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LITHIUM TOXICITY IN SEEDLINGS OF THREE COOL SEASON GRASSES*

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KEY WORDS

Grasses Herbage yield Lithium toxicity Root yield

SUMMARY

Lithium toxicity in seedlings of crested wheatgrass (*Agropyron desertorum*), Sherman bluegrass (*Poa ampla*), and Whitmar wheatgrass (*Agropyron inerme*) was investigated in 2 potted soil studies. Yields of roots and shoots were unaffected at 2.5 and 5 ppm but were significantly ($P < 0.05$) depressed at 15 and 60 ppm. Li was much higher in the herbage than in the roots of grasses grown in Li treated soils. Species tolerancy to Li appeared to be: crested wheatgrass > Sherman bluegrass > Whitmar wheatgrass.

INTRODUCTION

Lithium is readily absorbed into the plant system and can be identified spectophotometrically in the plant tissue. For those reasons, in addition to their belief that Li was non-toxic to plants Sayre and Morris[8] concluded that the technique could be useful for certain types of root studies. Hulbert used the technique in his investigations with wheatgrass (*B. tectorum*), but background Li in the soils precluded conclusive results. In both of the above investigations, levels of Li were rather high (> 300 ppm).

Toxicity of Li to citrus plants was first reported by Haas[6] and more detailed findings in citrus were published by Aldrich *et al.*[1] Tolerance in plants other than citrus was researched by Bingham *et al.*[2] They showed that growth of both Dallis and Rhodes grass was reduced about 25 per cent with Li concentrations of 25 and 65 ppm. Levels of Li in leaves were 340 and 2400 ppm for Dallis and Rhodes grass, respectively, with 180 and 205 ppm in the roots in the same order. Gupta[5] reported

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that growth of wheat and barley seedlings was not affected by levels of Li up to 5 ppm, but root growth was reduced at 10 ppm.

This paper presents data on growth of roots and shoots and on yield of 3 cool season grasses as influenced by Li. These results are discussed as they relate to the use of Li in studies of root growth.

MATERIALS AND METHODS

For a preliminary study seeds of Sherman bluegrass (*Poa ampla* Merr.) crested wheatgrasss (*Agropyron desertorum*, (Fisch. ex Link) Schult.), and Whitmar wheatgrass (*Agropyron inerme* (Scribn. and Smith) Rydb.) were planted in separate flats in the early fall. On october 4, at a 2-leaf stage, individual seedlings were transplanted into flexible plastic tubes 5.1 cm in diameter each containing approximately 550 g air dry soil blend. The tubes with perforated bottoms were suspended through a wooden frame into .95–1 jars (Fig. 1). The level of distilled water in the jars was maintained above the perforated level.

The soil consisted of 2 parts screened sand to 1 part screened top soil; both were collected on the Station. Mechanical analysis described the soil as a loamy sand containing 79% sand, 14% silt, and 7% clay. It contained 0.8% organic matter and the mean cation exchange capacity (C.E.C.) was 8.55 meq/100 g.

Amounts of technical grade lithium chloride required to provide 1.63, 16.3, and 326 ppm Li were diluted to 500 cc and atomized onto separate lots of soil, each weighing 5,400 g air dry. Each lot was

Fig. 1. Growth box system used to evaluate Li toxicity of cool-season grasses.

thoroughly mixed, allowed to air dry, and with an untreated soil lot transferred to nine plastic tubes.

Plant species (3) and lithium rates (4) were randomly allocated to frame positions with 3 replications of each. The plants were observed daily and observations were recorded on October 8, 14, 28, and November 11.

In the subsequent spring the above procedures were followed in a new trial for evaluating Li levels of 0, 2.5, 5.0, 15.0, and 60 ppm. Seedlings from the same flats which had over wintered in the field were transplanted into the prepared soil tubes on May 1. When transplanted, crested wheatgrass and Sherman bluegrass were in a 3 to 4-leaf stage and Whitmar wheatgrass was in a 4- to 5-leaf stage. Distilled water was added to the jars weekly in this trial and a Li free nutrient solution included on alternate weeks.

Observations of seedling performance were recorded on May 19 and June 16. On July 31, when the study was terminated, the herbage was clipped at the soil surface, placed into glass jars and permitted to air dry before the jars were sealed. The samples later were oven dried, weighed, and analyzed for Li. The root systems were washed clean of all soil, dried in a forced air dryer, weighed, stored in air-tight jars and later analyzed for Li. At all stages of sample handling, precautions were taken to prevent contamination of samples.

The study was conducted as a 3×5 factorial in completely randomized design with three replications. Data for yields of herbage and roots were treated by analysis of variance and means separated with Duncan's[4] multiple range test. Samples were extracted with ammonium acetate and read spectrophotometrically with a Beckman B spectrophotometer by comparison with lithium ammonium acetate standards [100% transmission at 100 (soil analyses) and 10 ppm (plant tissue)].

RESULTS

In the fall, temperature was low and growth was slow; the data were not analyzed statistically. Ten days after transplanting all seedlings in soils containing 326 ppm Li were dead. The 326 ppm level approximated the C.E.C. of this soil blend. After 24 days seedlings of Sherman bluegrass growing in 16.3 ppm were all dead, and after 48 days the study was terminated. At that time all plants in control tubes had added 1 new leaf and Sherman bluegrass had added 2 new leaves. Crested wheatgrass showed evidence of leaf damage at the 16.3 ppm level but grew a new leaf at levels of 1.6 and 16.3 ppm. Whitmar wheatgrass leaf tips were yellowed at 1.6 ppm and entire leaf yellowing occurred at 16.3 ppm Li. Sherman bluegrass showed leaf tip injury from 1.6 ppm Li even though it grew 2 new leaves.

In the spring study both Li concentrations and species were highly significant ($P < 0.01$) sources of variation in the yield of roots and shoots (Table 1). Yield of roots and shoots were greatest for crested wheatgrass and Sherman bluegrass and both were significantly ($P < 0.01$) greater than for Whitmar wheatgrass. Yields of shoots and roots were similar at 0, 2.5, and 5 ppm Li and were significantly ($P < 0.01$) greater than that produced at 15 or 60 ppm Li.

Nineteen days after transplanting seedlings at 15 and 60 ppm Li were either dead, had yellow leaves, or had brown leaf tips. Forty-five days after transplanting, all seedlings growing at 60 ppm Li were dead and one each of crested wheatgrass and Sherman bluegrass growing at 15 ppm Li was dead and at 5 ppm

Table 1. Herbage and root yield and their Li concentrations as influenced by Li soil concentrations

	Li soil concentrations (ppm)					
	0	2.5	5	15	60	Mean*
Herbage yield (g/pot)						
Agde**	0.69	0.85	0.86	0.54	0.02	0.59[a]
Poam	1.12	1.16	0.76	0.02	0.02	0.62[a]
Agin	0.46	0.21	0.30	0.25	0.02	0.25[a]
Mean	0.76[a]	0.74[a]	0.64[a]	0.27[b]	0.02[b]	
Root yield (g/pot)						
Agde	0.85	1.41	1.10	0.53	0.02	0.72[a]
Poam	1.17	1.44	1.17	0.01	0.01	0.77[a]
Agin	0.88	0.35	0.49	0.30	0.20	0.41[b]
Mean	0.97[a]	0.97[a]	0.92[a]	0.28[b]	0.01[b]	
Herbage Li (μg/g)						
Agde	1	4	48	150	491	39
Poam	1	1	11	1593	4257	1172
Agin	1	6	37	294	3789	825
Mean	1	4	32	679	3846	
Root Li (μg/g)						
Agde	1	2	0	27	159	38
Poam	1	2	2	***	—	—
Agin	1	4	1	13	226	49
Mean	1	3	1	13	192	

* Means covered by a different letter differ significantly at the 0.05 level.
** Agde (crested wheatgrass), Poam (Sherman bluegrass), Agin (Whitmar wheatgrass).
*** Inadequate sample.

Li one seedling each of Sherman bluegrass and Whitmar wheatgrass was dead.

Data for Li concentration in roots and tops were not statistically analyzed because many dead plants provided insufficient material. Lithium concentration was 19 to 23 times as great in the herbage as in the roots of seedlings grown in 15 or 60 ppm Li.

DISCUSSION

In subsamples of the untreated soil Li analyzed 1 ppm (the sensitivity limit of our analyzer). Analysis in a second laboratory confirmed this result. However, Li level in plants grown in control tubes ranged from 0 to 11 ppm. Interference from other minerals has been shown and possible clarifying procedures have been reported, Bradford and Pratt[3]. Techniques using exchange resins did not correct the interference, if such existed. Thus, it was inferred that the soil was free of Li and that the Li in control plants reflected interference readings. Concentrations shown in Table 1 are presented with amounts of Lithium in control plants subtracted out across all levels of Li on a mean replication basis.

Root and shoot production of these cool season grasses was reduced more at lower levels of Li (comparable to that reported by Gupta[5]) then was production of warm season grasses as reported by Bingham *et al.*[2] Like their results, higher concentrations of Li was determined in shoots then in roots. Though not significant, the data in the spring study suggests that crested wheatgrass was most tolerant to Li followed by Sherman bluegrass with Whitmar wheatgrass being the most susceptable; however, the differences were not significant ($P > 0.05$). Growth observations of the preliminary fall study also suggest that crested wheatgrass was the most tolerant of the 3 species.

In studies such as those of Sayre and Morris[8] and of Hulbert[7], root extensiveness could be determined even though the levels of Li were probably toxic. However, for quantitative root growth along with root growth activity then subtoxic levels must be used. The results of this study suggest that Li concentrations greater than 5 ppm depress the growth of roots and shoots of these 3 cool season grasses. For Whitmar wheatgrass in particular levels of Li below 5 ppm might depress growth. Thus, low levels of Li treatment were readily detected in the shoots of these cool season grasses but their extreme sensitivity suggest only limited use of this technique for the study of root growth.

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