Effects of Site and Season on Oxalate Content of Halogeton

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Introduction

The invasion of halogeton (*Halogeton glomeratus*) on range lands of the Intermountain West has done much to bring these lands into public attention. Large sums of money have been spent for study and control of this plant.

The soluble oxalates in this plant are toxic to livestock when consumed in large quantities over a short period of time. For this reason, a knowledge of the factors which affect the oxalate content is important. Therefore, a study was designed to determine the oxalate content of plants on various soils during different seasons of the year.

Study Areas

The sites on which halogeton was studied were located on salt desert areas in northwestern Utah (figure 1). All sites were on relatively flat bottomlands or low terraces developed from lake-laid sediments of old Lake Bonneville.

Six separate vegetation types were selected which were thought to have been formerly dominated, respectively, by greasewood (*Sarcobatus vermiculatus*), kochia (*Kochia vestita*), greasewood-kochia mixture, sagebrush (*Artemisia tridentata*), shadscale (*Atriplex confertifolia*), and winterfat (*Eurotia lanata*). These areas were almost devoid of the original native vegetation and, because of mismanagement, they supported vigorous stands of halogeton at the time of the study.

Methods and Procedures

Soil sampling: Trenches approximately 7.5 feet deep, 1.5 feet wide, and 20 to 25 feet long were excavated in each of the six areas. Soil samples were collected from each zone of the soil profile from each trench for chemical analysis.

Root studies: Root studies were made in the exposed sides of the open trenches. By use of an ice pick, root systems of halogeton were traced on both sides of the trenches. Detailed graphs were drawn for several halogeton plants showing lateral spread of the roots and depth of penetration. The trenches were dug about the first of August; therefore, halogeton plants were about five months of age.

Plant sampling: Beginning in August and continuing through April of the following spring, halogeton herbage was collected periodically near each trench. This material was air-dried and separated into two fractions, one containing the leaves and seeds, and the other the stems. These separate fractions were then analyzed for soluble oxalates.

To ascertain the effects of leaching by rain and melting

FIGURE 1. An experimental area heavily infested with halogeton.

[1] *Credit is given to David Williamson for chemical analysis of plant material and to James Thorne for chemical analysis of the soil.*

snow on the oxalate content of halogeton, a simulated leaching study was made. For this study, plant collections made on January 16 and February 27 were used. The leaf and seed fraction and the stem fraction each were divided into two portions. One was subjected to a leaching treatment and the other served as a control. To simulate leaching, the plant material was placed in a covered sieve and submerged in water for 30 minutes, then allowed to drain thoroughly. Later both samples were analyzed for oxalates.

Results and Discussion

Soil analysis:

Soils were considered saline when more than four millimhos per cubic centimeter were recorded as the saturation extract conductivity and, in like manner, soils were considered alkali when the percentage of exchangeable sodium was higher than 15 (table 1).

Greasewood and shadscale soils were both highly saline and highly alkali in the surface eight inches. The surface soils of kochia and greasewood-kochia areas were highly alkali, but only slightly saline. Sagebrush areas had surface soils that were non-alkali and only slightly saline. Winterfat areas had surface soils that were neither saline nor alkali.

All vegetation types had highly saline subsoils and all vegetation types had highly alkali subsoils except sagebrush, which was only slightly alkali.

There was a significant difference between vegetation types for exchangeable sodium content and base exchange capacity. A significant change with soil depth was found for all of the chemical factors analyzed. The variation with depth is largely the result of salts and colloidal clay material leached from the surface soil and accumulated in the subsoil.

Table 1. Average analysis of soils collected from two depths in halogeton-infested areas where formerly various native perennial vegetation grew[1].

Vegetation type	Total soluble salts, percent	Saturation extract conductivity[2]	Exchangeable sodium, me./100 g.	Base exchange capacity, me./100 g.	Percent exchangeable sodium
Greasewood-kochia					
Surface-soil[3]	0.2	6.9	4.9	16.0	31
Subsoil	2.1	29.0	9.5	11.5	83
Mean	1.2	18.0	7.2	13.8	52
			(0.7)	(—)	
Greasewood					
Surface-soil	0.9	19.6	7.8	22.8	34
Subsoil	1.3	22.0	8.9	18.0	49
Mean	1.1	20.8	8.4	20.4	41
			(3.5)	(15.2)	
Sagebrush					
Surface-soil	0 2	6.3	2.2	23.6	10
Subsoil	1.2	21.4	3.7	18.6	20
Mean	0.7	13.8	3.0	21.1	14
			(—)	(15.8)	
Shadscale					
Surface-soil	0.6	12.5	8.9	24.5	36
Subsoil	1.6	27.0	13.7	22.7	60
Mean	1.1	19.8	11.3	23.6	48
			(6.3)	(18.3)	
Kochia					
Surface-soil	0.3	8.6	7.8	25.6	30
Subsoil	1.0	16.1	11.1	28.8	39
Mean	0.6	12.4	9.4	27.2	34
			(4.4)	(21.8)	
Winterfat					
Surface-soil	0.5	1.4	0.8	19.2	4
Subsoil	1.1	22.4	5.7	17.0	34
Mean	0.8	11.9	3.2	18.1	18
			(—)	(12.0)	

[1]Figures in parenthesis represent the lower significant limit. Any mean lower than this value is significantly lower (at the .05 level) than the mean having this value (Duncan, 1955).

[2]The saturation extract conductivity is measured in millimeters per cubic centimeter, a unit of electrical charge. This is believed more meaningful than the total soluble salts percentage.

[3]Soil surface was 0 to 8 inches and subsoil was from 9 to 36 inches.

Since the halogeton plants appeared to be growing equally well on all areas studied, it appears that halogeton has a relatively wide range of tolerance to salt and sodium in the soil. The maximum tolerance was not determined.

Oxalate content of halogeton stems, and leaves and seed

The soluble oxalate content of halogeton leaves and seeds together varied from an average of 34.5 percent on January 16 to 20.4 percent on April 17 (table 2). The soluble oxalate content of halogeton stems varied from 5.2 percent in October to 3.8 percent in April.

Leaves and seeds combined appear to increase in soluble oxalates until mid-winter. However, seeds and seed bracts are relatively lower in oxalates than leaves, and some of this increase could have been a result of seed shattering during fall and early winter. The gradual decrease in

Table 2. Percent soluble oxalates, oven-dry basis, of halogeton collected from various range types during the non-growing season[1].

Date sample collected	Greasewood-kochia		Greasewood		Sagebrush		Shadscale		Kochia		Winterfat		Average	
	Leaves & seed	Stems	Leaves & seed	Stems	Leaves & seed	Stems	Leaves & seed	Stems	Leaves & seed	Stems	Leaves & seed	Stems	Leaves & seed	Stems
8/28/53	22.2	2.4	18.5	2.2	21.1	1.9	22.8	2.1	21.8	2.0	21.7	3.3	21.4 (19.0)	2.3 (....)
9/10/53	24.4	2.6	22.6	2.4	26.0	3.5	24.6	3.2	23.1	3.8	21.7	3.1	23.7 (21.2)	3.1 (1.1)
10/ 3/53	30.6	4.7	28.0	3.5	30.8	4.4	29.0	3.4	29.6	5.2	24.4	5.6	28.7 (26.0)	4.5 (2.2)
10/17/53	30.1	5.5	28.8	3.7	29.2	4.3	26.9	6.3	28.7	3.4	27.8	8.1	28.6 (26.0)	5.2 (2.9)
11/ 7/53	27.2	3.7	22.1	2.5	26.2	3.4	24.9	4.8	26.0	3.9	29.6	5.0	26.0 (23.4)	3.9 (1.9)
12/ 5/53	32.5	4.2	33.0	4.4	32.6	3.6	31.1	3.7	32.3	4.1	32.3	4.8	32.3 (29.4)	4.1 (1.9)
12/22/53	39.0	3.3	28.2	3.9	32.5	4.2	31.3	3.9	30.1	4.1	34.0	5.8	32.5 (29.7)	4.2 (2.0)
1/16/54	34.7	6.1	31.7	3.4	34.5	4.0	34.3	4.9	29.1	3.4	32.9	4.9	34.5 (31.7)	4.4 (2.1)
2/ 6/54	34.8	4.4	33.6	4.3	32.0	3.8	30.7	4.3	32.2	3.3	29.6	5.1	32.2 (29.4)	4.2 (2.0)
2/27/54	31.9	5.7	31.1	4.1	29.4	3.4	29.9	4.4	21.4	3.5	32.6	6.4	29.4 (26.7)	4.6 (2.3)
4/17/54	29.8	4.5	12.7	3.0	18.5	3.0	24.0	3.4	11.9	2.8	25.6	5.8	20.4 (....)	3.8 (1.9)
Average	30.6 (26.9)	4.3 (3.4)	26.4 (23.2)	3.4 (....)	28.4 (24.9)	3.6 (2.8)	28.1 (24.7)	4.0 (3.1)	26.0 (......)	3.6 (2.8)	28.4 (24.9)	5.3 (4.4)		

[1]Figures in parenthesis represent the lower significant limit. Any mean lower than this value is significantly lower than the mean having this value at the .05 level (Duncan, 1955).

oxalate content during the late winter and spring was attributed to leaching.

Data showing the soluble oxalate content of leached and unleached halogeton stems and leaves are shown in table 4. Statistical analysis of these data showed that a highly significant difference in soluble oxalate content existed between leached and unleached samples. These data offer further evidence that the soluble oxalate content of halogeton may be materially reduced by the leaching effect of rainfall and melting snow.

The soluble oxalate content of halogeton stems, and leaves and seed varied between vegetation types. Halogeton leaves and seed collected from a greasewood-kochia mixture contained an average of 30.6 percent soluble oxalates during the non-growing season, while leaves and seed collected from a kochia type contained only 26.0 percent (table 2). Halogeton stems varied in oxalate content from an average of 5.3 percent for collections made on winterfat areas, to 3.4 percent for collections made on greasewood areas.

By an analysis of variance, a significant difference in soluble oxalate content of halogeton leaves on the various vegetation types existed only among the kochia-greasewood mixture, the pure kochia type, and pure stands of greasewood (tables 3 and 4). The oxalate content of halogeton stems collected on winterfat types and kochia-greasewood mixtures was significantly higher than the oxalate content of stems collected from greasewood types. The oxalate content of halogeton stems on winterfat areas was significantly higher than those from any other area.

Table 3. Analysis of variance of soluble oxalate content of halogeton leaves and seeds and stems as affected by site and season

Source of variation	Degrees of freedom	Mean square: Leaves and seed	Mean square: Stems
Type	5	30.62**	5.21**
Season	10	123.91**	3.63**
Type x season	50	7.92	0.53

**Indicates significance at the .01 level

Soluble oxalate content of halogeton as affected by sodium content of the soil.

To ascertain whether the soluble oxalate content of halogeton is affected by the sodium content of the soil, regression coefficients were calculated comparing the average milli-equivalents of so-

Table 4. Soluble oxalate content of halogeton stems and combined leaves and seeds for six sites as affected by simulated leaching[1]

Vegetation type	Collected January 16, 1954				Collected February 27, 1954			
	Leaves and seeds		Stems		Leaves and seeds		Stems	
	Non-leached	leached	Non-leached	leached	Non-leached	leached	Non-leached	leached
	(percent)		(percent)		(percent)		(percent)	
Greasewood-kochia	34.7	23.2	6.1	1.9	31.9	18.9	5.7	2.4
Greasewood	31.7	24.9	3.4	1.8	31.1	21.3	4.1	2.3
Sagebrush	34.5	23.7	4.0	2.7	29.4	13.6	3.4	2.7
Shadscale	34.3	24.6	4.9	3.0	29.9	15.2	4.4	2.8
Kochia	29.1	20.6	3.4	2.6	21.4	12.7	3.5	2.7
Winterfat	32.9	19.5	4.9	2.3	32.6	24.9	6.4	3.0

[1]Leaching was simulated by submerging in a water bath for 30 minutes, then allowing to drain thoroughly.

dium per 100 grams of soil with soluble oxalate content of mature halogeton leaves. This regression coefficient was not significant. Likewise, non-significant regression coefficients were obtained when the exchangeable sodium content of only the surface layer in the soil was tested against the oxalate content of leaves and when the exchangeable sodium content of the subsoil was tested against the mean soluble oxalate content of the halogeton leaves.

This indicates that the soluble oxalate content of the halogeton plant is not influenced by the sodium content of the soil if the exchangeable sodium is three milli-equivalents per 100 grams of soil or more.

Root Systems

The average root system of a five-month-old halogeton plant in the greasewood-kochia area reached a depth of three feet and had a lateral radius of nine inches from the central taproot. Most of the roots, however, were concentrated in the surface twelve inches.

Halogeton roots extended to a depth of 40 inches, with a radial spread of one foot in soils on greasewood areas. In this case, the roots were concentrated in the surface eight inches.

In the sagebrush area, roots reached a depth of 30 inches and had a radius of two feet. The roots were largely confined to the surface 16 inches of soil.

On the shadscale areas, the roots reached a depth of 38 inches and attained a radius of two feet. In this profile, the roots were concentrated in the surface ten inches.

The roots of halogeton extended downward 28 inches and had a radius of eight inches on the kochia areas. In this site, they were mostly limited to the surface nine inches.

These studies indicate that halogeton roots tend to concentrate near the surface, especially if the soils are high in salinity; but they also grow extensively in the deeper soils, which are saline-alkali.

Conclusions

Halogeton now occupies soils in the salt deserts of the Great Basin region which were formerly occupied by various native plants. The soils vary significantly in amount of exchangeable sodium and in base exchange capacity.

The soluble oxalate content of both the stems and the combined leaves and seeds of halogeton varied significantly on different areas, and also between collections made at different seasons of the year. The soluble oxalate content of the halogeton leaves and seeds was not significantly influenced by the exchangeable sodium content of the soil.

The soluble oxalate percent of halogeton increased until mid-January and then decreased with approaching spring. The oxalate content of halogeton stems, and leaves and seeds was significantly reduced when subjected to a leaching treatment. This suggests that the reduction in soluble oxalates in halogeton during late winter and spring may result from leaching by melting snow and rainfall. Apparent increases in oxalate content during the fall were believed to be a result of seed shattering, since seeds and seed bracts are relatively low in oxalates.

Halogeton leaves and seeds collected April 17 contained an average of 20.4 percent soluble oxalates. This is still sufficient to be dangerous to livestock. Thus, halogeton maintained its poisonous characteristics throughout the winter and into the spring season.

Roots of halogeton were concentrated mostly in the surface layer of the soil. This was especially true when high salt content existed in subsoils. However, a few roots were found at deeper depths despite high salt content.

Summary

From August, 1953, to April, 1954, a study was conducted on salt desert range in northwestern Utah to determine the effect of site and season upon the oxalate content of halogeton.

Trenches were dug in six vegetation types where halogeton was present. Root depth and lateral spread were traced along the faces of the trenches. Soil samples were collected from the exposed layers and analyzed for soluble salts.

Collections of halogeton were made from each vegetation type at various seasons during the 1953-54 fall and winter grazing season. These samples were separated into leaves and seeds, and stems and analyzed for soluble oxalates. Two seasonal collections were subjected to leaching treatments.

Significant differences in exchangeable sodium and base exchange capacity were found in soils from the various vegetation types. The soluble oxalate content of halogeton is not influenced by the sodium content of the soil when more than three milli-equivalents of exchangeable sodium per 100 grams of soil are present.

The soluble oxalates in halogeton are subject to leaching. Both leaching and shattering of seeds affect oxalate content of the plants. Shattering seed tends to increase oxalates in the remaining plant until mid-winter; thereafter, leaching tends to decrease the oxalate content. Lethal amounts still remain until mid-April, however.

Halogeton roots are concentrated in the surface soil, especially when subsoils have high salt content. However, despite this, a few roots extended downward as far as 40 inches when only five months of age.

LITERATURE CITED

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