TECHNICAL NOTES

Frequency of Endomycorrhizal Infection in Grazed and Ungrazed Blue Grama Plants

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Highlight: The frequency of mycorrhizal infection in blue grama roots was determined from two criteria: (1) occurrence of any mycorrhizal element, and (2) occurrence of fungal vesicles. No significant differences were observed with respect to grazing using the first frequency criteria. However, roots of previously grazed plants had significantly higher frequencies of vesicles than those collected from exclosures. Frequency of vesicles was found to increase linearly with increase in rooting depth of blue grama. Significant grazing effects on the frequency of vesicles were observed primarily in the first sample depth, 0–10 cm.

A region of intense microbial activity exists in soil surrounding plant roots. The majority of plant species growing under natural conditions are dual organisms in that the organs through which they absorb water and nutrients consist of root and fungus tissue, mycorrhiza. The entire root system of an individual plant may be mycorrhizal or only a portion of the roots may be infected. However, relatively few species are completely nonmycorrhizal (Gerdemann 1968; Khan 1974).

Fungi which infect root systems of grasses are predominantly vesicular-arbuscular (V-A) endotrophs which are most commonly placed in the genus *Endogone* (Mosse 1973). V-A mycorrhiza have a loose network of hyphae in soil surrounding the root and extensive hyphal growth within the root cortex (Fig. 1). The external hyphae network may extend into the soil as much as 7 cm (Rhodes and Gerdemann 1975).

Recent interest has increased in examining the influence of mycorrhiza on tolerance of plants to various soil nutrient and water stresses (Williams et al. 1974). While the presence of mycorrhiza in grasslands was documented as early as 1929 (Weaver and Clements 1929), we are not aware of any published reports dealing with the influence of mycorrhiza on the tolerance of plants to grazing stress.

A study was conducted at the Eastern Colorado Research Center to examine the occurrence and extent of endomycorrhiza infection in roots of blue grama (*Bouteloua gracilis* (H.B.K.) Lag.) plants under grazed and ungrazed conditions on two soil types. The Center is located 26 km north of Akron, Colo., in the sandhills of northeastern Colorado at an elevation of 1,300 m. The climate is semiarid with cold, dry winters; moist, cool springs; hot, occasionally dry summers; and mild, usually dry autumns (Sims et al. 1973). Seventy percent of the long-term 38 cm average annual precipitation falls as rain from April 1 to August 31. The average frost-free period of 140 days usually begins in mid-May and ends in early October (Dahl 1963).

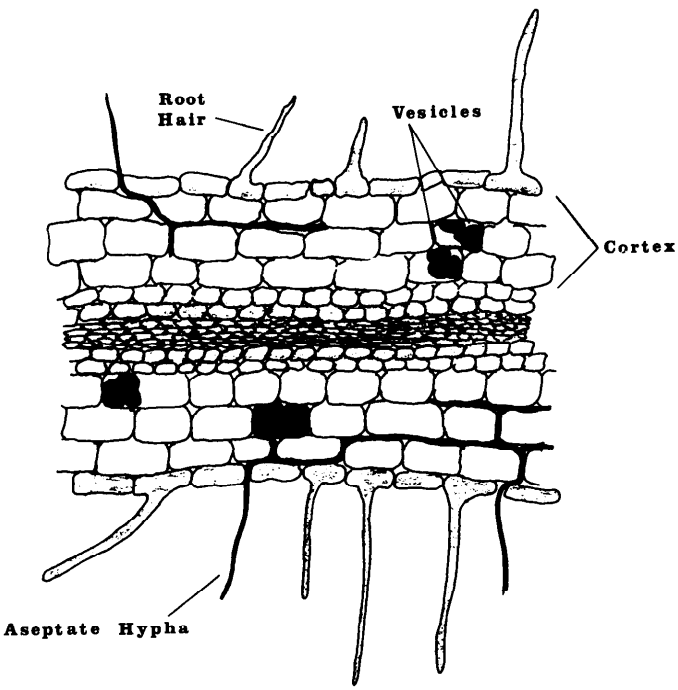

Fig. 1. *Enlarged view of blue grama root infected by endomycorrhizal fungi. Intercellularly located vesicles and intercellularly located aseptate hyphae are restricted to the root cortex.*

Five root cores (44.2 cm^2 × 100 cm) of blue grama were collected inside and outside exclosures, which were located on loamy sand and sandy loam sites. Cores were taken in early November with the aid of a pneumatic hammer and jack (Bartos and Sims 1974). Three 10-cm increments were taken from each core at 0–10, 20–30, and 40–50 cm soil depths. Samples were placed in ziplock plastic bags and stored at 5°C. Cores were rinsed with water over a 32-mesh screen, after which roots were bleached and stained according to procedures described by Trappe et al. (1973). Stained root segments (3 cm) were mounted in Howyer's solution and examined with a 100 × microscope. Frequencies of mycorrhiza were based upon occurrence of any mycorrhizal elements in 30 2-mm view segments of roots per slide. Because of the sampling procedure, the acropetal end of the root segments was not known and segments were randomly placed on the slides.

The 30 slides prepared from the loamy sand site were reexamined following the initial review. Frequency of mycorrhiza infection in the reexamination was determined by the occurrence of vesicles. The two

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Table 1. Mean frequencies (%) and standard errors (S.E.) of mycorrhizal infection in blue grama roots basedupon the occurrence of fungal elements, e.g., hyphae or vesicles in the root cortex, for soil types and grazing.

	Soil types				Grazing	
	Loamy sand		Sandy loam			
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Grazed	89	2.5	87	2.4	88	1.7
Ungrazed	89	2.8	84	6.4	86	3.5
Soil type	89	1.8	85	3.4		

sets of frequency data were analyzed separately using a factorial analysis of variance (Snedecor and Cochran 1973).

Results

Soil differences did not significantly influence the frequency of infection based upon occurrence of any mycorrhizal elements under grazed or ungrazed conditions (Table 1). Infection frequencies of previously grazed plants were not significantly different from previously ungrazed plants at either soil site (Table 1). Roots were equally infected at all three soil depths based upon occurrence of any mycorrhizal elements (Table 2).

Table 2. Mean frequencies (%) and standard errors (S.E.) of mycorrhizal infection in blue grama roots based upon the occurrence of fungal elements, e.g., hyphae or vesicles in the root cortex, for soil depths.

	Soil depth					
	0–10 cm		20–30 cm		40–50 cm	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Grazed	87	2.6	87	9.1	90	3.8
Ungrazed	92	2.4	81	2.7	86	4.6
Depth	90	1.8	84	4.7	88	2.9

The mean infection frequency (based upon the occurrence of vesicles) for previously ungrazed plants was 49%, while the mean infection for plants from the grazed pasture was higher at 67% frequency ($P = .025$). Significant differences ($P = .005$) among mean frequencies of vesicles for soil depths were also observed. Mean frequencies for the 0–10 and 20–30 cm soil depths were not significantly different from each other but both were significantly less than the mean frequency observed at the 40–50 cm soil depth. Overall, the frequency of vesicles increased linearly ($P = .001$) with increasing soil depth, 42, 52, and 80%, respectively. Grazing did not significantly modify the linearity of the increase in vesicle occurrence with increasing soil depth.

Discussion

Interpretation of mycorrhiza frequency data requires a review of factors influencing the occurrence of fungi in roots. Generally, as the length of root segments examined from a given sample increases, so will the frequency of mycorrhiza occurrence. Another point of concern is the influence of root growth upon this occurrence. Neill (1944) observed that vigorous, actively growing roots of citrus trees were rarely infected and that as the rate of growth declined the infection increased. Harley (1959) suggested that any external factor which causes a slow growth rate of roots or which reduces the proportion of actively growing tissue on a root system will appear to increase infection. Furthermore, plants growing in fertile soil tend to have more roots than comparable plants growing in less fertile soil. Thus, it is possible that the plant in fertile soil with a lower percent of mycorrhizal roots might have a greater total length of mycorrhiza (Gerdemann 1968). It is important, however, to note that increased absorbing tissue provided by greater abundance of mycorrhizal hyphae under stress conditions may be a significant compensation for reduced root development (Trappe et al. 1973; Williams et al. 1974).

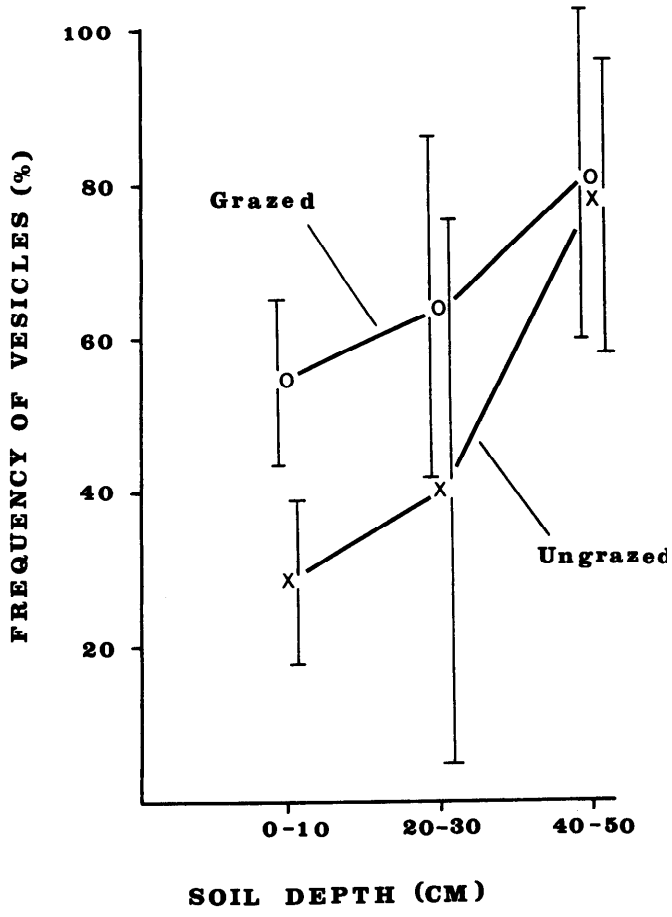

Fig. 2. *Mean frequencies (%) of mycorrhizal infection in blue grama roots from the loamy sand site based upon occurrence of vesicles in the root cortex. Vertical lines represent 95% confidence intervals for frequencies of vesicles with respect to grazing treatment.*

The literature does not provide adequate information for a thorough discussion of the differences observed between frequencies based upon the two criteria used in this study. While morphological characteristics of V-A fungal developmental stages have been described, there is still much to be learned about their ecological significance, especially with respect to vesicles (Cox and Sanders 1974; Old and Nicholson 1975). It has been suggested that vesicles may function as storage units for nutrients such as phosphorus and potassium (Gerdemann 1968). However, the availability of these nutrients to an infected plant is not known. It has also been stated that vesicles with thickened walls can function as resting spores (Carson 1974).

Treatment differences were observed but the present void in understanding the ecological significance of vesicles limits the extent of the discussion. The difference observed between grazing treatments appears to have been the result of reduced root growth. Further examination of mean occurrence of vesicles for each grazing treatment indicated that differences occurred primarily in the first soil sampling depth (Fig. 2). The root system of blue grama tends to be shallow and spreading with a major portion of root biomass production generally occurring above 30 cm (Weaver 1958; Bartos and Sims 1974). Grazing tends to reduce root growth (Crider 1955; Weaver 1958), which may be the reason for the higher occurrences of vesicles in grazed than ungrazed plants. Substantiation of this plant-fungi relationship will require examination of root length and biomass and mycorrhiza infection frequency of samples collected during several periods within a growing season. The influence of mycorrhizal fungi upon the resistance of blue grama to grazing stress might best be studied by conducting greenhouse experiments in which infected and uninfected plants are defoliated.

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