BORON AND SELENIUM REMOVAL IN BORON-LADEN SOIL BY BIRDSFOOT TREFOIL

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INTRODUCTION

High concentrations of boron (B) and selenium (Se) found in the soils are detrimental to sustainable agriculture in the western USA. Vegetation management may be a remediation strategy designed to reduce soil B and Se concentrations to non-toxic levels, since extensive leaching with water is a practice which consumes excessive water in drought stricken areas and causes drainage water and runoff problems in perched water table farming areas. In this regard, Parker et al. (1991) suggested using perennial grasses and/or legumes as candidate crops for removal of Se from soils high in B. Plant removal of B with B and Se tolerant plants may economically be more feasible and more environmentally sound than physically removing B contaminated soil or taking B-laden regions out of crop production. The objective of this field study was to determine if birdsfoot trefoil (*Lotus corniculatus* L.) tolerates high B soils and simultaneously lowers extractable B and Se in soil by plant uptake of each respective ion.

METHODS AND MATERIALS

Field experiments were established between May and November of 1990 and 1991 in the west side of San Joaquin Valley, California. The site was chosen because of the high levels of B in the soil. The soil belongs to the Los Banos Clay-loam, fine mixed thermic Typic Haploxeralfs. The treatment design for both years on two similar sites was a completely randomized design with two treatments; a) planted to *Lotus corniculatus* L. in 1991 and b) bare plot where no plants were planted. In 1990, each 5X5 m plot was replicated nine times and in 1991, each 10X10 m plot was replicated three times. Triplicate soil cores were collected within each plot from depths of 0-30 and 30-60 cm, respectively, prior to planting and at harvest. Selected ions and other parameters were extracted from saturated soil extract (mean values are shown in Table 1). Water extractable B (any mention of soil B references water extractable B) was determined spectrophotometrically by the azomethine H method (Bingham, 1982). Total Se was determined by atomic absorption with continuous hydride generation after soil samples were wet digested with HNO_3/H_2O_2.

Table 1. Selected chemical properties of soil saturation extracts from the 1990 and 1991 experiments.

Soil Depth (cm)	Ions							Saturation Water	
	Ca	Mg	Na ($mg\ L^{-1}$)	PO_4	SO_4	Cl (mMol)	Ec (dSm^{-1})	pH	Percentage (%)
Experiment 1990[†]									
0-30	240(95)	85(31)	267(34)	22(34)	800(245)	6(2)	2.8(.7)	7.9(.2)	47
30-60	300(125)	70(25)	305(55)	16(5)	667(104)	4(1)	2.2(.6)	7.8(.2)	48
Experiment 1991									
0-30	225(80)	79(25)	258(29)	19(4)	756(158)	6(3)	3.1(.5)	7.8(.2)	48
30-60	273(69)	71(26)	295(39)	16(6)	692(111)	5(2)	2.5(.6)	7.7(.3)	49

[†] Mean values presented with standard deviations in parenthesis.

Plants were first established under controlled greenhouse conditions, hardened for two weeks under field conditions and then transplanted as clumps every 20 cm with 125-150 plants/m^2. *L. corniculatus* plots were each hand clipped at 60, 85, and 115 days after the plants were at least 5.0 cm in height. Subsamples were taken from four one square meter sites within each plot, washed three times, oven-dried at 45°C for 7 d, weighed, and ground in a stainless steel Wiley mill. Plant B was determined spectrophotometrically after wet acid digestion and plant Se was determined by atomic absorption with continuous hydride generation. Irrigation scheduling was based on the local California Irrigation Management Information System (CIMIS) weather station. Irrigation was performed with a sprinkler system. Spacing of 9 m x 8 m resulted in an irrigation rate of about 10 mm hr^{-1}. Mean irrigation depth for the two years was 825 mm. The total amount of evaporation throughout the growing season averaged 1000 mm, which resulted in an irrigation coefficient of 0.82. Irrigation water contained negligible concentrations of both B and Se.

RESULTS

The mean dry matter yield of *L. corniculatus* was 0.9kg/m^2 in 1990 and 1 kg/m^2 in 1991. Yields might have been higher if the plants had been grown longer than one year (only three clippings made). The mean tissue B and Se concentrations are shown in Table 2 for each clipping. Each clipping removes additional B and Se from the soil. Table 3 shows the reductions of soil B and Se after the final harvest of *L. corniculatus*. Reductions of soil B and Se in bare plots were probably due to some leaching from the sprinkler irrigation and/or the partial transformation of soil B to other forms of B which were not extractable by water.

Table 2. Mean tissue concentrations of boron and selenium in birdsfoot trefoil grown in 1990 and 1991 experiments.

	Clipping	Boron Concentrations Shoot	Root	Selenium Concentrations Shoot	Root
			($mg\ kg^{-1}$ DM)		
1990 Experiment†‡					
	I	84(6)a	--	0.44(.03)b	--
	II	131(12)b	--	0.87(.09)a	--
	III	135(14)b	95(10)	0.90(.10)b	0.10(.08)
1991 Experiment					
	I	116(11)b	--	0.36(.06)bc	--
	II	116(6)b	--	0.29(.04)bc	--
	III	118(8)b	110(9)	0.22(.03)bc	0.14(.01)

†Values presented represent means followed by standard error of mean in parenthesis from a minimum of 20 separate samplings in 1990 and 12 samplings in 1991. Means are separation within columns and within each experiment by a Tukey's range test. The same letters represent no significant difference between means at the P=0.05 level.

‡Root samples were not taken, for first 2 clippings in each experiment.

Table 3. Mean preplant and postharvest soil concentrations of extractable B and total Se between 0-60 cm for 1990 and 1991 experiments.

Species	1990 Experiment† B Preplant	B Postharvest	Se Preplant	Se Postharvest	1991 Experiment‡ B Preplant	B Postharvest	Se Preplant	Se Postharvest
		($mg\ L^{-1}$)				($mg\ L^{-1}$)		
Control (bare plots)	4.47(0.52)	3.99(0.66)a§	0.49(0.11)	0.43(0.01)a	3.57(0.60)	3.43(0.11)a	0.88(0.046)	0.86(0.02)a
Birdsfoot trefoil plots	5.14(0.57)	2.26(0.38)b	0.39(0.10)	0.12(0.07)b	4.16(0.71)	2.98(0.22)b	0.82(0.075)	0.71(0.03)b

†Values represent the mean from 36 soil samples followed by the standard error of mean in parenthesis.

‡Values represent the mean from 16 soil samples followed by the standard error of mean in parenthesis.

§Mean separation in columns obtained by Tukey's range test. The same letters represent no significant difference between species at the P = 0.05 level.

We suggest that utilizing harvested *L. corniculatus* as animal forage is worthy of economic consideration, especially because of its high quality as animal forage. More importantly, tissue levels of B and Se were under the maximum tolerable limits established by the National Research Council (1980) for plant material used as animal forage. Using vegetation management in conjunction with efficient irrigation management may be a critical component of remeditation strategy to reduce soil and drainage water concentrations of B and Se to safe levels.

LITERATURE

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