Sodium and Potassium Accumulation by Greasewood and Hopsage Leaves
Author(s): W. H. Rickard
Source: *Botanical Gazette*, Vol. 126, No. 2 (Jun., 1965), pp. 116-119
Published by: The University of Chicago Press
Stable URL: http://www.jstor.org/stable/2473197
Accessed: 23/10/2013 15:13

BOTAN. GAZ. 126(2):116–119. 1965.

SODIUM AND POTASSIUM ACCUMULATION BY GREASEWOOD AND HOPSAGE LEAVES[1]

W. H. RICKARD
Biology Laboratory, Hanford Laboratories, General Electric Company, Richland, Washington 99352

ABSTRACT

During their annual leaf-retention periods in 1963, greasewood and hopsage leaves accumulated large amounts of sodium and potassium, respectively. Hopsage leaves abscised in mid-July after soil moisture in the upper meter of soil profile became depleted. Leaf drop was preceded by about 6 weeks of lowered leaf moisture content. Greasewood leaves persisted throughout the summer months without gross changes in leaf moisture content, indicating that greasewood was obtaining water from a deep water table.

Mineral uptake, leaf abscission, and the subsequent decay of leaves resulted in increased sodium and potassium content in the soils beneath greasewood and hopsage, respectively. Cheatgrass plants growing adjacent to greasewood canopies had a higher sodium content than those growing adjacent to hopsage canopies or in adjacent intershrub areas.

Introduction

Mineral analyses of leaves of crop plants and of forest trees have often been used to assist in the interpretation of the nutrient status of soils of various habitats. Numerous analyses have also been made of the physicochemical properties of sap expressed from the leaves of native shrubs of desert and desert-steppe habitats (HARRIS, 1934). Little information is available, however, concerning the seasonal uptake of minerals by shrubs of desert-steppe habitats.

This paper presents the results of mineral analyses of the leaves of greasewood, *Sarcobatus vermiculatus* (Hook.) Torr., and hopsage, *Grayia spinosa* (Hook.) Moq., collected periodically from spring leaf-out to leaf-fall during 1963.

Material and methods

Leaves were picked by hand from mature greasewood and hopsage shrubs growing in mixed stands on the 800-acre radioecology field facility located near the western margin of the Hanford Reservation, Benton County, Washington. About the same quantity of leaves from four shrubs of each species was picked, promptly weighed, then dried at 105° C. The dry leaves were crushed and mixed to form a single sample for analysis of calcium, sodium, and potassium by flame spectrophotometric techniques, and EDTA titration was used for magnesium determinations. Plant material was ashed at 450° C and digested in nitric acid. The influences of other elements in photometric analysis were recognized and corrected for. Determination of calcium was made after coprecipitation with strontium oxalate (KEOUGH, 1964). Soil moisture content was also periodically determined on soil samples taken at 2 dm intervals to a depth of 1 m in intershrub areas. Percentage of soil moisture was determined on a dry-weight basis, that is, after drying at 105° C. Soil analyses were made by the Soil Testing Laboratory, Washington State University, Pullman, Washington.

Results and discussion

Greasewood and hopsage are brittle-stemmed, intricately branched, spinose shrubs belonging to the family Chenopodiaceae. Both shrubs have wide geographic distribution in the arid region of western United States. In the Great Basin greasewood is the principal phreatophyte of the shadscale vegetation zone, except along permanent streams, while hopsage is scattered throughout the matrix vegetation of the zone (BILLINGS, 1951). Hopsage is also a component of the matrix vegetation of the creosote-bush zone in southern Nevada (RICKARD, 1963). In the Hanford Reservation sagebrush (*Artemisia tridentata* Nutt.) usually dominates the natural vegetation mosaic, but hopsage is often associated with it over wide areas. Greasewood is limited in distribution, however, being restricted to a few acres in the vicinity of the study area.

Sodium was the most abundant cation measured in greasewood leaves and potassium the most abundant in hopsage leaves (fig. 1). Sodium content of greasewood leaves steadily increased from about 45 mg/g in late April to 118 mg/g in early November. Potassium steadily increased in hopsage leaves from 40 mg/g in early April to 108 mg/g in mid-July (fig. 1). Potassium was high in greasewood leaves, exceeded only by sodium, but sodium was only sparingly represented in hopsage leaves. The calcium and magnesium contents of hopsage leaves were higher than those of greasewood leaves. As the growing season progressed the potassium content of greasewood leaves decreased and calcium content increased

[1] Work performed under Contract no. AT(45–1)-1350 between the Atomic Energy Commission and General Electric Company.

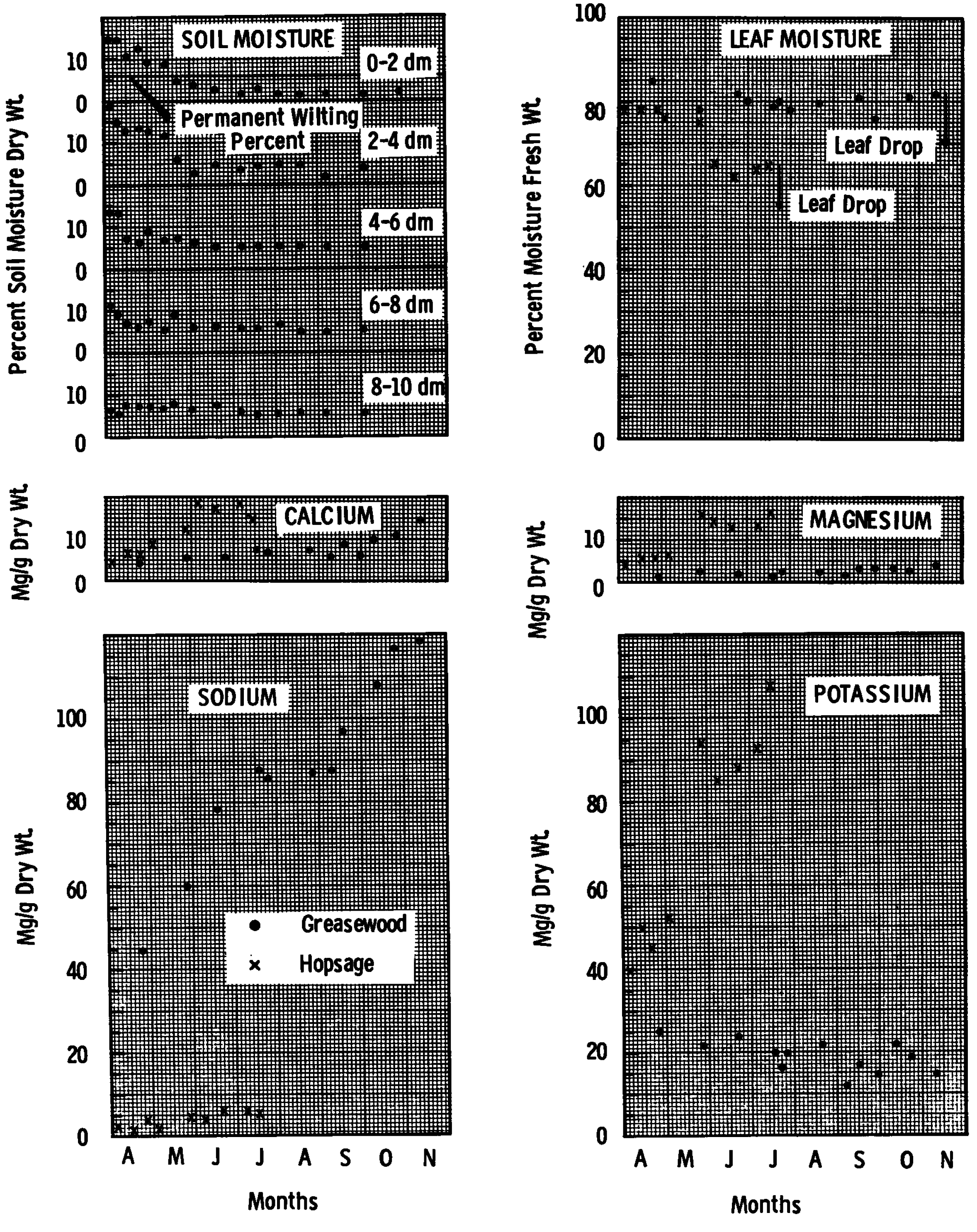

FIG. 1.—Seasonal trends in mineral accumulation by greasewood and hopsage leaves in relation to soil and leaf moisture contents.

(fig. 1). The potassium and calcium contents of leaves of loblolly pine and apple have been reported to follow a somewhat similar pattern, with potassium apparently being translocated from leaves to perennial tissues (OLAND, 1963; WELLS and METZ, 1963). Apparently, potassium is not translocated out of the leaves of hopsage prior to abscission, possibly because of a deficiency of soil moisture and changes in internal physiology. The moisture content of hopsage leaves abruptly declined in early June at the time of a marked depletion of soil moisture in the upper meter of the soil profile (fig. 1). The moisture content of greasewood leaves remained high through the summer and into early fall, substantiating the observations made by BILLINGS (1951) that greasewood is capable of obtaining moisture from a deep water table. The early summer leaf abscission of greasewood emerge in the spring, soil moisture is optimal, at least in this region of marked winter precipitation, and leaves are relatively low in mineral content. When soil moisture stresses had increased and leaf mineral content was maximal, leaf abscission occurred in hopsage (fig. 1). Greasewood leaves abscised late in the season, when sodium content was high but when available soil moisture was probably not greatly diminished, assuming that greasewood obtains the water used in metabolic processes from a permanent water table. An inference is that leaf abscission in greasewood is an effective means of removing excess sodium from the plant system but is not necessarily a mechanism for water conservation.

The uptake of large quantities of sodium and potassium by greasewood and hopsage, respectively,

TABLE 1

CHEMICAL PROPERTIES OF SOIL AT DIFFERENT DEPTHS (DM) BENEATH GREASEWOOD AND HOPSAGE CANOPIES, HANFORD RESERVATION, WASHINGTON

	HOPSAGE		GREASEWOOD	
	0–1	1–2	0–1	1–2
Exch. Na (meq/100 g)	0.15±0.13	0.23±0.14	7.3±1.3	6.8±0.61
Exch. K (meq/100 g)	5.9 ±0.75	4.6 ±0.49	3.5±0.78	2.9±0.92
Exch. capacity (meq/100 g)	15.0 ±1.7	14.0 ±0.83	14.0±1.7	13.0±0.48
Na (% exch. cap.)	1.0	1.6	52.0	52.0
K (% exch. cap.)	39.0	33.0	25.0	22.0
pH (paste)	8.3	8.2	9.5	9.4
Conductivity (mmhos/cm) (saturation extract)	2.0 ±0.89	1.3 ±0.64	1.2±0.10	1.7±0.49

TABLE 2

CATION CONTENT OF CHEATGRASS (MG/G) GROWING BENEATH SHRUB CANOPIES AND IN INTERSHRUB AREAS[a]

Cation	Under greasewood	Under hopsage[b]	No canopy
Na	1.30±0.090	0.54	0.53±0.059
K	0.23±0.024	0.25	0.18±0.017
Ca	2.30±0.430	2.50	1.80±0.350
Mg	1.50±0.088	2.00	1.40±0.067
Total	5.3	5.3	3.9

[a] ± Standard error of mean of samples from three places.
[b] Average of two samples.

hopsage functions to reduce transpiration during the hottest and driest months of the year and may also be an effective means of removing annual accumulations of ions from the plant system.

Members of the Chenopodiaceae are acknowledged halophytes. The cellular uptake of ions is believed to enable these kinds of plants to obtain water from saline soils. When new leaves of hopsage and has ecological ramifications concerning the spatial distribution and mineral nutrition of associated herbaceous non-halophytes. Greasewood contributed to increases in the exchangeable sodium content of soil beneath shrub canopies, while hopsage contributed to the exchangeable potassium content of soils beneath their canopies (table 1). Studies in Utah salt-desert communities have suggested that greasewood does not require sodium for growth but merely tolerates alkali conditions (FIREMAN and HAYWARD, 1952; GATES, STODDART, and COOK, 1956).

The role of greasewood and hopsage on the mineral uptake of associated herbaceous plants remains to be investigated. A few precursory analyses were made on the mineral content of cheatgrass (*Bromus tectorum* L.) growing adjacent to greasewood and hopsage canopies and in adjoining intershrub areas (table 2). Sodium content was higher in cheatgrass plants adjacent to greasewood than in those adjacent to hopsage and from the adjoining non-canopy areas. It has been reported that when sodium was added to soil, an increase in the sodium content of crop plants was noted (BERNSTEIN and PEARSON, 1956). Calcium and potassium were better represented in the grass samples collected from beneath both greasewood and hopsage than in those collected in intershrub areas. Although grass samples taken beneath shrub canopies may contain cations contributed by leaf drip and leaching from overhanging shrub branches, contribution of cations from these sources is probably minimal in this region of low rainfall.

Five greasewood shrubs in the study area were selected for harvest. The ground area occupied by the canopy-spread of each shrub was determined. All leaves present in mid-July were picked by hand from each shrub after clipping all leafy branches. The weight of leaves harvested varied according to the size and vigor of individual shrubs. Dry-leaf yields ranged between 166 and 270 g/m^2 of canopy-spread and averaged 213 g/m^2. One hopsage shrub harvested in mid-July, when the plant was in full leaf, yielded 97 g of dry leaves/m^2 of canopy-spread.

Employing the cation contents of leaves just prior to the time of leaf abscission (*see* fig. 1), it was calculated that an average value of 25 g of sodium and 3.2 g of potassium was contained in the leaves of greasewood/m^2 of canopy-spread, while hopsage leaves contained about 10.5 g of potassium/m^2 of canopy-spread.

A line-intercept analysis of a 30×30m plot in the study area showed that 15% of the ground was occupied by the canopies of greasewood shrubs and 5% by hopsage canopies. The amount of sodium present in greasewood leaves/m^2 of ground was calculated to be about 3.75 g/m^2 and the amount of potassium about 0.48 g/m^2. Only a small amount of sodium was present in hopsage leaves, but about 0.52 g/m^2 of potassium was present. It was determined that about 3.8 g of sodium and 1 g of potassium/m^2 of habitat is annually deposited by greasewood and hopsage in this desert-steppe community.

Such pronounced mineral accumulations by greasewood and hopsage have ecologic implications for mineral-cycling studies and suggest the employment of radioisotopes to elucidate the cycling rates of minerals in a desert-steppe ecosystem.

LITERATURE CITED

BERNSTEIN, L., and G. A. PEARSON. 1956. Influence of exchangeable sodium on the yield and chemical composition of plants. I. Green beans, garden beets, clover and alfalfa. Soil Sci. **82**:247–258.

BILLINGS, W. D. 1951. Vegetational zonation in the Great Basin of western North America. Union Int. Sci. Biol., Ser. B, **9**:101–122.

FIREMAN, M., and H. E. HAYWARD. 1952. Indicator significance of some shrubs in the Escalante Desert, Utah. BOTAN GAZ. **114**:143–155.

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

HARRIS, J. A. 1934. The physiochemical properties of plant saps in relation to phytogeography. Univ. Minnesota Press, Minneapolis.

KEOUGH, R. F. 1964. Unpublished manuscript. Biology Laboratory, Hanford Laboratories, General Electric Company, Richland, Washington.

OLAND, K. 1963. Changes in the content of dry matter and major nutrient elements of apple foliage during senescence and abscission. Physiol. Plantarum **16**:682–694.

RICKARD, W. H. 1963. Vegetational analyses in a creosote bush community and their radioecologic implications. Pp. 39–44 *in* Radioecology, V. SCHULTZ and A. W. KLEMENT, JR. [eds.] Reinhold Publ. Corp., New York.

WELLS, C. G., and L. J. METZ. 1963. Variation in nutrient content of loblolly pine needles with season, age, soil, and position on crown. Soil Sci. Soc. Am., Proc. **27**:90–94.