Emergence and Growth of Annual and Perennial Grasses and Forbs in Soils Altered by Halogeton Leachate[1]

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Competition, as it influences plant distribution, is an integral part of community ecology. However, competition for factors of the environment is not the only effect one plant has upon another. Some plants, for instance, chemically alter the environment, usually the soil, so that many species of plants cannot become established, or if they are present, growth is impaired.

Several workers have found growth-inhibiting substances in various plants. Muller (1953) extracted growth-inhibitors from *Franseria dumosa* and *Encelia farinosa*. The former plant harbors shrub-dependent herbs while the latter does not normally do so. Muller suggests that *Franseria* creates an environment where microflora can flourish and destroy the toxin. Toxic organic substances have been found in other plants (Bonner and Galston, 1944; Gray and Bonner, 1948; Kommedahl *et al.*, 1958, 1959; Bennet and Bonner, 1953; Woods, 1960; and Nord and Van Atta, 1960).

Bonner (1950) stated that association or non-association of different species is, in some instances, the result of specific chemical compounds secreted by one of them. Muller (1953), however, concluded that inhibiting organic toxins are ineffective in nature presumably because they are broken down by soil microflora or absorbed by soil colloids and are not accumulated.

Inorganic substances, such as salts, would not be broken down by microflora but may concentrate in sufficient quantities to inhibit growth. The influence of inorganic substances on inhibition of germination and growth has received considerable attention in the field of irrigated crops but little study in the salt-desert-shrub vegetation type. Gates *et al.* (1956) suggest that inhibiting substances could be functional in the maintenance of pure stands of various species on the salt-deserts of Utah. Others have found that extracts of halogeton residues impaired germination and growth of plants (Smith and Rauchfuss, 1958; and Haas, 1957). Eckert and Kinsinger (1960) have shown that leachate from halogeton may alter the chemical and physical properties of 3 soils supporting salt-desert-shrub vegetation. Sodium from halogeton mulch leached into the soil was found to be most influential in causing decreased permeability and capillary rise of water, and increased crusting strength of the soils.

Since sodium from halogeton can alter the chemical and physical properties of soil, information is needed concerning the effect of altered soils on the emergence of various species of grasses and forbs. The data obtained may be useful as a basis for recommending species for revegetating halogeton infested areas and for determining what successional stages may be expected on soils altered by halogeton.

The objective of the study described was to evaluate the emergence of grasses and forbs in soil altered by leachate from halogeton. No attempt was made to evaluate the effects of limited soil moisture, soil crusting, and competition on the germination, emergence, and establishment of species. All of these factors would need to be considered, together with chemical properties of soil, to explain success or failure of seeding made under field conditions.

Procedure

The surface 5 inches of 3 salt-desert soils was sampled. The soils were supporting relatively pure stands of whitesage (*Eurotia lanata*), shadscale (*Atriplex confertifolia*), and saltsage (*Atriplex nuttallii*) when collected in the field. For brevity in the text and tables, soil supporting these vegetation types will be referred to as whitesage, shadscale, and saltsage soils, respectively. Finely ground halogeton mulch was placed on the surface of the soils contained in 6-inch clay pots. The depths of halogeton mulch added were none (0), 1, and 3 inches, equivalent to none (0), 27,000, and 95,000 pounds of air-dry mulch per acre.[3] Water was poured through the halogeton-soil system. The effluent was collected in aluminum dishes and poured back into the pots so that the soil would become thoroughly impregnated with any water-soluble inhibitor present in halogeton. The treatment combinations (soil and mulch depths) were compared in a randomized-block factorial design with 3 replications.

After leaching, the mulch was

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[3] *Air-dry yields of halogeton in 1959 ranged from 800 to 10,000 pounds per acre depending upon the site.*

removed, the soil in each pot was dried, ground and thoroughly mixed, and 1.75 pounds placed in 8-inch aluminum dishes for emergence trials. Chemical analyses of the 3 soils after treatment are presented in Table 1.

Species selected for planting in the treated soils included some which were known to be drought-tolerant and salt-tolerant, or which might invade denuded areas in the salt-desert type. Other species were included to determine their response to the treated soils. The 12 grasses and 4 forbs included in the study were: tall wheatgrass *(Agropyron elongatum)*, crested wheatgrass *(A. desertorum)*, intermediate wheatgrass *(A. intermedium)*, pubescent wheatgrass *(A. trichophorum)*, Russian wildrye *(Elymus junceus)*, medusa-head wildrye *(E. caput-medusae)*, rye *(Secale cereale)*, Pampean brome *(Bromus brevis)*, cheatgrass *(B. tectorum)*, Indian ricegrass *(Oryzopsis hymenoides)*, bulbous bluegrass *(Poa bulbosa)*, barley *(Hordeum vulgare)*, bassia *(Bassia hyssopifolia)*, halogeton, yellow sweetclover *(Melilotus officinalis)*, and Russian thistle *(Salsola kali)*.

One hundred seeds of each species were planted in an aluminum dish. After 2 weeks, the number and the average height of the seedlings in each dish were recorded. During this time the soil was kept moist to minimize the effects of limited soil moisture and soil crusting. The number emerged was coded based on 100 percent emergence in the control (no mulch). All data were analyzed statistically. Duncan's multiple range test (Duncan, 1955) was used to compare treatment main effects and interactions.

Table 1. Chemical characteristics of 3 soils as affected by depth of halogeton mulch.

Soil characteristic	Whitesage soil 0	Whitesage soil 1	Whitesage soil 3	Saltsage soil 0	Saltsage soil 1	Saltsage soil 3	Shadscale soil 0	Shadscale soil 1	Shadscale soil 3
	(Depth of mulch in inches)								
pH	8.1	8.2	9.2	8.2	8.3	8.8	8.2	8.2	9.2
Conductivity ($E.C.x10^3$)	0.76	2.90	18.50	0.76	2.75	17.00	0.80	2.50	13.00
Exchangeable cations (Me/100g):									
Sodium	0.39	4.66	10.71	0.42	5.43	13.57	0.53	3.13	10.17
Potassium	3.10	4.04	5.10	5.13	5.69	7.23	3.71	4.20	5.19
Soluble cations (Me/100g):									
Sodium	0.06	0.94	3.06	0.08	0.79	4.28	0.06	0.59	2.84
Potassium	0.04	0.05	0.14	0.05	0.07	0.17	0.04	0.05	0.11
Calcium	0.10	0.21	0.09	0.08	0.15	0.08	0.07	0.11	0.10
Magnesium	0.04	0.04	0.12	0.03	0.06	0.11	0.03	0.03	0.10

Results and Discussion

Emergence of grasses

Increased sodium and perhaps potassium in the soil (Table 1) were considered the primary cause of the effects measured. In soils altered by halogeton leachate, percent emergence of tall wheatgrass, Russian wildrye, and crested wheatgrass decreased least while emergence of pubescent wheatgrass and bulbous bluegrass decreased most. Intermediate wheatgrass, Indian ricegrass, and Pampean brome were intermediate in response (Table 2). Under ordinary circumstances tall wheatgrass would not be seeded in the salt-desert type due to lack of sufficient available moisture. Russian wildrye and crested wheatgrass, however, would be suitable for seeding halogeton-infested areas. None of the species included in the study could be recommended for seeding in soils that have

Table 2. Percent emergence of perennial and annual grasses and forbs as influenced by soil and various levels of halogeton mulch. The control (no mulch) was taken as 100 percent.

Species	Whitesage soil 1	Whitesage soil 3	Saltsage soil 1	Saltsage soil 3	Shadscale soil 1	Shadscale soil 3
	(Depth of mulch in inches)					
	(Percent)					
Perennial grasses						
Tall wheatgrass	95	58	98	54	92	54
Russian wildrye	89	13	100	26	87	28
Crested wheatgrass	85	12	90	9	106	23
Intermediate wheatgrass	72	4	80	11	95	3
Indian ricegrass	38	4	63	4	136	4
Pampean brome	63	3	79	5	87	3
Pubescent wheatgrass	52	5	68	4	47	10
Bulbous bluegrass	44	2	46	2	16	3
Annual grasses						
Barley	85	23	94	22	95	16
Rye	70	11	84	19	83	11
Medusa-head wildrye	79	3	65	12	55	3
Cheatgrass	52	2	73	5	84	2
Forbs						
Bassia	88	49	206	64	170	60
Halogeton	39	24	236	182	58	22
Yellow sweetclover	51	6	84	6	82	8
Russian thistle	54	25	193	80	70	53

been seriously altered by halogeton leachate (treated with 3 inches of mulch).

Cheatgrass or medusa-head wildrye may invade disturbed areas in the salt-desert type. One or the other may eventually occur in a successional stage with or following halogeton. Partially altered soils (treated with 1 inch of mulch) appear to be favorable for either species since the emergence of these 2 weedy annual grasses in the halogeton-treated soils was similar. Barley or rye may be used as replacement vegetation on halogeton-infested ranges since emergence of these cereal grasses was relatively high on partially altered soils. In fact, poisoned barley used for rodent control grew well in some halogeton areas. Under the heavy mulch treatment, emergence of all annual grasses was poor.

On soils treated with 1 inch of mulch, average emergence of perennial grasses was reduced 24 percent; with 3 inches, by 86 percent. The decrease was approximately the same for annual grasses (Table 2). All perennial species except pubescent wheatgrass and bulbous bluegrass maintained a relatively high percentage emergence on soils treated with 1 inch of halogeton mulch. However, on soils treated with 3 inches of mulch emergence of all species except tall wheatgrass was greatly reduced. Differences in the response of perennial grasses due to soils were not significant; however, some interesting trends were evident. Indian ricegrass and crested wheatgrass emerged better on the shadscale soil with 1 inch of mulch than on any other treated soil or the control. Emergence of Russian wildrye on the saltsage soil treated with 1 inch of mulch was the same as the control but decreased on the other 2 soils at the same mulch level. Emergence of annual species was similar on all 3 soils at each mulch level.

In addition to reducing total emergence, mulch treatment also increased the time required for emergence. In general, in relation to the time required for emergence in the control, emergence was 2 days later in the 1-inch treatment, 5 days later in the 3-inch treatment.

Emergence of forbs

Average percentage emergence for sweetclover, Russian thistle, bassia, and halogeton was 60, 86, 104, and 96 percent, respectively (Table 2). The reduction in sweetclover emergence was significantly greater than the other 3 forbs at the .05 level of probability. Average emergence of all forbs on whitesage, saltsage, and shadscale soils was 61, 120, and 77 percent, respectively.

In the whitesage and shadscale soils, emergence of forbs decreased with each increment of halogeton mulch; however, the decrease was not proportional for the 2 soils (Figure 1). On the shadscale soil, the decrease was 5 percent in the 1-inch mulch treatment, but on the whitesage soil the decrease was 42 percent in the same mulch treatment. Bassia was particularly outstanding on the shadscale soil with 170 percent emergence compared to the control. Emergence of all forbs on the saltsage soil increased to 180 percent with 1 inch of mulch compared to the control at 100 percent. Emergence of bassia, halogeton, and Russian thistle increased to 206, 236, and 193 percent of the control, respectively, on the saltsage soil treated with 1 inch of mulch. Average emergence of forbs was still about 83 percent with 3 inches of mulch on saltsage soil. Halogeton maintained a 182 percent emergence under the heaviest mulch treatment on the saltsage soil. Results indicate that of the 3 soils used in this study, the saltsage soil was the most favorable for germination and emergence of halogeton.

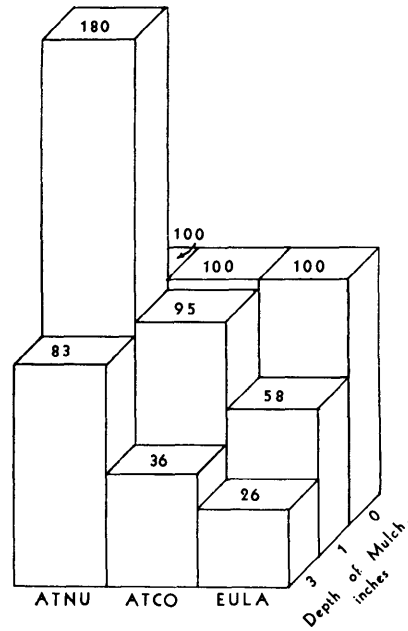

FIGURE 1. Percent emergence of forbs on soils supporting Nuttall's saltbush (ATNU), shadscale (ATCO), and whitesage (EULA) as influenced by 3 levels of halogeton mulch.

Height of grass seedlings

Grass species which emerged best in the treated soils were also those which attained greatest height in the 2-week growing period. Because of increased salt content of the treated soil, seedling height measured after 2 weeks is a reflection of retarded germination, emergence, and growth. The average height of perennial grasses was 4.2, 3.0, and 0.9 centimeters when depth of mulch was 0, 1, and 3 inches, respectively. For the annual grasses, heights were 6.2, 5.4, and 1.1 centimeters for the same mulch depths. Each added increment of mulch significantly reduced the height growth. This decrease was not as great on the saltsage soil as on the other 2 soils. Height growth of pubescent wheatgrass and bulbous bluegrass was most severely affected by the 1-inch mulch treatment. With 3 inches of mulch, the height growth of tall wheatgrass was least affected. For the annual grasses, 1 inch of mulch reduced height growth an average of 15 percent in all species. With 3 inches of mulch, cheatgrass was most severely retarded. Seedling heights averaged 2.5, 3.0, and 2.6 centimeters on the whitesage, saltsage, and shadscale soils, respectively.

Height of forb seedlings

Average heights after 2 weeks for sweetclover, Russian thistle, bassia, and halogeton were 0.9, 2.4, 1.1, and 1.0 centimeters, respectively. Average heights for the different levels of halogeton mulch were 1.8, 1.6, and 0.6 centimeters with 0, 1, and 3 inches of mulch, respectively.

The height of bassia increased with 1 inch of mulch. Height of bassia and halogeton decreased only slightly at the heaviest rate compared to no mulch, while the growth of sweetclover and Russian thistle was reduced substantially by the 3-inch mulch treatment. Height of sweetclover, bassia, and halogeton did not differ significantly on any of the soils. Russian thistle grew significantly better on the shadscale and whitesage soils than on the saltsage soil. Although percentage emergence of forbs was greatest on the saltsage soil, height growth of seedlings was not as great as on the other soils.

Summary and Conclusions

Soils which supported whitesage, shadscale, and saltsage vegetation types were treated with halogeton mulch under greenhouse conditions. Eight perennial grasses, 4 annual grasses, and 4 forbs were planted in the treated soil and the emergence and height of the seedlings were recorded after 2 weeks.

Sodium and perhaps potassium appear to be the water soluble materials responsible for reducing the emergence and growth of the species tested. One inch of mulch (27,000 pounds per acre air-dry weight) and three inches of mulch (95,000 pounds per acre air-dry weight) reduced the percent emergence and height growth of most perennial and annual grasses. One inch of mulch on the saltsage soil increased the percent emergence of all forbs except sweetclover and reduced slightly the height growth of all forbs. Under the 3-inch treatment percent emergence of tall wheatgrass, bassia, and Russian thistle was reduced about 45 percent while the emergence of halogeton was reduced an average of only 24 percent. On the saltsage soil treated with 3 inches of mulch the emergence of halogeton was 182 percent.

Results of the study indicate that soils altered by halogeton leachate are more favorable for halogeton and other low value or worthless forb species than for desirable grass species. Of the 3 soils used, the saltsage soil appears to be most favorable for germination and emergence of halogeton.

LITERATURE CITED

BENNET, EDWARD L., AND J. BONNER. 1953. Isolation of plant growth inhibitors from *Thamnosma montana.* Amer. Jour. Bot. 40:29-33.

BONNER, J. 1950. The role of toxic substances in the interactions of higher plants. Bot. Rev. 16:51-65.

________, AND S. W. GALSTON. 1944. Toxic substances from the culture media of guayule which may inhibit growth. Bot. Gaz. 106: 185-198.

DUNCAN, D. B. 1955. Multiple range and multiple F test. Biometrics 11:1-42.

ECKERT, RICHARD E. JR., AND FLOYD E. KINSINGER. 1960. Effects of *Halogeton glomeratus* leachate on chemical and physical characteristics of soils. Ecology 41:764-772.

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

GRAY, R., AND J. BONNER. 1948. An inhibitor of plant growth from the leaves of *Encelia farinosa.* Amer. Jour. Bot. 35:52-57.

HAAS, ROBERT H. 1957. Proceedings of the 1957 Halogeton Research Tour. Sept. 4-7. pp. 16-17.

KOMMEDAHL, THOR, JAMES E. DEVAY, AND CLYDE M. CHRISTENSEN. 1958. Factors affecting dormancy and seedling development in wild oats. Weeds 6:12-18.

________, J. B. KOTHEIMER, AND J. V. BERNARDINI. 1959. The effects of quackgrass on germination and seedling development of certain crop plants. Weeds 7:1-12.

MULLER, CORNELIUS H. 1953. The association of dessert annuals with shrubs. Amer. Jour. Bot. 40:53-60.

NORD, EAMOR C. AND GEORGE R. VAN-ATTA. 1960. Saponin—a seed germination inhibitor. Forest Science 6:350-353.

SMITH, DIXIE, AND FRANK RAUCHFUSS. 1958. Effects of aqueous extracts of halogeton tissue on germination of seeds and growth of seedlings. Jour. Range Mangt. 11:300-302.

WOODS, FRANK W. 1960. Biological antagonisms due to phytotoxic root exudates. Bot. Rev. 26:546-569.