (1960) concluded that factors influencing soil moisture relations were key influences upon twig production in the shrub *Cercocarpus montanus,* and that as soil depth increased, more water was stored for use by plants.

Older branches growing on the outer edges of blackbrush plants (terminal) were compared with sprouts and younger branches arising from within the plant's canopy (basal) for production of CSG, and terminal branches outproduced basal branches on heavily browsed plants (Table 2). However, terminal branches did not outproduce basal branches on control plants, and production of CSG by basal branches was not significantly different among the treatments (Fig. 2). The average leader length was longer for basal than terminal branches, which concurred with the finding of Bowns (1973) that the average leader length for basal twigs was twice that of terminal twigs. Twig production on heavily browsed plants, however, was primarily from terminal branches due to the large number of twigs produced.

The number of years of browsing and rest from browsing that blackbrush plants received also affected production of CSG (Fig. 3). Browsing stimulated production of CSG by blackbrush, and even after 4 years, heavily browsed plants (greater than 95% of the CSG removed) still outproduced unbrowsed plants. A comparison of plants that were heavily browsed for 4 years with plants that were heavily browsed for 1 year (Fig. 3, last 2 bars in 1980), indicated that current season's twig production did not decline as a result of heavy browsing. Abundant soil moisture during 1978 and 1979 likely increased the resistance of blackbrush to browsing. Nevertheless, the shrub appeared to be capable of survival with sustained twig removal. When browsing was terminated, however, production of CSG declined.

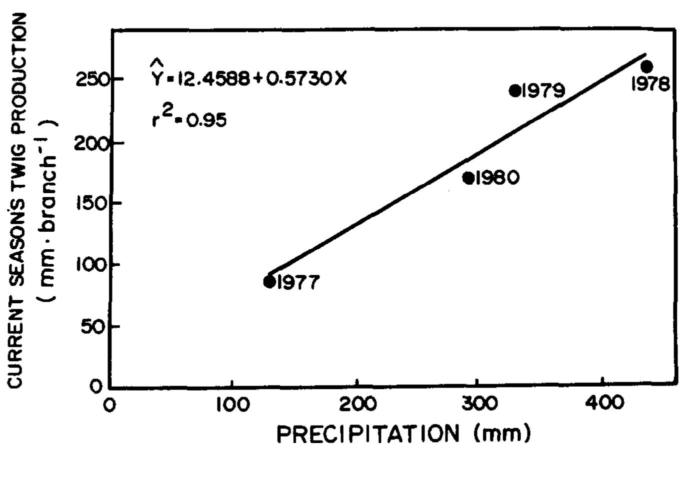

Fig. 1. *Relationship between the amount of precipitation received from December through June and current season's twig production by unbrowsed blackbrush plants.*

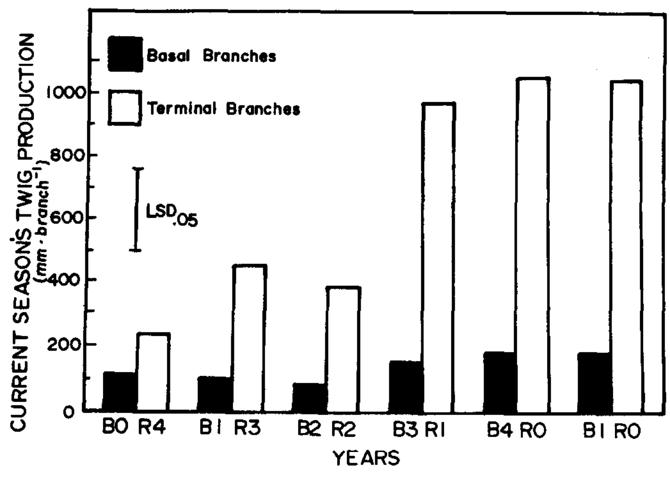

Fig. 2. *Current season's twig production by basal and terminal blackbrush branches in 1980. B and R represent browsed and rested from browsing and the numbers represent years.*

Table 2. Current season's twig production by the terminal and basal branches of heavily browsed blackbrush plants growing on deep and shallow soils.

	Current season's twig production (mm • branch^{-1})			
	Terminal branches		Basal branches	
Year	Deep soils[1]	Shallow soils[1]	Deep soils[1]	Shallow soils[1]
1977	528^a	322^b	152^a	173^a
1978	1616^a	858^b	377^a	234^a
1979	1396^a	638^b	158^a	152^a
1980	925^a	444^b	159^a	106^a

[1]Average depth to the imprevious caliche layer for deep and shallow soils was 71 cm and 39 cm, respectively.
[ab]Means in the same row, for a given branch location, are significantly different (LSD, $P<0.05$).

The data in Figure 3, when combined with a knowledge of how goats and cattle browsed blackbrush plants, provides implications for management. Blackbrush plants that were browsed and subsequently rested accumulated significant quantities of relatively new twig growth, while plants that were browsed without rest produced only current season's twigs (Table 3). When plants were browsed 1 year and rested for the next year or 2, a larger quantity of *more palatable* twig material was available for consumption than when plants were browsed year after year. The increased palatability was apparently related to a decrease in astringent tannins as the proportion of current season's (high in tannins) to older (low in tannins) twigs decreased (Provenza and Malechek 1983). The decrease in astringent tannins as twigs aged presumably resulted from the polymerization of tannins with proteins and carbohydrates; the resulting large molecular weight compounds were less astringent and as a result the older twigs were more palatable.

Browsing systems for blackbrush rangelands should be established that employ heavy winter browsing followed by 1 or 2 years rest from browsing, depending on blackbrush twig production. Rest from browsing allows blackbrush plants to accumulate more twigs that are lower in astringent tannins, and therefore more palatable. The primary purpose of rest is to allow an accumulation of palatable forage for consumption by livestock, rather than to benefit the plants, since blackbrush is apparently capable of withstanding heavy winter twig removal.

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Table 3. Cumulative production of current season's twigs by blackbrush plants during a three year period.

	Current season's twig production (mm • branch^{-1})			Available for consumption (mm • branch^{-1})	
Treatment	1977	1978	1979	1978	1979
Browsed 1977, Rested 1978, 1979	345	676	384	1021	1405
Browsed 1977, 1978, 1979	341	974	903	974	903
Unbrowsed 1977, 1978, 1979	93	326	218	419	637

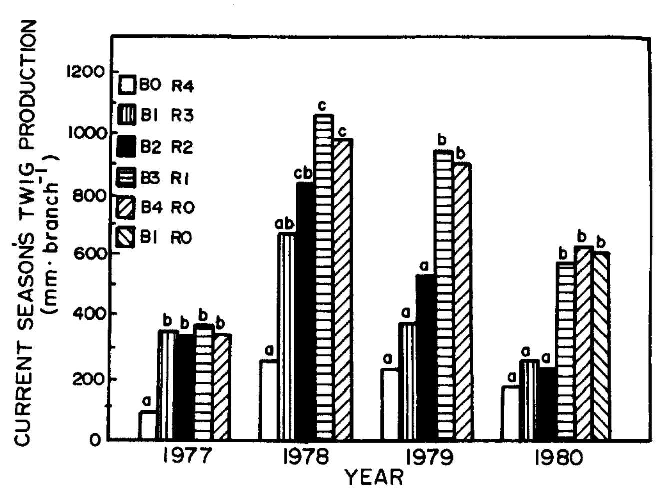

Fig. 3. *Current season's twig production by blackbrush plants. B and R represent browsed and rested from browsing and the numbers represent years. Letters above the bars represent statistically significant differences within years (LSD, P<0.05).*