Interference of Sand Sagebrush Canopy with Needleandthread

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Abstract

The influence of sand sagebrush (*Artemisia filifolia*) on the biomass of several components of needleandthread (*Stipa comata*) was studied on grazed and ungrazed sites in eastern Colorado. The components examined were seeds, stems-leaves combined, crowns, and total plant biomass. A significant grazing $\times$ association interaction was observed in terms of seed biomass and stem-leaf combined biomass. Sagebrush afforded protection for needleandthread from grazing, which outweighed the effects of interference on grazed sites. In contrast, on the ungrazed site needleandthread biomass was greater in the open than underneath the sage. These results imply that a comparison of yield in pure and mixed stands on grazed sites are not valid for measuring interference effects between shrubs and grasses. The advantage of measuring several plant components in competition studies was also discussed.

It has been recognized since the early 1900's that overgrazing has given a competitive advantage to less desirable forage plants and has resulted in poor range conditions (Wootton 1908). Fluctuations in vegetation responses resulting from range management manipulations are best understood only when interference relationships can be accurately described (Hanson et al. 1931; Stoddart et al. 1955).

Effects of interference between sagebrush (*Artemisia* spp.) and grasses have been previously documented (Robertson and Pearse 1945; Blaisdell 1949; West and Tueller 1972; Rittenhouse and Sneva 1976). Often these effects were studied in the greenhouse or in pots placed in the field (Robertson 1972; Bailey and Gupta 1973; Rennie 1974) and such experiments have been criticized because the extrapolation of results from artificial environments to natural conditions was of questionable value (Harper 1961; Palmblad 1968a,b; Risser 1969).

Many experiments of plant interference, even those performed under natural field conditions, had parameters that consisted solely of collective aboveground and belowground components (Bailey and Gupta 1973; Rennie 1974; Rittenhouse and Sneva 1976). Harper (1961) noted that as density increased, the allocation of assimilatory products to the various organs of the plant may change. This indicated that a more critical examination of these component organs would be in order. Some recent research has dealt with components such as leaf, stem, seed, crown and root biomass (Grafius 1972; Rennie 1974).

Many studies involving interference between shrubs and forage grasses have tended to emphasize shrub control treatments or effects on reseeding practices (Robertson 1969;

Schlatterer and Tisdale 1969; Eckert et al. 1972; Scifres and Polk 1974). Perhaps because of limited practical applications, studies strictly concerned with the ecological aspect of interference between grasses and shrubs are few in number. Ecological studies involving forage species in association with sand sagebrush (*Artemisia filifolia* Torr.) are virtually nonexistent.

The purpose of the present study was to determine the effects of interference and grazing on total aboveground biomass of needleandthread (*Stipa comata* Trin. & Rupr.), and furthermore how individual aboveground compartments of this grass were affected by interference from sand sagebrush and grazing.

Site Description

The Eastern Colorado Agriculture Research Center is located in the Central Great Plains about 27 km north of Akron in the sandhills of northeastern Colorado. The elevation averages 1,300 m and the topography varies from nearly level to slightly rolling dunes (Sims et al. 1976). The study site has a continental climate with hot, dry summers, mild, dry autumns, cold winters, and moist, cool springs (Trewartha 1968; Sims et al. 1976). Average annual precipitation ranges between 33 and 43 cm, of which 75 to 80% occurs during the growing season (USDA 1975). There are about 140 frost-free days starting in mid May and ending in early October (Dahl 1963). The area frequently experiences high intensity summer storms with hot, dry periods between storms being common.

This study was conducted on Blakeland loamy sand which has a deep sandy profile. Moisture penetration is rapid and deep, which prevents great losses as a result of evaporation. Rapid drying of the surface soil contributes to reduction of evaporation at lower depths and moisture is given up rapidly to plant roots (USDA 1975). The drainage pattern is undefined in the dune area, and the soils are relatively low in organic matter.

The study site was located in an area moderately grazed since 1970. A 0.2-hectar exclosure was used as an ungrazed site, while the area outside of the exclosure served as the grazed site. The exclosure had not been grazed since 1953.

Sims et al. (1976) described the native vegetation of this area as heterogeneous, consisting of short, mid, and tall grasses, as well as mixtures of cool- and warm-season species. The major species include blue grama [*Bouteloua gracilis* (H.B.K.) Steud.], prairie sandreed [*Calamovilfa longifolia* (Hook.) Scribn.], needleandthread, sand bluestem (*Andropogon hallii* Hook.), western wheatgrass (*Agropyron smithii* Rydb.), and sand dropseed [*Sporobolus cryptandrus* (Torr.) Gray]. Sand sagebrush occurs as the principal shrub and sun sedge (*Carex heliophila* Mack.) is the principal dryland sedge. Common forbs in the area include perennial ragweed (*Ambrosia coronopifolia* Torr. and Gray), cudweed sage (*Artemisia ludoviciana* Nutt.), wild alfalfa (*Psoralea tenuiflora* Pursh), and bush morning glory (*Ipomoeae leptophylla* Torr.).

Methods

Twenty-four cages, approximately 1 m² in area, were used as mini-

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enclosures to define sampling areas in the grazed pasture. The cages prevented grazing during the current year. Twelve cages were placed around sand sagebrush plants which had needleandthread plants growing as understory species. The remaining 12 cages were paired with the others but were placed in the open pasture away from the influence of sand sagebrush plants. Inside the 0.2-ha enclosure the ungrazed treatments consisted of sampling 12 plots of needleandthread plants in association with sand sagebrush and 12 plots containing needleandthread plants away from the sagebrush.

Sampling was conducted over a four- to five-day period at two stages of plant development. The first sampling period was the last week in June, when needleandthread was fully matured but prior to seed shatter. The second sampling period was the last week in July. At this time, sand sagebrush had reached its full potential biomass.

Six cages which contained a sagebrush plant were sampled during each period. Six plots within the long-term enclosure were also sampled. A paired cage or plot which did not contain a sand sagebrush plant was sampled at the same time in addition to each cage or plot which contained a shrub.

Sampling the sand sagebrush-needleandthread association consisted of clipping the aboveground biomass of four separate groups of plants: needleandthread, sand sagebrush, other grasses, and forbs. The paired cages in the open were treated similarly, with the exception of the shrub. An area of 1 m² was marked around sand sagebrush plants and in the open in the 0.2-ha enclosure. These areas were sampled in the same manner as described for cages. Individual needleandthread plants in each plot were also counted.

Needleandthread components (stems and leaves, crowns, and seed) were separated by hand. All plant material was oven dried at 70°C and weighed. Seven variables useful in the data analysis were obtained: (1) biomass of needleandthread seed, (2) biomass of needleandthread crown, (3) biomass of needleandthread stems and leaves, (4) total needleandthread biomass, (5) biomass of other grasses, (6) biomass of forbs, and (7) density of needleandthread/plot.

Effects of interference resulting from needleandthread grass association with sand sagebrush were examined by measuring the biomass of several components of needleandthread. A covariate analysis was used to initialize all plots with respect to biomass of other grasses and forbs, and density of needleandthread/plot. A factorial design was utilized to determine significant main effects of sampling date, grazing, and association, as well as significant interactions. Statistical significance was based on a 0.10 level of probability.

Results and Discussion

Significant main effects of sampling date and presence or absence of grazing were observed in terms of biomass of seeds/m². Significant interactions of date and grazing and

grazing and association were also observed. This latter interaction, of grazing × association, was most interesting with regard to plant interference. An interpretation of this relationship indicated that grazing pressure outweighed interference effects (Fig. 1A). In the open pasture on grazed sites there was less seed biomass than in plots associated with shrubs. Apparently, the shrub acted as an enclosure and protected understory needleandthread plants from grazing. In contrast, the opposite situation was evident in the enclosure. Needleandthread plants in the open had more seed biomass than those in association with sand sage. Therefore, in ungrazed areas the interference effect of sand sagebrush suppressed seed production. This effect was not evidenced in the grazed areas because the protective nature of the shrub resulted in a grazing × association interaction.

In terms of combined biomass of stems and leaves, only the effects of grazing and the grazing × association interaction were significant. This biomass combination interaction was the most interesting from an interference standpoint (Fig. 1B). Sand sagebrush protected understory needleandthread plants in the grazed pasture so that biomass was greater in the shrub-associated plots than in the open pasture. Grazing masked interference effects on the grazed site, but plants in the open within the enclosure exhibited greater stem and leaf biomass. The effect of the shrub interference was to suppress needleandthread yield which was detectable only in plots protected from grazing.

In terms of crown biomass of needleandthread, statistical significance resulted only between grazed and nongrazed treatments. Grazing × association interaction was not significant. Stems and leaves, because of their accessibility, were obviously affected by past livestock grazing. Association with the shrub-protected needleandthread foliage and resulted in a significant grazing × association interaction. Since moderate grazing did not affect the crown biomass, protection provided by the shrub was of little consequence.

An analysis of total aboveground biomass of needleandthread plants showed only the main effect of grazing to be statistically significant. The grazing × association interaction of total biomass was not significant, but its pattern was worthy of note since it was generally the same as that of the seed and stem and leaf grazing × association interaction (Fig. 1C). This interaction indicated that the protective nature of the shrub did not allow a valid comparison to be made between pure and mixed stands in the grazed pasture.

Fig. 1. Diagrams depicting the grazing × association interaction of: (A) needleandthread seed biomass; (B) needleandthread stem and leaf biomass; and (C) total needleandthread biomass. (O = open; W = with shrub.)

A greenhouse study of the effects of sand sagebrush interference on needleandthread may indicate that this shrub suppresses grass yield, as was indicated in the enclosure of this study. However, to extrapolate such results to a grazed condition would be a mistake. For under grazing pressure, the protective nature of the shrub caused yields of needleandthread to be greater in the shrub understory than in the open pasture. Therefore, since effects of grazing far outweigh those of interference, it becomes a formidable task to quantify competition based on comparison of grazed pure and mixed stands. Field experiments measuring effects of interference between shrubs and grasses should, therefore, be performed on ungrazed sites which preferably have been protected for several years.

In studies of shrub and grass interference effects, in enclosures where grazing is not confounded with association, examination of plant yield is a valid comparison. Results from this study suggested that plant yield or biomass might not be the best parameter to measure effects of interference of successional changes related to these effects, especially in areas with a history of grazing. Plant yield in the presence of a shrub does not appear to be adversely affected because of confounding with grazing. Over a long-term period, however, grass yields have been shown to decrease in the presence of shrubs (Rittenhouse and Sneva 1976). The grazing $\times$ association interaction of this study indicated that the protective nature of the shrub on grazed areas will not allow valid comparisons to be made between yields of plants associated with a shrub and yields of plants in the open to determine effects of the shrub interference. Some characteristic besides yield would be beneficial in detecting this decrease on grazed sites over a short term. Perhaps gross energy, cover, or crown diameters would provide more accurate estimates of the effects of the shrub on grasses.

This study indicated that measurements of several plant components rather than total biomass alone were more sensitive in detecting changes which resulted from the combined effects of grazing and association. Significant grazing $\times$ association interaction was detected using biomass of seeds and stems and leaves, whereas total plant biomass did not indicate a significant interaction.

As optimum production of forage plants becomes more important in an increasingly populated world, knowledge of the relationship between valuable and undesirable plants in association with each other becomes a necessity. This work has examined the effect of sand sagebrush on the yield of several components of needleandthread. It has also shown that effects of association can be confounded by grazing pressure, and measures of yield alone in grazed areas may lead to erroneous conclusions regarding the effect of the shrub. In addition, this study has shown that measures of the biomass of multiple components of a grass are more sensitive in detecting the

combined effects of plant interference and grazing than are measurements of total aboveground biomass alone.

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