

Vesicular-Arbuscular Mycorrhizae of Halophytic Grasses in the Alvord Desert of Oregon

Abstract

In an eastern Oregon high desert, Alvord Desert (an alkali, dry lake bed), vesicular-arbuscular (VA) mycorrhizal fungi were found in the roots of two halophytic grasses—(*Festuca idahoensis* and *Distichlis stricta*). Four samples were taken from depths of 10, 20, 30, and 40 cm at sixteen randomly selected sampling sites. Abundant spores were found in these generally harsh vegetative environments. Eighty percent of VA-mycorrhizal fungus were *Glomus mosseae*, and the remainder were *G. macrocarpum*. Soil pH ranged from 9.2 to 10.5. Spore numbers were inversely proportional to the concentration of sodium in the soil. Use of VA-mycorrhizal fungi to increase the salt tolerance of plants on vast alkali wastelands could aid in developing rangeland with halophytic grasses and eventually in the reclamation of much of the high-saline soil for crop production.

Introduction

Vesicular-arbuscular mycorrhizal fungi occur with roots of most plant species in nearly all types of habitats, even desolate ones. The alkali Alvord Desert of southeastern Oregon has only 186 mm of rainfall per year, but a preliminary examination of grass roots from the desert revealed heavy mycorrhizal infection. The discovery means that these VA-mycorrhizal fungi might be used to increase salt tolerance of plants on vast alkali wastelands. This could aid in development of new rangeland with halophytic grasses and, eventually, in the reclamation of much of the world's high-saline soil into crop production at the least cost. This paper reports the results of quantitative assessment of VA-mycorrhizae and identification of the fungi.

The Study Area

The Alvord Desert (13 km wide by 18 km long and at an elevation of 1220 m) is a playa in Harney County, southeastern Oregon. Directly to the west of the desert, the Steens Mountains rise abruptly to an elevation of 2950 m. Plateaus and ridges around the other sides of the desert are at elevations of about 1500 m (Figures 1, 2). Water from snow melting in the mountains in spring and from occasional thunder showers in the summer provides moisture for early season growth of many halophytes, including the facultatively halophytic grasses, *Festuca idahoensis* and *Distichlis stricta*.

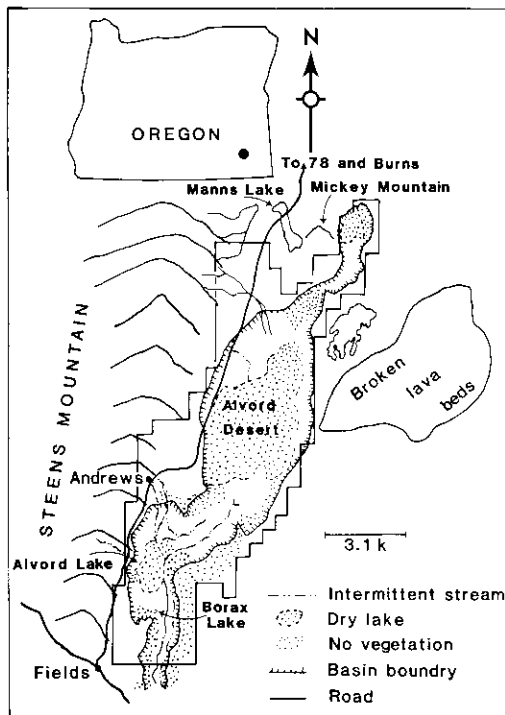


Figure 1. Alvord Desert, southeastern Oregon.

Methods

Sixteen soil and root samples were taken at intervals of about 200 m around the edge of a dry alkaline lake bed 500 m south of the road in the Alvord Desert in July 1979. A 10-cm² hole was dug with a straight-edged shovel at each sample

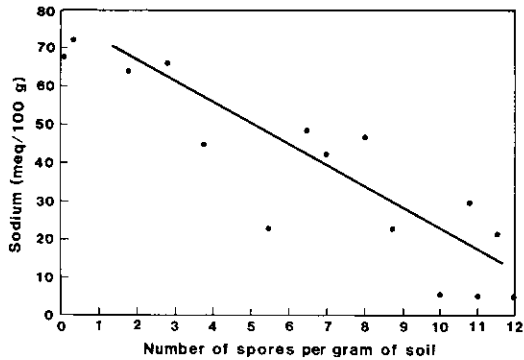


Figure 2. Correlation coefficient of soil sodium concentration vs. spore number.

site. Soil and roots from each hole were segregated by 10-cm depth classes down to 40 cm. A separate, adjacent sample was taken for soil analysis at a depth of 20 cm. Species composition of the surface vegetation was recorded at the same time.

Soil and root samples were air dried and screened through a no. 850 sieve. Roots were separated, dried, and weighed. Root samples were cleaned and then stained with acid fuchsin in lactophenol to examine mycorrhizal infection. Four 10-g aliquots of screened soil were made from each soil depth sample, and each was placed in a 100-ml graduated cylinder. Ten ml of water were added to wet the sample, and 100 ml of 1-M sucrose solution were added to float spores. After soil particles settled down, the supernatant was poured through a no. 100 (pore size, 150 μ m) sieve and was rinsed several times with tap water. This procedure was repeated several times. The materials left on the surface of the sieve were carefully washed into petri dishes for counting and identification. Only those spores appearing to be viable were counted.

Results and Discussion

Sheikh *et al.* (1975) reported that soil at pH 6.2 contains the greatest number of spores of VA-mycorrhizal fungi and that the number decreases with an increase in pH. Results of analysis of soil samples (Table 1) in this study revealed that the pH value was very high, ranging from 9.2 to 10.5, yet the number of spores was also high. Low phosphorus and nitrogen are usually favorable

for mycorrhizal development (Gerdemann 1968, Hayman and Mosse 1972). In this study no statistically significant correlations were found between the number of spores and the concentration of soil elements except for sodium. Concentration of sodium was inversely correlated to the number of spores present (≤ 0.05), (Figure 2).

Preliminary examination of roots from grasses indicated heavy VA-mycorrhizal infection in every sample. The predominant species (80 percent of samples) of VA-mycorrhizal fungus was *Glomus mosseae* (Nicol. and Gerd.) Gerd. and Trappe. Next was *Glomus macrocarpum* Tul. and Tul. (<20 percent) and insignificant numbers of spores of *G. macrocarpum* var. *geosporum* (Nicol. and Gerd.) Gerdemann and Trappe, *Acaulospora laevis* Gerdemann and Trappe, and *Glomus fasciculatum* (Thaxter sensu Gerd.) Gerdemann and Trappe.

The population of VA-mycorrhizal fungi in Alvord Desert, based on the number of viable spores counted, varied from averages of 23.7 to 96 spores/g of soil (Table 2). Schwab and Reeves (1981) found that the potential for infection of sage community soil by VA mycorrhizae in western Colorado decreases greatly at depths greater than 30 cm. In this study, no statistically significant differences were detected in the number of spores at each soil depth; however, number of spores is not necessarily related to infection potential. Some samples had decreases in number of spores with increased depth, but others had increases that were presumably due to variations in the microenvironment; for example, soil moisture content and alkali deposit could be affected by differences in microrelief. Nutrient distribution and transformation activities are highly structured in desert ecosystems (West 1981) and result in unequal microbial and chemical activities in the soil horizon. This study indicates that most grasses in their natural habitat, except those in areas under water during the entire growing season, were colonized by some VA mycorrhizae. These highly salt-tolerant VA-mycorrhizal fungi, judging by spore numbers, were apparently not affected by high pH, low soil moisture, nor high soil salinity as evidenced by spore population. The high level of activity by VA-mycorrhizal fungi during periods of moisture availability may be important in nutrient cycling and maintenance of alkali desert plant communities.

TABLE 1. Soil analysis.²

Sample no.	pH	P (PPM)	Extractable cations					Salts ² (mmhos/cm)	Total N (percent)	Cation exchange (meq/100g)	Spore no.
			K (PPM)	Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)	B (PPM)				
1	9.2	9	2220	47	6.9	21.7	2.92	3.62	0.10	39.8	11.5
2	9.7	7	1560	38	4.6	47.0	4.40	4.50	0.08	36.8	8.0
3	10.1	5	1240	40	2.7	30.0	1.56	4.00	0.05	30.7	10.8
4	10.1	11	2280	38	3.1	45.0	5.55	4.50	0.07	39.9	3.8
5	9.6	7	2860	43	8.9	23.0	4.65	2.22	0.16	42.5	8.8
6	9.4	7	1800	40	6.9	23.1	1.87	1.26	0.11	57.5	5.5
7	10.4	7	1740	34	1.5	64.0	7.00	5.01	0.04	43.2	1.8
8	10.2	8	1360	34	1.9	68.0	3.22	2.98	0.05	45.1	0
9	10.5	7	1160	30	1.1	66.0	5.60	5.10	0.06	50.3	2.8
10	10.4	16	1520	30	1.3	72.0	7.65	13.00	0.05	47.6	0.3
11	10.2	15	2500	35	2.0	47.0	7.25	9.10	0.07	25.6	5.5
12	9.8	8	2220	35	3.1	49.0	3.67	5.70	0.09	43.2	6.5
13	9.4	5	1120	47	6.3	42.0	3.85	5.70	0.04	46.4	7.0
14	9.7	5	1800	38	5.8	5.3	5.65	6.75	0.11	20.5	12.0
15	9.9	7	1520	40	4.5	5.8	7.30	3.12	0.03	40.9	10.5
16	10.2	5	1520	35	2.1	5.7	5.00	3.70	0.04	35.0	11.8

¹Analysis done by Oregon State University Soil Testing Lab.

²U.S. Salinity Laboratory for evaluating saline soils are as follows: conductivity of saturated extracts (mmhos/cm)/plant growth condition: <2—salinity effects mostly negligible; 2-4—yields of very sensitive crops may be restricted; 4-8—yields of many crops restricted; 8-16—only tolerant crops yield satisfactorily; >16—only very tolerant crops yield satisfactorily.

TABLE 2. Correlation coefficients of soil elements and spore number.

Soil element	Correlation coefficient
pH	-0.550
P	-0.516
K	0.133
Ca	0.603
Mg	0.532
B	-0.267
Salt	-0.339
N	0.261
Cation exchange	-0.538
Na	-0.902*

*Significant at $P \leq 0.05$.

TABLE 3. VA-mycorrhizal fungal species, number of species and root mass.

Dominant VAM fungal species	Number of sites	Soil depth (cm)	Mean number of spores g ⁻¹ soil	Mean root mass g.g ⁻¹ soil
A. <i>Festuca idahoensis</i>	<i>Glomus mosseae</i>	10	69 ± 18	26.6 ± 6.0
		20	54 ± 10	3.0 ± 2.0
		30	53 ± 12	1.3 ± 0.7
		40	48 ± 9	0.5 ± 0.2
	<i>G. macrocarpum</i>	10	54 ± 7	15.5 ± 3.9
		20	34 ± 6	1.1 ± 0.5
		30	49 ± 12	0.5 ± 0.2
		40	24 ± 5	0.4 ± 0.2
B. <i>Distichlis stricta</i>	<i>G. mosseae</i>	10	57 ± 16	11.8 ± 3.4
		20	81 ± 20	1.0 ± 0.8
		30	39 ± 14	0.4 ± 0.2
		40	68 ± 18	0.3 ± 0.2
	<i>G. macrocarpum</i>	10	96 ± 10	33.7 ± 15.7
		20	71 ± 13	2.9 ± 1.7
		30	46 ± 9	1.2 ± 1.0
		40	44 ± 10	0.7 ± 0.2

Inoculating VA-mycorrhizal fungi capable of increasing salt tolerance in plants will aid in developing new rangeland for animal production

from current vast expanses of wasteland. Eventually millions of hectares of the world's high-saline soil could be reclaimed for crop production.

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