EVALUATION OF THE NH_4HCO_3-DTPA (AB-DTPA) SOIL TEST

FOR IDENTIFYING SELENIFEROUS SOILS[1/]

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Abstract.--Two experiments were conducted to determine the correlation between soil selenium (Se) extracted by the AB-DTPA soil test of Soltanpour and Schwab (197) and plant uptake of Se. A fairly high correlation (R^2 = 86%) was found between soil samples taken between 15 and 6D cm deep and Se concentration in greaseweed (Sarcobatus vermiculatus)leaves.

INTRODUCTION

About fifty years ago, it was discovered that the element selenium (Se) was the toxic factor in "alkali disease", an often fatal disorder afflicting grazing animals in various regions of the western U.S. For more than a decade, mostly during the 1930's, investigations were conducted on Se in rocks, soils, vegetation, and animal tissues (Anderson et al., 1961). From these studies it was established that certain plant species, termed "primary accumulator plants", take up Se from soil readily. The belief is widely held that these plants will grow only in areas where their roots can absorb Se from the soil. According to Beath (1982), many other plant species are capable of accumulating Se if it is readily available in the soil in a water soluble form.

Beath (1982) cited certain localities in Wyoming as "super-toxic areas". At these locations the level of plant available Se was reported to be so high that virtually all of the vegetation rooted there is selenium-toxic or potentially so.

One result of the intensive investigations carried out during the 1930's was that many areas of Se toxic plants were identified and delineated. As ranchers and other herdsmen became aware of these problem areas and the plant types associated with them, livestock losses due to Se poisoning were lessened through management practices.

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Some western coal deposits are located in regions that have a history of Se toxicity. This has led to concern that surface coal mining operations might create Se problems by bringing seleniferous overburden or spoil materials into contact with aquifers and plant rooting zones. Many states recognize this possibility and require analysis of Se in soil and overburden materials (Berg, 1983).

While many states prescribe specific soil testing methods for Se assessment, it is difficult to correlate the values obtained with uptake by perennial rangeland plants because of the scarcity of these kind of data. Realistic interpretation of soil test results requires an adequate data base relating test values to the particular plant species of interest.

The ammonium bicarbonate-DTPA (AB-DTPA) soil test (Soltanpour and Schwab, 1977) was developed for simultaneous extraction of macro- and micronutrients from alkaline soils. It is used routinely by the Colorado State University Soil Testing Laboratory (CSU-STL) for soil fertility evaluation. The multielement extraction capability of the AB-DTPA soil test and its speed and convenience make it an attractive procedure for routine use. This convenience is further augmented at CSU-STL because the lab is equipped with an inductively coupled plasma (ICP) emission spectrometer which is capable of determining many elements simultaneously.

The NH_4HCO_3-DTPA extracting reagent has chemical properties which appear to make it suitable for extraction of Se from soil samples. Bicarbonate can desorb selenate in a manner similar to phosphate desorption (Soltanpour, 1985). Since the solution is aqueous, water soluble forms of Se are released. During the shaking process, CO_2 evolves from the open flask and the pH of the solution rises from its original value of 7.6 to

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about 8.5. Some organic constituents are brought into solution in this alkaline environment.

Soltanpour and Workman (1980) conducted a growth chamber study and found a high degree of correlation between Se uptake by alfalfa (Medicago sativa) plants and AB-DTPA extractable Se from soils treated with sodium selenate (Na_2SeO_3).

The objective of the research reported in this paper was to determine if Se extracted from naturally occurring seleniferous soils by the AB-DTPA soil test could be correlated with Se uptake by native range plants. Two basic approaches were employed: indoor growth studies, and field sampling.

MATERIALS AND METHODS

Field Sampling Experiment

Leaf samples were taken from greasewood plants [Sarcobatus vermiculatus (Hook.) Torr.] at ten locations (numbered 1 - 10) within an approximately one square mile area at the so-called "Poison Basin" west of Baggs, Wyoming. This area contains numerous abandoned uranium mines and is one of super-toxic sites that was identified by Beath (1982). Greasewood was chosen because this species had a wide distribution over the area we desired to sample and because it has some forage value (for sheep). At each sampling location three greasewood plants were randomly selected and leaf samples were taken. The plants were designated A, B, and C. A king tube sampling probe was used to extract three soil cores around a 30 cm radius from the base of each plant sampled. Three depth increments were taken from each core site: 0-15 cm, 15-60 cm, and 60-120 cm. Cores from identical depth increments were combined into the same sample container, resulting in a composite sample consisting of three cores for each depth. In summary, leaf samples were collected from three plants (A,B,C) at each of ten separate locations (1-10). For each plant sample, there were three separate soil samples corresponding to three different composited depth increments.

Leaf samples were oven dried at 55°C, ground to pass through a 10 mesh screen, wet digested in a 6:2 nitric-pechloric acid mixture (Havlin and Soltanpour, 1980), and Se was determined in the digest using rapid hydride generation coupled with ICP emission spectrometry (Soltanpour et al., 1982).

Soil samples were air dried, disaggregated and sieved through a 2 mm stainless steel sieve, and analyzed for AB-DTPA extractable Se (Soltanpour and Workman, 1981).

Indoor Growth Studies

During the summer of 1984, a brief survey was conducted in which soil and plant samples were taken in areas of Wyoming where seleniferous soils were considered likely to be encountered. The presence of primary accumulator plants, particularly Astragalus bisulcatus (Hook.) Gray, and Astragalus pectinatus Dougl., was used as a guide for choosing sampling sites. Soil samples were analyzed for AB-DTPA extractable Se, and total Se was determined on plant samples by methods previously discussed. Sites that appeared to have soils with high extractable Se levels were then selected. Large soil samples were collected in plastic trash containers, air dried, and stored for future use. In addition, a sample of non-seleniferous soil was collected from the CSU Agronomy Center.

Table 1.--Approximate sampling location of soil samples collected for indoor growth studies

Soil Desig.	County	Details
C-2	Carbon(Wyo.)	N. of Sinclair
C-3	Carbon	Baggs (Poison Basin)
C-4	Carbon	Baggs (Poison Basin)
C-5	Carbon	Baggs (Poison Basin)
A-1	Albany (Wyo.)	E. of Rock River
A-2	Albany	E. of Rock River
CB	Albany	E. of Chalk Butte
N-2	Niobrara (Wyo.)	N. of Lusk near
N-6	Niobrara	N. of Semen Hills
CH	Larimer (Colo.)	CSU Agronomy Ctr

The soil samples listed in Table 1 were used as treatments in two indoor growth studies. On 10 January, 1985 an experiment was initiated in which western wheatgrass [Pascopyrum smithii (Rydb.) Love = Agropyron smithii (Rydb.)] was seeded into plastic lined cardboard pots which contained 2 kg of soil. The seeding rate was about 25 seeds per pot. Prior to seeding the soils were fertilized by incorporating 100 ppm N (dry soil weight basis) and 50 ppm P into each pot.

Soil mixture in the pots was maintained at near field capacity by daily watering with distilled water. The experiment consisted of the ten soil treatments. Each treatment was replicated four times, resulting in a total of 40 experimental units. The pots were laid out in a completely randomized design. Pot locations were re-randomized on a weekly basis.

The plants were grown under artificial lights at room temperature (25°C) for approximately 5 months. The plants were clipped twice during the course of the study on 15 March and 28 June, 1985. The procedures employed for plant sample preparation and analysis for total Se content were identical to those previously discussed.

A similar growth study was carried out in a greenhouse in order to assess whether a different set of environmental conditions would affect Se uptake by the western wheatgrass plants. The greenhouse experiment was identical to the other growth study except that the ten soil treatments were replicated three times instead of four. The study was initiated on 10 February, 1985. The plants were clipped twice, on 15 May and 30 June, 1985.

RESULTS AND DISCUSSION

The results for the field sampling experiment are presented in Table 2. It can be seen that both soil and plant Se values were quite high. Se concentration in greasewood leaves was variable among locations and ranged as high as 502 ug/g.

Table 2.--Se concentration in greasewood leaves versus AB-DTPA extractable Se in soil sampled at three depth increments.

Loc.	Plant #	Plant Se	Soil Se Depth Increment 0-15 cm	15-60 cm	60-120 cm
		ug/g			
1	A	167	0.06	1.07	0.74
	B	243	1.68	6.84	1.96
	C	502	1.43	0.24	0.71
2	A	371	0.16	6.69	5.53
	B	212	0.17	4.85	4.51
	C	212	0.34	3.60	2.48
3	A	14.1	0.05	0.13	0.14
	B	10.0	0.06	0.28	0.23
	C	9.73	0.05	0.39	0.14
4	A	68.1	0.04	0.04	0.03
	B	140	0.49	3.45	1.64
	C	63.9	0.15	0.70	0.57
5	A	2.68	0.04	0.29	0.15
	B	12.3	0.02	0.07	0.27
	C	13.7	0.09	0.22	0.40
6	A	13.1	0.04	0.10	0.26
	B	23.0	0.03	0.14	1.01
	C	21.9	0.03	0.11	0.65
7	A	148	0.27	3.02	2.66
	B	26.2	0.11	1.14	0.77
	C	85.0	0.89	2.40	2.67
8	A	73.6	0.29	1.83	1.29
	B	137	0.27	1.73	1.19
	C	111	0.89	2.40	2.67
9	A	46.4	1.58	0.69	0.94
	B	26.0	0.04	0.08	0.27
	C	76.3	0.27	1.41	1.74
10	A	17.9	0.04	0.15	0.22
	B	253	0.21	1.91	1.99
	C	125	0.08	3.96	6.58

AB-DTPA extractable soil Se values were consistently lower in the top 15 cm than deeper in the profile. This may indicate that surface soil sampling may not be sufficient and that deeper sampling may be necessary in order to adequately characterize the Se status of a soil.

Se concentrations in leaves were averaged according to location. AG-DTPA extractable soil Se was also averaged by location for each depth increment. Regression analysis revealed that there was a close linear relationship between averaged plant Se and averaged AB-DTPA extractable soil Se in the 15-60 depth increment. These data are presented in Table 3.

Table 3.--AB-DTPA extractable Se in 15-60 cm depth increment averaged over each location versus Se conc. in leaves averaged over each location.

Location	Plant Se	Soil Se
	ug/g	
1	304	3.38
2	265	5.05
3	11.3	0.27
4	90.7	1.40
5	9.6	0.19
6	19.3	0.12
7	86.4	2.19
8	107	1.90
9	49.6	0.73
10	132	2.01

Linear regression analysis of these data resulted in an R^2 value of 86%.

These results demonstrated that there was a positive relationship between AB-DTPA extractable soil Se and Se uptake by greasewood. In this experiment virtually all of the plant Se concentration values would be considered potentially toxic.

The results for the two indoor growth studies are presented in Table 4. Se concentrations in plant tissue were generally higher for plants grown under artificial light than those grown in the greenhouse. Linear regression analysis of mean plant Se concentration on mean AB-DTPA extractable soil Se revealed a poor fit. This poor fit was attributable mostly to soils "C-3" and "N-2". Soil N-2 may be of most concern since the plant Se concentration values were high but AB-DTPA extractable soil Se values were low. In this case the soil test failed to predict relatively high plant Se uptake. In the other case AB-DTPA extractable Se on soil C-3 was high but plant uptake was low. Correlation between plant uptake and AB-DTPA extractable soil Se would have been excellent without the two "outlier" soils. Research is being conducted to determine the reason for high Se uptake by western wheatgrass on soil N-2.

Table 4.--Se concentration of western wheatgrass plants grown under artificial light and of plants grown in the greenhouse.

Soil#	-----Total Plant Se----- Light Table Indiv.	Mean	Greenhouse Indiv.	Mean	AB-DTPA Soil Se
	----------------	ug/g	----------------		
C-5	2.47	3.02c*	1.69	2.05b	0.03
	3.47		2.31		
	1.94		2.15		
	4.21				
C-4	2.63	2.52c	1.19	1.43b	0.08
	3.03		1.27		
	1.94		1.82		
	2.46				
C-3	1.49	1.48c	1.85	1.44b	0.84
	1.60		1.37		
	1.35		1.09		
	1.47				
C-2	13.9	10.6a	5.72	6.31a	0.58
	10.1		5.56		
	9.03		7.64		
	9.36				
CH	0.98	0.74c	0.44	0.57b	0.02
	0.73		0.57		
	0.71		0.69		
	0.55				
CB	5.70	7.33b	8.42	6.69a	0.54
	6.41		4.39		
	9.10		7.27		
	8.12				
A-1	1.50	1.89c	1.93	1.62b	0.30
	1.92		1.48		
	2.66		1.44		
	1.46				
A-2	0.81	0.83c	0.65	0.67b	0.13
	0.80		0.66		
	0.78		0.69		
N-2	11.1	10.4a	7.40	6.50a	0.08
	10.1		6.36		
	9.50		5.74		
	10.7				
N-6	1.63	1.69c	0.86	0.66b	0.03
	1.43		0.58		
	1.78		0.55		
	1.78				

* Means within any one column followed by the same letter are not significantly different at the 5% probability level.

CONCLUSIONS

1. AB-DTPA extractable Se from soil samples taken between between depths of 15 and 60 cm appeared to be a good predictor of Se concentration in greasewood leaves.

2. When taking soil samples in the field for Se assessment, surface sampling may not be adequate and deeper samples should be taken if possible.

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RECLAMATION INVENTORY ANALYSIS