ɪted From The Journal of
: Management, Volume 15,
er 4, July, 1962.

6-54

uence of Soil Salinity and 2, 4-D Treatments ɜstablishment of Desert Wheatgrass and ɪtrol of Halogeton and Other Annual Weeds[1]

ROBERT H. HAAS, HOWARD L. MORTON AND PAUL J. TORELL

Assistant Professor, Texas Agricultural Experiment Station, Research Agronomist, ARS, U.S. Department of Agriculture, College Station, Texas and Assistant Agronomist, Idaho Agricultural Experiment Station[2].

:ert wheatgrass, (*Agropyron torum* (Fisch.) Schult.), ɪeen established on many ands of acres of rangeland he control of halogeton, *geton glomeratus* C. A. , which has become wideɪ in the western states. ous stands of desert wheat- have not only suppressed eton growth and greatly re- . the hazard of livestock ɪing, but they have also in-:d range productivity. How- in areas where saline or -alkaline soils are prevamany sites within desert :grass plantings, and in instances entire plantings, failed to produce a satisfactand of grass. Here halogeɪnd other annual weeds : on a disturbed site free of ɜtition from perennial ɜtion.

Erickson *et al.* (1952) and Tisdale and Zappetini (1953) have reported that some halogeton-infested sites have failed to support vigorous stands of grass. Tisdale and Zappetini (1953) concluded that the high salt content of the soil and the presence of vigorous stands of halogeton seemed responsible for increased seedling mortality of desert wheatgrass. Miller (1956) concluded that if sufficient grass is present, halogeton will be scanty or absent. However, these studies failed to segregate the effects of salinity from the effects of annual weed competition on the establishment of the grass seedlings.

Soil salinity data in reference to the distribution of native shrub vegetation have been reported by Billings (1949), Fautin (1946), Gates *et al.* (1956), Shantz (1938), Shantz (1940), and Stewart *et al.* (1940), but none of these investigators have given information regarding the effect of soil salinity on the establishment of perennial vegetation under arid conditions. However, available information indicates that soil salinity predominately influences plant-water relationships. Eaton (1941) showed that osmotic pressure, rather than specific ion effect, is primarily involved in water uptake. Wadleigh and Ayers (1945) found that similar effects were produced on plants regardless of whether water stress was due to osmotic forces or to moisture tension. Furthermore, Magistad *et al.* (1943) found that sodium was not an unduly toxic ion.

Since both soil salinity and weedy vegetation were suspected of influencing the establishment and growth of desert wheatgrass, a study was initiated in 1954 to determine: (1) the amount of soil salinity which desert wheatgrass will tolerate during the establishment period, (2) the influence of soil salinity on the abundance and floristic composition of annual weed populations, (3) the influence of annual weeds on the establishment of desert wheatgrass under saline and non-saline conditions, and (4) the influence of soil salinity and annual weeds on the forage yield of desert wheatgrass.

Materials and Methods

A study site was selected in the Raft River Valley, Cassia county, Idaho, on a soil type tentatively classified as Idahome silt loam. Before plowing in September 1954, the land was producing a dense, vigorous stand of big sagebrush, (*Artemisia tridentata* Nutt.), on the study area. Only scattered, broadleaved annuals grew among the brush. Analyses of the soil at the study site revealed that the soil was uniformly non-saline.

Sodium chloride was added to the non-saline soil at rates of 0, 20, 40 and 80 pounds per 1.5-square-rod plot. The resulting salinity levels will be referred to as "control," "low," "moderate," and "high," respectively. The salinization treatments were

ɜrative investigations of the Agricultural Experiment Staɪnd the Crops Research Divi-Agricultural Research Service, Department of Agriculture. ɜhed with the approval of the tor of the Idaho Agricultural ·iment Station as Research · No. 533.

ɜnd Morton were formerly Reɪ Agronomist, Crops Research on, ARS, U.S. Dept. of Agri-·e and Assistant Agronomist, laho Agricultural Experiment n, respectively.

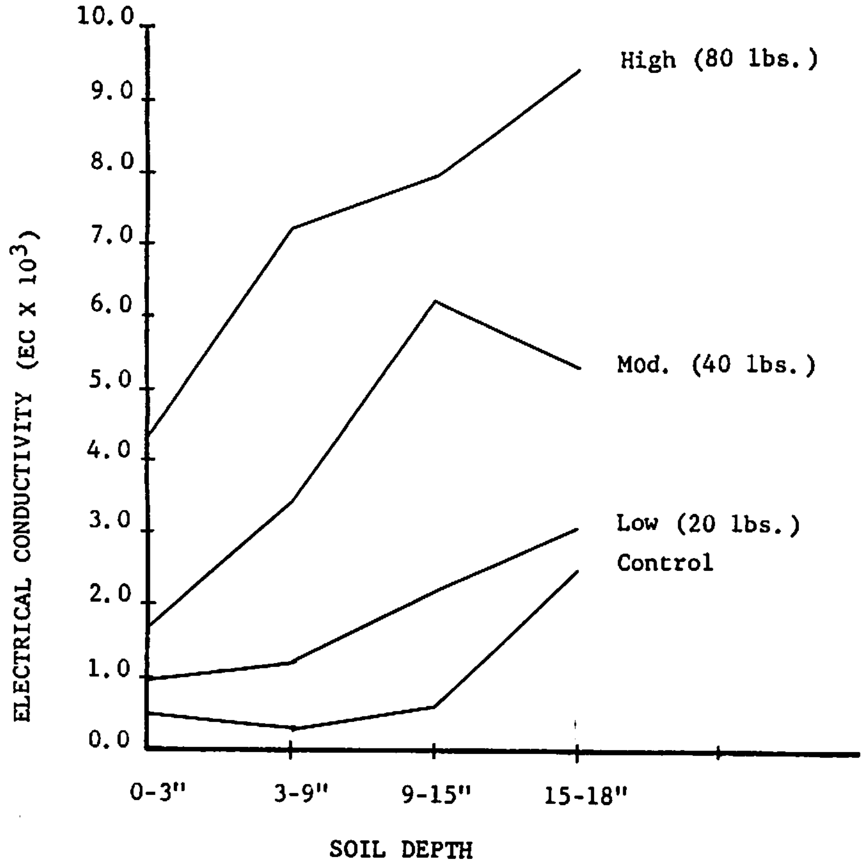

FIGURE 1. Electrical conductivity (EC X 10^3) of soils treated with 0, 20, 40, and 80 pounds of NaCl per 1.5 square rods. Samples collected July 1956.

made in a split application with half of the material applied in the fall of 1954 and half in the fall of 1955. The treatments were arranged in a 4 x 4 Latin-square design. The study area was uniformly seeded by drilling with standard desert wheatgrass at the rate of 8 pounds per acre in November 1955.

To study the influence of annual weed control on the establishment of desert wheatgrass, each salinity plot was subdivided into three one-half square-rod sub-plots. One subplot was sprayed with 2,4-dichlorophenoxyacetic acid (2,4-D) on June 12, 1956, the second was sprayed on July 9, 1956, and the third was left unsprayed.

Annual weeds and desert wheatgrass plants were counted on each plot prior to the early application of 2,4-D. Weed and grass plants were counted again in July 1957 and 1958. Ground cover data for both weeds and desert wheatgrass were also taken in July 1957 and 1959. The ground cover measurements were recorded from random samples taken on each plot. Foliage cover was measured for each annual weed species, but the crown area of desert wheatgrass was measured on plants which had been clipped 1.5 inches above the soil surface.

The air-dry forage yields of desert wheatgrass plants were measured in July 1958 and 1959 on plants clipped 1.5 inches above the soil surface. The 1958 yield data were collected from random samples taken from within each plot, but the 1959 data were collected from the entire plot area.

Soil samples were collected from all plots at four soil depths (0-3, 3-9, 9-15, and 15-18 inches) in July 1956 and 1959. The soils were analyzed for pH, electrical conductivity, and moisture percentage. Soil pH was recorded on the saturated soil paste and electrical conductivity readings were taken from the saturated soil extract. Both pH and electrical conductivity readings were made according to procedures outlined in Agricultural Handbook 60 (1954).

Monthly precipitation was recorded at the study site from October through September throughout the duration of the study. These data are compared with the 9-year precipitation record from Malta, Idaho.

Results and Discussion

Soil Salinity and Soil Moisture

Analyses of the soil samples collected in 1956 revealed that the salinity levels ranged from non-saline on the untreated check to moderately high salinity with the high salt application (Figure 1). It is apparent from the electrical conductivity data taken in 1959 that during the course of the study the salts leached from the surface 9 inches of soil into the lower soil horizons (Figure 2). According to information published by the U.S. Salinity Laboratory (1954), it may be concluded that the level of salinity in the lower horizons is sufficient to permit growth of only salt-tolerant species. The moderate salinity level is within the range that restricts the growth of many crop plants and the low salinity level is only slightly more saline than the non-saline control.

The soil pH measurements recorded in both 1956 and 1959 indicate that the soil alkalinity was not significantly changed at any soil depth by the sodium chloride treatments. The soil reaction was variable at all salinity levels; ranging from pH 7.8 to 8.3.

The total precipitation for each of the years, 1955-56, 1956-57, 1957-58 and 1958-59, was 8.4, 11.5, 8.1 and 8.3 inches, respectively. Although 1956, 1958, and 1959 precipitation totals are similar and approach the 9-year mean of 9 inches for this area, the distribution of precipitation in the

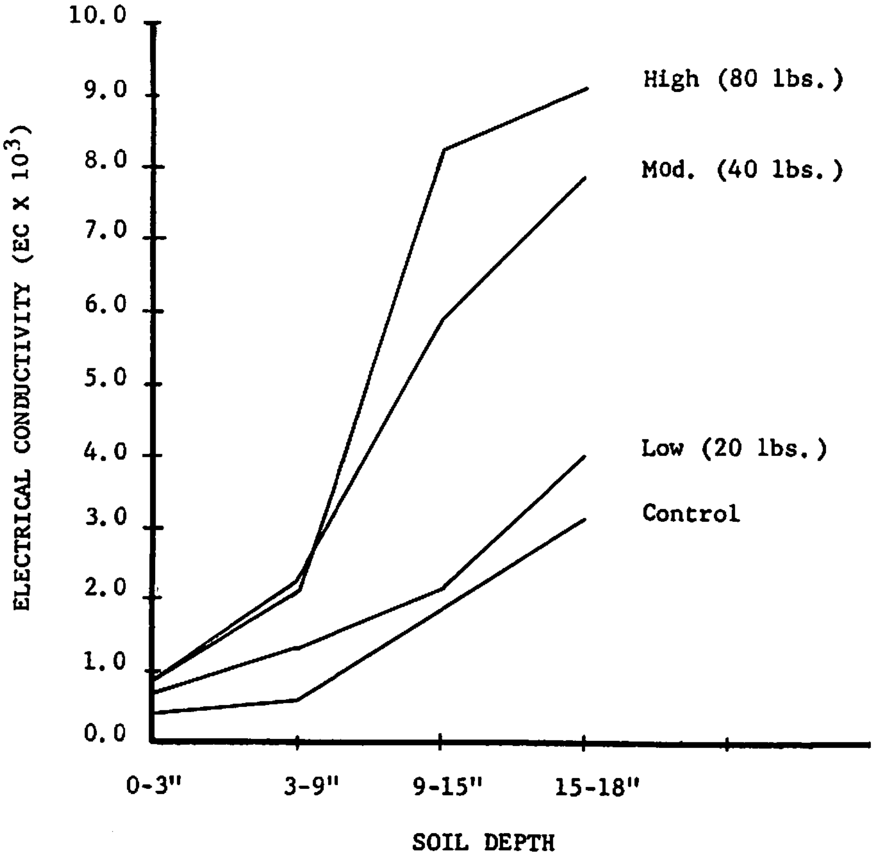

FIGURE 2. Electrical conductivity (EC X 10^3) of soils treated with 0, 20, 40, and 80 pounds of NaCl per 1.5 square rod. Samples collected July 1959.

spring in 1956 was much more favorable for plant growth than during this period in 1958 or 1959. Moisture contents of soil samples collected in July 1956 varied from 3.1 to 4.8. Those collected in July 1959 varied from 3.6 to 3.9 percent. The low soil moisture in early July indicates that essentially all available soil moisture is depleted at this time. Usually, the soil moisture is only replenished by late fall or winter rain and snow.

Weed and Grass Populations

The effects of soil salinity on desert wheatgrass, halogeton Russian thistle, (*Salsola kali* L.), and other annual weeds for 1956, 1957, and 1958 are shown in Table 1. During the establishment year, more than twice as many desert wheatgrass plants were present on the non-saline plots than on the high salinity plots. In 1957, desert wheatgrass numbers decreased to about one-third of the original stand with a greater percentage decrease occurring with each increased level of salinity. Desert wheatgrass populations continued to decline into the third growing season with greater declines continuing with increased salinity.

In 1957, the numbers of halogeton plants were found to increase as the salinity levels increased. Conversely, the numbers of Russian thistle plants decreased as the salinity levels increased. In 1958, halogeton and Russian thistle populations were reduced at all salinity levels, but population trends of these two species were the same as in 1957. These trends indicate that increased soil salinity is more favorable for the growth of halogeton than for Russian thistle or desert wheatgrass.

Although other annual plants were present in 1956 and 1957, dense stands of clasping-leaved peppergrass, (*Lepidium perfoliatum* L.), and flixweed, (*Descurainia sophia* (L.) Webb.), were present in 1958. More abundant populations of peppergrass and flixweed were noted at each increased level of salinity. Possibly the occurrence of these winter annual weeds was responsible for the decreased Russian thistle populations in 1958.

The two 2,4-D treatments applied in 1956 were timed to coincide with the optimum and the latest spraying dates for obtaining a satisfactory kill of halogeton and Russian thistle (Morton *et al.* 1959.) Treatments applied in June 1956 completely controlled all annual weeds dur-

Table 1. Desert wheatgrass, halogeton, Russian thistle, and other annual plants per square foot as affected by salinity levels.[1]

Plant and year	Control	Low	Moderate	High	Average
Desert wheatgrass:					
1956	13.0	10.4	9.7	6.2	9.8
1957	4.9	3.0	2.5	1.6	3.1
1958	3.5	2.9	1.9	0.8	2.3
Halogeton:					
1956	11.5	27.8	50.2	38.8	32.0
1957	10.1	16.3	34.3	38.8	24.8
1958	2.2	8.0	12.2	24.4	11.7
Russian thistle:					
1956	48.1	41.6	21.8	36.8	37.1
1957	8.9	6.6	4.4	2.5	5.6
1958	1.1	0.3	0.2	0.5	0.6
Other annuals:					
1956	1.2	1.3	0.2	0.2	0.7
1957	1.2	1.1	0.8	0.3	0.9
1958	4.0	9.0	20.1	16.4	12.4

[1]Desert wheatgrass was planted November 1955.

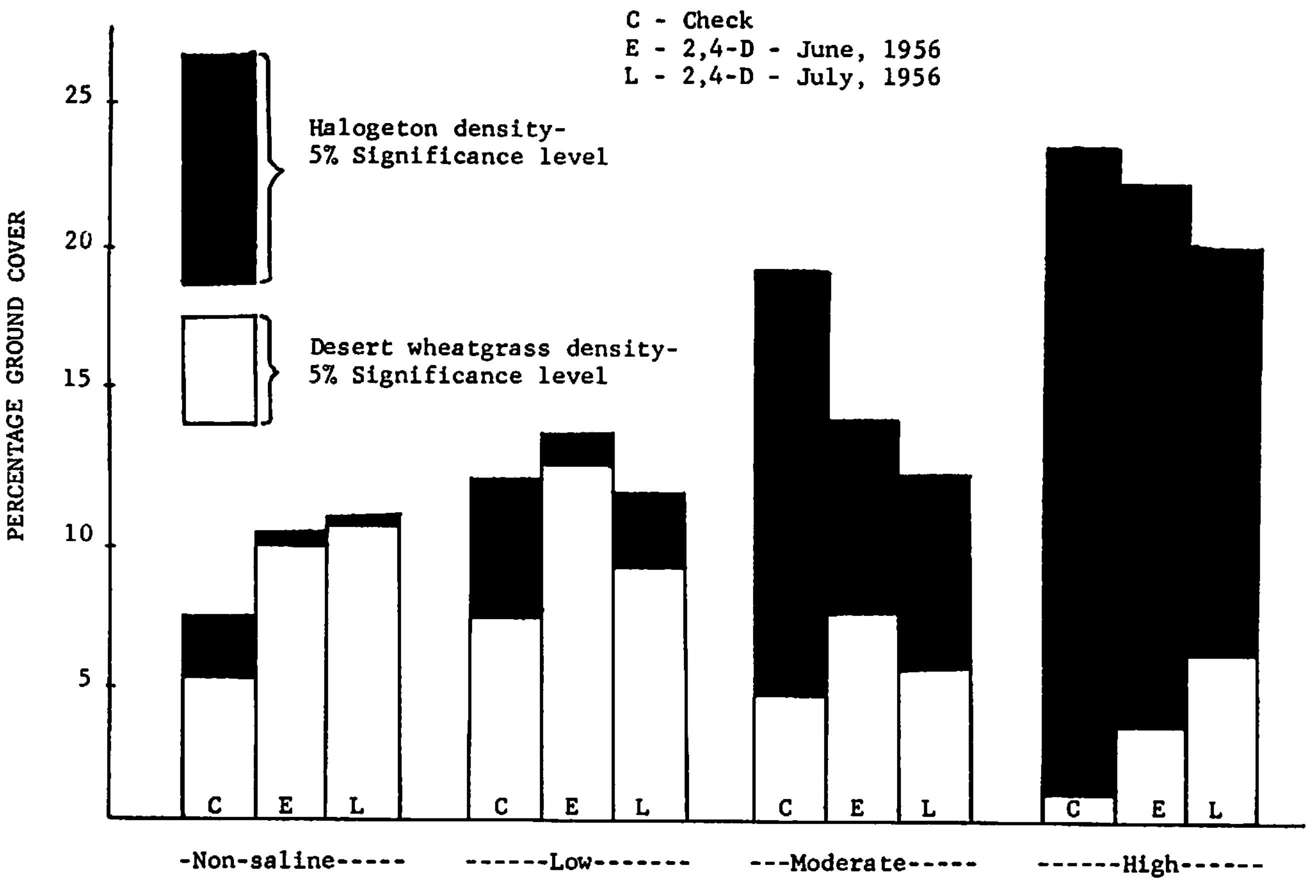

FIGURE 3. Halogeton density and desert wheatgrass density compared at several levels of soil salinity in 1959.

ing the 1956 growing season. July treatments gave approximately 85 percent control of halogeton and Russian thistle.

Table 2 shows the effect of the 1956 2,4-D treatments on the total annual weed populations in 1957 and 1958. In addition to halogeton and Russian thistle, clasping-leaved peppergrass and flixweed are included in the total annual weeds. In 1957, the annual weed populations in the early 2,4-D treatments were about one-tenth as great as those on the unsprayed check. However, by 1958 the annual weeds had increased on all sprayed plots and were not significantly less than on the unsprayed treatment regardless of the level of salinity.

Halogeton and Desert Wheatgrass Ground Cover

In addition to being the most abundant weed, halogeton was also the most persistent weed throughout the study. On the unsprayed plots, halogeton cover was greater at each increased salinity level and did not change greatly from 1957 to 1959. (Table 3). On sprayed plots, halogeton appeared to increase at the highest level of salinity and to decrease at the lower levels; however, these differences are not statistically significant.

Table 4 shows the effect of soil salinity and 2,4-D treatments on the percent ground cover of desert wheatgrass in 1957 and 1959. Only the differences due to soil salinity were significant in 1957. In 1959, the average desert wheatgrass cover on the sprayed plots was nearly double

Table 2. Broad-leaved weeds per square foot as affected by soil salinity level and treatment with 2,4-D.

2,4-D treatment and year	Control	Low	Moderate	High	Average
Check (unsprayed):					
1957	20.2	24.0	39.4	41.6	31.3
1958	6.3	17.3	32.5	41.3	24.4
Early spray[1]:					
1957	2.1	2.4	4.0	4.6	3.3
1958	7.9	3.7	18.3	33.9	16.0
Late spray[2]:					
1957	2.6	5.6	7.4	6.9	5.6
1958	8.1	10.0	23.4	38.9	20.1
Average:					
1957	8.3	10.7	16.9	17.7	13.4
1958	7.4	10.3	24.7	38.0	20.1

[1] 2,4-D at 2 lbs./A. on June 12, 1956.
[2] 2,4-D at 2 lbs./A on July 9, 1956.

Table 3. Ground cover of halogeton in the first and third years after establishment as influenced by soil salinity and 2,4-D treatments.

Salinity Level	Unsprayed		Sprayed on June 12, 1956		Sprayed on July 9, 1956		Average	
	1957	1959	1957	1959	1957	1959	1957	1959
	(Percent)							
Control	4.6	1.9	0.6	0.4	0.4	0.1	1.9	0.8
Low salinity	7.1	4.6	2.0	1.1	3.5	2.4	4.2	2.7
Moderate salinity	19.2	14.7	4.8	6.6	7.5	6.6	10.5	9.3
High salinity	25.5	22.6	5.1	18.9	9.1	14.1	13.2	18.5
Average	14.1	11.0	3.1	6.7	5.1	5.8	7.4	7.8

5% L.S.D. for salinity means: 1957—4.1 percent; 1959—7.6 percent

5% L.S.D. for spraying treatment means: 1957—3.5 percent; 1959—N. S.

that of unsprayed plots. This increase was highly significant. Thus, the removal of the weedy vegetation during the establishment year and the subsequent reduction of weeds in the second year permitted the development of more vigorous desert wheatgrass plants on sprayed plots.

Covariance analyses indicated that the ground cover for halogeton in 1959 was inversely related to the desert wheatgrass cover. In 1959, desert-wheatgrass-stand differences accounted for more than 90 percent of the variation in halogeton cover on sprayed vs. unsprayed plots. However, when the influence of desert wheatgrass cover was removed, a significantly greater halogeton cover remained on the higher levels of soil salinity. These relations indicate that halogeton will persist in established desert wheatgrass stands at a level inversely proportionate to the density of the grass stand, but a relatively greater halogeton cover can be expected with increased soil salinity. The relation of halogeton to desert wheatgrass at the various salinity levels is shown graphically in Figure 3.

Desert Wheatgrass Yields

Desert wheatgrass yields for 1958 and 1959 are contained in Table 5. Soil salinity was a major factor in reducing yields in both years as forage yields were inversely correlated with the mean soluble salts in the soil. Decreased yields due to increased soil salinity were associated with both stand reductions and lower yields from individual grass plants. Desert wheatgrass yields were decreased approximately 58 and 77 pounds per acre for each 0.1 percent increase in soluble salts in 1958 and 1959, respectively.

In 1959, the yields of desert wheatgrass were significantly greater on plots which had been sprayed with 2,4-D. Since there were no significant differences in halogeton or other annual weeds on sprayed and unsprayed plots in 1958 or 1959, it is evident that the yield differences were not caused by current weed competition. Therefore, the significant yield differences on sprayed and unsprayed plots must be ascribed to the vigor of the grass stand during the year of establishment. These yield differences indicate that favorable establishment conditions have a long-term influence on the yield potential of desert wheatgrass plantings.

The pronounced influence of soil salinity on establishment and productivity of desert wheatgrass indicates the hazard of attempting to establish this grass on saline sites. The results of this study also suggest the possibility of utilizing soil analyses for determining the desirability of marginal sites for desert wheatgrass plantings.

Summary

The effects of soil salinity and the control of annual weeds on the establishment of desert wheatgrass were studied on artificially salinized plots. Four soil salinity levels were created on a medium-textured soil by adding sodium chloride at rates of 0, 20, 40 and 80 pounds per 1.5 square rods before seeding desert wheatgrass. The salinity conditions ranged from non-saline to a salinity level which would permit growth of only salt-tolerant species. The pH of the soil was unchanged at the several levels of salinity.

Halogeton was more tolerant to soil salinity than Russian thistle or desert wheatgrass. Russian thistle was more readily

Table 4. Ground cover (crown area) of desert wheatgrass in the first and third years after establishment as influenced by soil salinity and 2,4-D treatments.

Salinity level	Unsprayed		Sprayed on June 12, 1956		Sprayed on July 9, 1956		Average	
	1957	1959	1957	1959	1957	1959	1957	1959
	(Percent)							
Control	5.2	5.2	4.0	9.6	5.0	10.4	4.7	8.4
Low salinity	2.3	7.2	6.9	12.4	2.3	8.9	3.8	9.5
Moderate salinity	1.9	4.5	1.8	7.3	1.4	5.4	1.7	5.7
High salinity	1.0	0.8	1.9	3.3	1.9	5.9	1.6	3.4
Average	2.6	4.4	3.6	8.1	2.7	7.7	3.0	6.7

5% L.S.D. for salinity means: 1957—1.0 percent; 1959—1.4 percent

5% L.S.D. for spraying treatment means: 1957—N. S.; 1959—0.6 percent

Table 5. Air-dry desert wheatgrass forage per acre in the second and third years after establishment as influenced by soil salinity and 2,4-D treatments.

Salinity level	Unsprayed		Sprayed on June 12, 1956		Sprayed on July 9, 1956		Average	
	1958	1959	1958	1959	1958	1959	1958	1959
	(Pounds)							
Control	470	640	442	606	427	633	446	626
Low salinity	333	521	511	576	381	570	408	556
Moderate salinity	247	439	355	478	361	458	321	458
High salinity	101	249	241	365	229	367	190	327
Average	287	462	387	506	349	507	341	492

5% L.S.D. for salinity means: 1958—88 lbs./A.
1959—76 lbs./A.

5% L.S.D. for spraying treatment means: 1958—N. S.
1959—40 lbs./A.

suppressed by competing vegetation than was halogeton.

In the fourth growing season, halogeton occurred in inverse proportion with desert wheatgrass; but, when the influence of the grass density was removed, significantly more halogeton occurred at the higher salinity levels.

The removal of annual weeds by the use of 2,4-D in the establishment year did not significantly increase the number of desert wheatgrass plants established in 1957; however, two years later the ground cover of desert wheatgrass on the sprayed plots was more than twice that of plants on the unsprayed plot and the yield of desert wheatgrass was significantly greater on sprayed than on unsprayed plots. These results indicate that the favorable establishment conditions had a long-term influence on the yield potential of this desert wheatgrass planting.

Decreased desert wheatgrass yields due to increased soil salinity were attributed to both stand reduction and lower yields per individual grass plant. Desert wheatgrass yields were decreased approximately 58 and 77 pounds per acre for each 0.1 percent increase in soluble salts in 1958 and 1959, respectively. This study showed the pronounced influence of soil salinity on the establishment of desert wheatgrass and indicated the hazard of attempting to establish this grass on saline sites.

LITERATURE CITED

BILLINGS, W. D. 1949. The shadscale vegetation zone of Nevada and eastern California in relation to climate and soils. Amer. Midland Nat. 42:87-109.

EATON, F. M. 1941. Water uptake and root growth as influenced by inequalities in the concentration of the substrate. Plant Physiol. 16:-545-564.

ERICKSON, L. C., H. L. MORTON, E. W. TISDALE AND G. ZAPPETINI. 1952. The present status of the halogeton problem. Weeds 1:321-328.

FAUTIN, R. W. 1946. Biotic communities of the northern desert shrub. Ecol. Mono. 16:251-310.

GATES, D. H., L. A. STODDART, AND C. W. COOK. 1956. Soil as a factor influencing plant distribution on salt-deserts of Utah. Ecol. Mono. 26:155-175.

MAGISTAD, O. C., A. D. AYERS, C. H. WADLEIGH, AND H. G. GAUCH. 1943. The effect of salt concentration, kind of salt, and climate on plant growth in sand cultures. Plant Physiol. 18:151-166.

MILLER, R. K. 1956. Control of halogeton in Nevada by range seedings and herbicides. Jour. Range Mangt. 9:227-229.

MORTON, H. L., R. H. HAAS, AND L. C. ERICKSON. 1959. Halogeton and its control. Ida. Agr. Expt. Sta. Bull. No. 309.

SHANTZ, H. L. 1938. Plants as soil indicators. U.S. Dept. of Agr. Yearbook, *Soils and Men.* Pp. 835-860.

SHANTZ, H. L., AND R. L. PIEMEISEL. 1940. Types of vegetation in Escalante Valley, Utah, as indicators of soil conditions. U.S. Dept. Agr. Tech. Bull. No. 173.

STEWART, G., W. P. COTTAM, AND S. S. HUTCHINGS. 1940. Influence of unrestricted grazing on northern salt desert plant associations in western Utah. Jour. Agr. Res. 60: 289-316.

TISDALE, E. W., AND G. ZAPPETINI. 1953. Halogeton studies on Idaho ranges. Jour. Range Mangt. 6:225-236.

UNITED STATES SALINITY LABORATORY STAFF. 1954. Diagnosis and improvement of saline and alkali soils. U.S. Dept. of Agr. Handbook 60.

WADLEIGH, C. H., AND A. D. AYERS. 1945. Growth and biochemical composition of bean plants as conditioned by soil moisture tension and salt concentration. Plant Physiol. 20:106-132.