IDENTIFICATION AND IMPACT OF EXCESS SOIL POTASSIUM ON CROP AND LIVESTOCK NUTRITION 1/

P.O. Kresge, R.G. Gavlak, S.G. Custer, C.W. Robbins and J.S. Jacobsen 2/

Introduction

Several soils have been identified in the Intermountain West which contain excessive amounts of extractable postassium (K). A "normal" ammonium acetate extractable potassium level may be from 200 to 500 parts per million (ppm), while the high potassium soils contain 1,000 to over 7,000 ppm. Initial observation of crops grown on these soils continually showed poor crop yield, general chlorosis and failure to respond to fertilizer additions.

While not widely reported in the literature, these soils have been identified at sites in Idaho, Montana, Oregon, Utah and Wyoming. Their discovery suggests a need to further explore the distribution and origin of high extractable K soils. We may also be able to define steps to improve crop and livestock productivity on the sites. This paper presents what we know about excess-K soils and outlines current efforts to determine their origin, chemistry and impacts on crops and livestock.

1/ Proceedings, 39th Annual Far West Regional Fertilizer Conference, Bozeman, Montana, July 11-13, 1988.

2/ Agronomist, ConAgra Fertilizer Co., P.O. Box 671, Knoxville, Tennessee 37901; Extension Soil Scientist, Univ. of Idaho, Twin Falls; Department Head, Earth Science, Montana State Univ., Bozeman; Soil Scientist, USDA-ARS, Kimberly, Idaho; and Extension Soil Scientist, Montana State Univ., Bozeman.

Soil Chemical Characteristics

Table 1 shows chemical analysis data from samples taken in Montana, Utah, Idaho, Oregon and Nevada. A common characteristic of the sites is abnormally high soil potassium. Ammonium acetate extractable potassium in problem soils ranges from about 800 ppm to over 7000 ppm. When soluble salts, measured by electrical conductivity (ECe), are low the soil pH has been measured as high as 9.5. Sodium levels in most of the soils are not high enough to be causing the high pH levels. When soluble salts are high, as at the Feddes site, measured pH is near neutral.

Table 1. Chemical analysis data from high K soils

Site	Depth	pH	EC	Ammonium Acetate Extract			
				K	Ca	Mg	Na
	-in.-			----------ppm----------			
Montana (Gallatin Valley)							
Boylan	0 - 4	9.2	4.7	3995	3676	1550	1335
	4 - 8	9.6	2.1	4108	3564	811	1179
	8 - 12	9.5	1.9	3569	3546	842	1047
Spring	0 - 6	8.7	3.8	620	7400	920	72
	6 - 12	8.9	6.2	6280	6000	1100	100
	12 - 18	9.1	4.8	5120	5200	1180	78
Feddes	0 - 8	7.7	9.6	2040	5881	901	242
Idaho (Twin Falls)							
Rock Cr.	0 - 8	7.7	1.6	2400	8800	420	10
	8 - 12	8.0	1.2	2400	7800	360	88
	12 - 18	8.3	0.7	1480	6800	240	106
Rock Cr.	0 - 12	9.8	2.2	7300	4400	200	100
Malta	0 - 8	7.7	8.9	2478	5806	866	681
Oregon							
Vale	0 -	9.0	1.5	2515	1825	520	813
Vale	0 -	9.0	3.5	5385	1810	310	1683
Nevada							
Elko	0 - 8	8.1	11.4	2610	5472	845	--

High soil pH results in reduced availability of the heavy metal nutrients copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn). Extraction with the chelating agent DTPA is commonly used as an indicator of heavy metal fertility. Results of this extraction from three high potassium sites are shown in Table 2.

DTPA-extractable Cu, Zn and Fe levels have been low in the high K soils. High pH explains low heavy metal availability at most of the sites. However, extractable heavy metal levels at the Feddes site are low and pH is near neutral, so alternate explanations and a larger sample population are desireable to explore micronutrient deficiency.

Table 2. Availability of Heavy Metals in High-K Soils

			DTPA Extraction			
Site	Depth - in-	Soil pH	Cu	Fe	Mn	Zn
			ppm			
Boylan	0-4	9.2	1.1	1.9	16.5	0.7
	4-8	9.6	0.8	1.6	7.1	0.3
Spring	0-8	8.8	0.5	2.1	2.9	0.4
Feddes	0-8	7.7	0.4	3.5	3.1	1.0

Landscape and Physical Characteristics

Alluvial deposits along stream courses are typical sites where excess extractable K causes reduced crop production. Most have a water table within three to five feet of the surface. Potassium is concentrated in low knolls or raised areas and distribution is quite variable. The individual areas of excess K may not be extensive, often less than an acre. The largest contiguous area is about 60 acres in extent. One site has been identified in an upland area adjacent to the Boylan alluvial site in the Gallatin Valley of Montana. Plant symptoms are less apparent and yield is not severely reduced at this site. We feel that high extractable K can be found in a variety of landscape positions but that the water table tends to contribute to concentration of K and possibly to other chemical anomalies.

In sharp contrast to sodic soils, excess K soils have extremely friable structures. They have been described as 'fluffy' or 'floury'. They powder easily, even when quite dry. Friability is often dramatic enough to be a diagnostic characteristic for field identification.

Crop and Livestock Behavior

Plant production is severely reduced in excess K soils. Growth is stunted and plant density may be very low at the highest extractable K levels. Grasses often have interveinal chlorosis though general chlorosis and bright yellow vegetation are observed.

Various soil and foliar treatments have been applied with no response. Nutrient treatments have included N, P, S, and all of the micronutrients. High application rates of sulfur, intended to lower soil pH, have not resulted in improved production. A greenhouse experiment showed some improvement in plant growth when leaching was combined with high rates of N and P fertilizer.

Livestock nutritional disorders have not been positively attributed to excess soil K. Indirect evidence suggests that Cu deficiency may result from low plant levels. Low liver Cu levels have been confirmed in cattle at the Feddes site in Montana. Excess K in conjuction with low to normal Mg levels could result in Mg deficiency in grazing livestock, a possibility which is under investigation.

Cattle grazing in excess K pastures have been observed licking and pawing at bare areas. Such activities have resulted in formation of depressions 2 to 4 feet in diameter and as much as 4 inches deep. Further study is required to quantify the extent of soil ingestion by livestock.

Current Hypotheses

As we locate more areas with excess K soils, similarities suggest a possible geologic source. The soils in the Twin Falls, Idaho area are near the hills south of the Snake River Plain. The parent materials consist of rhyolitic welded tuffs and volcanic ash. Weathered rhyolite, which is relatively high in K, is a prime candidate for the souce material. Excess K soils in southwestern Montana appear to be associated with tertiary-age sedimentary deposits. Many of the deposits contain volcanic ash and weathered tuff which could provide a similar parent material to the Idaho sites.

Investigation of excess K soils is proceeding on several fronts. Excess-K soils continue to be located, adding to our knowledge of chemical parameters and distribution. As we gather more information on distribution, a better understanding of the origin of the problem may emerge. We are also studying the impacts of excess K on plant and animal nutrition. Fertilizer treatments and soil amendments have proven ineffective to date but some additional combinations will be tested. This fall we will establish some forage nurseries to identify best-adapted species for this type of problem soil. Finally, a graduate research project is beginning at Utah State University to deal with chemical characterization of excess K soils.