Seeding Response and Soil Characteristics on Adjacent Sagebrush and Desert Molly Soils

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Vegetation of the shadscale and sagebrush zones in the Great Basin area commonly display a mosaic pattern. Vegetation of the sagebrush zone in northwestern Utah appears to be a homogeneous expanse of sagebrush *(Artemisia tridentata)* but close observation reveals the presence of islands of dense halogeton *(Halogeton glomeratus)* and a few desert molly *(Kochia vestita)* plants without sagebrush. Vestiges of root crowns indicate that these islands once supported mainly desert molly with an occasional winterfat *(Eurotia lanata)* plant.

Seeding experiments on these areas in northwestern Utah showed that areas formerly occupied by sagebrush supported dense stands of Russian thistle with a fair stand of crested wheatgrass following plowing and planting. However, the areas formerly occupied by desert molly and winterfat supported dense stands of halogeton with an extremely poor stand of grass following tillage and seeding (Figure 1).

At first it was believed that halogeton presented more competition for grass seedlings than Russian thistle because there was a poorer stand of grass where halogeton predominated. Later, established vegetation type lines showed that sagebrush and Russian thistle were restricted to certain areas and desert molly and halogeton to others.

These differential responses in areas lying adjacent to one another led to a study of some of the soil and moisture conditions favoring growth of various plant species in the two vegetation types. The study was conducted during 1957 and 1958. The precipitation was 12.6 inches during 1957 and 10.2 inches during 1958.

Methods and Procedures

Areas displaying sharp contrasts between pure stands of sagebrush, and mixtures of halogeton and desert molly were studied at three separate locations. Both sagebrush and desert molly areas were plowed and seeded to crested wheatgrass at each location, and compared to undisturbed vegetation in each case.

During the spring of 1958, while the soil was moist, bulk density was determined on both plowed and unplowed areas on both vegetation types. The bulk density samples were collected by use of steel cylinders 2 inches in diameter and 6 inches high. Twelve paired samples were taken, one on each side of the ecotone between types on both plowed and unplowed conditions. The top inch of soil was removed to eliminate trash, therefore, the core for determining bulk density included the soil 6 inches below the surface inch.

During the late summer of 1958, when the soil was dry, infiltration tests were made on each vegetation type and on both plowed and unplowed areas. The tests were made with steel cylinders 8 inches in diameter and 18 inches high. They were driven into the soil 4 inches. Twelve paired samples were taken on opposite sides of the ecotone between sagebrush and desert molly on both plowed and unplowed areas. One sample of each pair was taken on opposite sides of the ecotone.

Precisely 9000 cc of water were poured into each cylinder on a baffle plate to avoid disturbing the soil surface. The rate of infiltration was measured during the first three 5-minute intervals, during the next three 15-minute intervals, followed by

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three 30-minute intervals, and finally at 1-hour intervals until all of the water disappeared. Immediately after all water had soaked into the soil, the infiltrometers were removed and bisects were dug directly under them to determine maximum depth and maximum lateral spread of water.

Soil moisture was determined at 2 depths (0 to 8 inches and 8 to 16 inches) under both plowed and unplowed conditions on both vegetation types from early spring to fall in 1958. Nine paired soil cores were taken along the sides of the ecotone between the two vegetation types on both plowed and unplowed areas.

Six paired soil cores along the sides of the ecotone were collected at 2 depths (0-8 and 8-16 inches) from both plowed and unplowed areas from each vegetation type for chemical analyses.

Procedures used for chemical analyses are described by the U. S. Salinity Laboratory (1954). Methods used were as follows: for electrical conductivity, method 4 a; for soluble salts, method 5; for cation-exchange capacity, method 19; for pH, method 21a and 21b; and for sodium, method 10a.

Results and Discussion

Soil Description

Sagebrush: The surface soil (0-3 inches) is a silt loam, with a structure described as slightly vesicular, fine platy to massive. From 3 to 8 inches in depth the soil is a heavy silt loam with a weak fine platy structure, breaking into single grains. Below 8 inches the soil is a clay loam with weak large prismatic arrangement, breaking into single grains.

Desert molly: The surface soil (0-2 inches) is a silt loam with a vesicular weak fine platy to massive structure. From 2 to 6 inches in depth the soil is a silt loam with a weak fine platy arrangement. Below 6 inches it is a clay loam with a moderate to weak large prismatic structure, breaking into sub-angular blocks.

Bulk Density

Bulk density is an index to pore space to determine the air and water capacity of the soil. In this study it was expressed as weight of oven-dry soil (soil core) per unit of volume.

The sagebrush areas had significantly lower bulk density readings than the desert molly areas ($P<.05$). Plowing reduced the bulk density of the soils under sagebrush but had no pronounced effect on soils under desert molly (Table 1).

Infiltration

The sagebrush soils absorbed water significantly faster ($P<.05$) than the desert molly soils. Plowing doubled the rate of infiltration on sagebrush areas but decreased the rate by one-half on desert molly areas (Table 2).

The time required for 9000 cc of water to enter the soil varied widely. It averaged 185 minutes on unplowed sagebrush areas and 96 minutes on plowed sagebrush areas compared to desert molly areas which averaged 347 minutes on unplowed soil and 469 minutes on plowed. These differences between vegetation types and the interaction of plowing with vegetation types were statistically significant ($P<.05$). Thus, plowing sagebrush areas increased rate of infiltration but plowing desert molly areas decreased the rate of infiltration.

The water from the infiltrometers penetrated to a significantly greater depth on sagebrush areas but the wetted lateral spread was significantly greater on desert molly areas. This was true for both plowed and unplowed area (Table 3).

Soil Moisture

During early spring (March 21) the total moisture ranged from 13.3 to 15.5 percent in the surface 8 inches of soil and from 10.3 to 18.7 percent in the lower depth (8-16 inches). At this date soil moisture was higher in the 0 to 8 inch depth on the plowed sagebrush areas (Russian thistle) than on the unplowed sagebrush areas or on any of the desert molly areas, but at the 8 to 16 inch depth the soil mois-

FIGURE 1. Area in foreground is desert molly invaded by halogeton and in background big sagebrush. Both areas have been plowed on the right side of the figure and undisturbed on the left.

Table 1. Bulk density determinations on plowed and unplowed sagebrush and desert molly areas at two dates

Vegetation types	March 15	May 15	Averages
	(gms/cc)		
Unplowed			
Sagebrush	1.165	1.132	1.148
Desert molly	1.253	1.279	1.266
Plowed			
Sagebrush (Russian thistle)	1.148	0.985	1.066
Desert molly (Halogeton)	1.328	1.256	1.292

ture was higher on the unplowed desert molly areas.

During the summer the percent moisture decreased at both depths within both vegetation types under all conditions. By fall (September 1) the soil moisture had decreased to about 4.5 percent in the upper 8 inches of soil and to about 8 percent in the lower depth. The soil moisture at the lower depth was somewhat higher in both the plowed and unplowed sagebrush areas than in the desert molly areas.

Chemical Analysis of Soil

Soils from both vegetation types at both depths (0-8 and 8-16 inches) had rather high pH values and no significant differences were found among them (Table 4).

The amount of salt in the soil can be expressed by either percent total soluble salt or conductivity of the saturation extract. Conductivity of the saturation extract is a somewhat better estimate of the effect of total salts upon plant response than percent total soluble salt. Conductivity takes into account the salt-dilution effect in fine-textured soils due to their higher moisture retention and it is directly related to osmotic pressure.

The percentage of total soluble salts in desert molly soils was significantly higher ($P<.01$) than in sagebrush soils. This difference was more pronounced in the deeper soil depth (Table 4).

Soils were considered saline when the saturation extract conductivity exceeded 4 millimhos per cubic centimeter (U.S. Salinity Lab. 1954). Sagebrush soils were not saline at either depth but the desert molly soils were highly saline at both depths (Table 4).

Both the physical and chemical properties of the soil may be affected by the presence of exchangeable sodium. High sodium tends to cause deflocculation of the soil and thereby decreases aeration and permeability. High sodium content may decrease the availability of water and cause nutritional deficiencies in plants.

The soils were considered alkali when the percent exchangeable sodium was higher than 15 (U.S. Salinity Lab. 1954). Sagebrush soils were non-alkali in the surface 8 inches but they were alkali in the second 8 inch depth. The desert molly soils were highly alkali at both depths (Table 4).

The exchange cation capacity may be a result of many minerals and organic material, and is commonly expressed in milliequivalents of cations per 100 grams of soil that are held on the soil particles and are capable of being replaced by other cations. Calcium and magnesium are the main cations entering into the exchange complex of most soils in arid regions, but sodium frequently is the dominant cation on many desert ranges of the Great Basin Area. In these saline desert soils, most of the exchangeable calcium and magnesium may be replaced by sodium.

The base exchange capacity values for the desert molly soils were approximately the same for both depths but sagebrush soils had considerably higher values in the soil surface than at the 8 to 16 inch depth. The surface soils in both plowed and unplowed sagebrush areas had higher base exchange capacity than surface soils in the desert molly areas but the deeper soil depth in the unplowed sagebrush area had lower values than unplowed desert molly soil (Table 4).

The percent moisture at saturation was slightly higher in the surface soil layer than at lower depths for both plowed and unplowed sagebrush areas but percent moisture at saturation was considerably lower in the surface soil than at deeper

Table 2. Average infiltration rates during successive time periods on plowed and unplowed sagebrush and desert molly areas

	Unplowed area		Plowed area	
Time interval	Sagebrush	Desert molly	Sagebrush (Russian thistle)	Desert molly (Halogeton)
(minutes)	(Inches per hour)			
0- 5	5.38	3.25	10.75	2.13
5-10	2.75	1.88	5.50	.92
10-15	2.63	1.50	5.60	.80
15-30	2.38	1.21	4.33	.58
30-45	2.17	1.29	4.03	.58
45-60	2.08	1.09	3.95	.46
60-90	1.60	1.00	3.77	.38
90-120[1]	.83	.92	3.60	.47
Average	2.50	1.50	5.20	0.79

[1] Only two of the 30-minute intervals shown because the plowed sagebrush areas absorbed 9000 cc. of water in an average of 96 minutes.

Table 3. Maximum depth and lateral spread of water in soil following infiltration tests on unplowed and plowed sagebrush and desert molly areas[1]

Treatment and vegetation type	Measurement	Average
Unplowed area		(Inches)
Sagebrush	Depth	9.04
	Spread	12.88
Desert molly	Depth	8.83
	Spread	13.38
Plowed area		
Sagebrush	Depth	10.46
(Russian thistle)	Spread	12.42
Desert molly	Depth	7.08
(Halogeton)	Spread	13.21

[1] 9000 cc of water were used in 8" diameter infiltrometers. Measurements for total depth and spread were made immediately after the water disappeared from the infiltrometer.

depths in desert molly areas for both plowed and unplowed conditions.

There appeared to be little difference in lime content between the soils from the two vegetation types. Both soils from the two vegetation types were calcareous at both depths (Table 4).

Seeding Response

The average number of spring seedlings from 3 fall seedings of crested wheatgrass made in 3 separate years on plowed sagebrush and desert molly areas was 2.6 plants per square foot for sagebrush areas and 0.3 plants per square foot on desert molly areas. Average mortality of crested wheatgrass seedlings during the first growing season was 66.8 percent on sagebrush areas and 80.3 percent on desert molly areas. Three years after seeding, the crested wheatgrass plants were so sparse that it was necessary to measure the abundance of plants present in each area by distance between plants rather than plants per plot. This was accomplished by pacing along a transect and counting the steps between plants encountered along the line. A plant was recorded only when some part of the plant appeared within a square foot frame carried parallel to the ground at waist height and directly in front of the body. The average distance recorded between plants was 17.6 feet on sagebrush areas and 125.9 feet on desert molly areas.

Conclusions

The sagebrush soils studied had a somewhat better soil structure than desert molly soils and as a result had a lower bulk density and more rapid water infiltration.

Desert molly soils were higher in total soluble salts, exchangeable sodium, and saturation extract conductivity; therefore, sagebrush soils were considered better for seeding crested wheatgrass from the standpoint of salinity and alkalinity.

It was concluded that Russian thistle will not grow in saline-alkali soils of the nature of the desert molly soils observed in this investigation. However, Russian thistle successfully competed with halogeton in non-saline soils where the moisture supply was 10 inches or more annually. It was also concluded from this study that crested wheatgrass was not more susceptible to competition from halogeton than Russian thistle, but, rather, did not thrive on saline-alkali soils where halogeton predominated.

Summary

During 1957 and 1958 a study was conducted on semi-desert lands of northwestern Utah to determine some of the soil and moisture conditions favoring growth of various plant species

Table 4. Average chemical composition of soils collected from plowed and unplowed sagebrush and desert molly areas.

Treatment and vegetation type	Depth	pH Paste	pH 1:5	Total soluble salts	Sat. Ext. Cond.	Exch. Na	Exchangeable Na	Base Exch. Cap.	Moist. at Sat.	Lime[1] $CaCO_3$
	(inches)			(Percent)	$(Kx10^3)$	(Percent)		(Me/100g)	(Percent)	
Unplowed										
Sagebrush	0-8	7.9	8.6	.07	1.8	7.8	1.5	19.1	40	+
	8-16	8.1	9.0	.15	3.4	22.0	3.7	15.6	39	++
Desert molly	0-8	8.1	9.3	.48	8.3	35.0	6.5	18.5	36	++
	8-61	8.1	9.0	1.50	25.2	50.0	9.1	18.5	47	++
Plowed										
Sagebrush	0-8	8.1	9.0	.07	1.8	12.0	2.4	19.8	40	++
(Russian thistle)	8-16	8.3	9.3	.07	1.2	19.0	3.4	18.2	39	++
Desert molly	0-8	8.0	8.9	.94	24.0	34.0	6.2	18.1	38	++
(Halogeton)	8.16	8.0	8.7	2.00	35.0	43.0	7.7	17.8	46	++

[1] The relative amount of lime has been indicated by + or ++ depending upon the degree of effervescence when acid was added.

in adjacent sagebrush and desert molly types.

Bulk density determinations were significantly lower on big sagebrush areas than on desert molly areas and plowing reduced bulk density on sagebrush soils but had no effect on desert molly soils.

Sagebrush soils absorbed water significantly faster than desert molly soils and plowing doubled the rate on sagebrush areas but decreased it materially on desert molly areas.

Desert molly soils were saline-alkali at both surface and deeper depths and sagebrush soils were nonsaline-nonalkali at the surface, and nonsaline-alkali at deeper depths.

When plowed areas of sagebrush and desert molly were seeded to crested wheatgrass, poor stands were obtained on desert molly areas and fair stands on sagebrush areas.

It was concluded that Russian thistle would not grow in saline-alkali soils found on desert molly areas and that Russian thistle successfully competed with halogeton in non-saline soils where moisture was adequate. It was also concluded that crested wheatgrass would not produce satisfactory stands on desert molly areas because of the high content of salts in the soil.

LITERATURE CITED

U. S. SALINITY LABORATORY. 1954. Diagnosis and Improvement of Saline and Alkali Soil. U. S. Department Agr. Handbook 60.