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RESPONSE OF SOYBEAN ZINC CONCENTRATION IN NUTRIENT SOLUTION*

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The influence of a wide range of Zn concentrations (O to 100 μM) on the growth and Zn accumulation by soybean (*Glycine max*(L.) Merr. cv ,A msoy) was studied under controlled ecological conditions. [At Zn levels below 0-5μM the dry weight of soybean tops and roots was reduced due to Zn deficiency. At higher Zn concentrations (> 50 μM) the growth of tops as well as that of roots was also markedly reduced due to Zn toxicity but maximum growth of soybean plants was recorded in the range of 1 – 5 μM. The lower critical Zn level at which Zn is required at a minimum concentration for maximum growth was 21μg/g in tops. The upper critical Zn level at which maximum Zn concentration in tops that can be tolerated for maximum growth was 502 μ/g.

The main objective of plant analysis is to predict the nutrient requirements of plants and to evaluate the extent of availability of soil nutrients with the aid of nutrient calibration curves. It has been clearly established that plant species differ in their requirements for Zn under field as well as green house conditions (Shukla and Hans Raj, 1980). Soybean is a very sensitive crop with respect to its Zn requirements. Yield reduction due to Zn deficiency had been observed and these, deficiencies had been corrected either with foliar sprays of the nutrient or by band application of ZnO or other Zn salts in the soil. Usually differences in susceptibility to a nutrient deficiency can be attributed to either differences in the plant's ability to absorb the nutrient element from the soil and translocate it to the shoots or to differences in the soil concentrations of the element as needed by the plant for healthy growth (Carrol and Loneragan, 1968). Recent reports clearly indicate that the genotypes of different plant species differ markedly in their ability to absorb and translocate the nutrient elements within the plant system; and to tolerate excess mineral elements including Zn (Shukla and Hans Raj 1980).

However, the mineral composition of plants is a more sensitive indicator of crop response to environmental changes although it is much more difficult to interpret. Lower critical Zn levels in plant tissue have been established for several crops such as sugarbeets (Rosell and Ulrich, 1969); corn,

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soybean and wheat (Melsted*et al.*, 1969). Although, there ,*u* is limited information in the literature about the upper critical Zn level for different soybean cultivars grown in nutrient solution. Polson and Adams (1970) reported growth reduction in navy beans due to excessive Zn concentration as high as 777 $\mu g/g$ in the leaf. Zinc toxic symptoms were associated with more than 200 $\mu g/g$ in oranges (Chapman, 1960). These studies illustrate the Zn concentrations that are associated with toxicity symptoms in some crops. However, the upper critical Zn levels associated with growth reductions in crops are not well documented. Ohki (1975) had reported the lower and upper critical Zn levels in cotton grown in nutrient solution.

The objective of the studies reported here was to determine the lower and upper critical Zn levels associated with the maximum growth and development of soybean plants, cv. Amsoy.

MATERIAL AND METHODS

Soybean seeds (*Glycine max* (L.) cv. Amsoy were surface sterilized with 3% H_2O_2, washed several times with distilled water and soaked in aerated distilled water for 6h. The seeds were then placed between moist paper towels and allowed to germinate, After 3 days of germination, healthy, uniform seedlings were selected and placed in the holes of plant support discs which were positioned in vessels containing nutrient solutions with different concentrations of Zn (0 to 100 μM as $ZnSO_4 . 7H_2O$). Nutrient solutions were continuously aerated and renewed daily in order to maintain constant nutrient concentration. The levels of other nutrients (in ,*u*M) in the solutions were: $(NH_4) SO_4$ 714, KH_2PO 32, KCl 510, $CaCl_2$ 500, $MgSO_4 . 7H_2O$ 82, H_3BO_3 5.0, $MnCl_2 . 4H_2O$ 0.9, $CuSO_4 . 5H_2O$ 0.3, H_2MoO_4 0.01 and Fe (EDTA) Na 0. 9. The pH of the nutrient solutions was maintained at 5.5 ± 0.2. The plants were grown in a phytotron where the ecological conditions were as follows; day and night temperatures 26 and 20°C respectively; day length period 13h, light intensity 16 K. lux and relative humidity 75%.

The experiment was replicated 4 times with 15 Zn levels. Visual symptoms of deficiency and toxicity of Zn were recorded. At the age of 20 days, the plants were harvested and separated into roots and tops. The roots were rinsed several times with deionized water. Roots and tops were dried at 70°C in an oven and the dry weights of roots and tops were recorded. Dried samples of roots and tops were separately ground in a blender with stainless steel interior to pass through a 40-mesh stainless screen and digested with HNO_3, H_2SO_4 and $HClO_4$ acid mixture (ratio 10:1:4). Zinc concentration in the plant samples was determined by atomic absorption-spectrophotometry.

RESULTS AND DISCUSSION

Symptoms of Zn deficiency were observed inplants grown under lower levels of Zn (0 to 0.5,*u*M). Intervenal chlorosis and necrotic spots were observed in Zn deficient plants and their growth was also reduced. The deficiency symptoms observed in soybean are in agreement with the observations made by Chapman (1960) and Ohki (1975) in cotton; Viets et al., (1954) in kidney beans; Nelson and Barber (1964) in soybean plants. It was interesting to observe that the deficiency symptoms of Zn were of the same pattern even though the plants are genetically different. Under higher level of Zn (> 50μM) severe Zn toxicity symptoms were observed. The leaves exhibited chlorotic symptoms with dark green veins and the plants showed stunted growth. A similar pattern of Zn toxicity had also been reported by Ohki (1975) in cotton plants grown in nutrient solution, and by Polson and Adams (1970) in navy beans. In the present investigation, due to Zn deficiency (0 to 0 5 μM and toxicity (> 50 μM), the dry weight of roots as well as the tops was markedly reduced. Maximum production of dry matter was observed at the Zn concentration of 1 to 5 μM (Table 1). It was evident that the growth of tops was affected to a greater magnitude than that of roots indicating that root growth is less sensitive to higher concentration of Zn due to the high mobility of Zn from the roots to the tops. Similar observations were also made by Ohki (1975) in cotton plants grown under comparable condition.

The nutrient calibration curve which relates the dry weight of tops to its Zn concentration ranging from deficiency to toxicity, shows the lower as well as the upper critical levels of Zn (Fig. 1). Ulrich and Hills (1973) defined lower critical Zn level as the concentration in the tissue associated with a 10% growth reduction from maximum growth due to Zn deficiency at sampling time. Similarly, the upper critical level of Zn was defined as the maximum Zn concentration in the tissue associated with a 10% reduction due to Zn toxicity (Ohki, 1975). The present results indicate that the lower and upper critical levels of Zn in tops are 21 and 502 μg/g respectively indicating that maximum growth was attainable in the range of 21 to 400 μg/g. Growth of tops was reduced to the magnitude of 10% when the tissue concentration of Zn was 21 and 502 μg/g due to deficiency and toxicity effects respectively. The lower critical level of Zn observed in this study for soybeans was in the range that had been reported for corn (Rosell and Ulrich, 1964) and for cotton (Ohki, 1975). Information on the upper critical level of Zn in soybean is scanty and the primary concern in the production of the crop is to prevent deficiency and toxicity problems and to maintain Zn concentrations at sufficiently adequate levels. The information contained in the literature reported that the upper critical level of Zn is 673 μg/g for navy beans (Polson and Adams, 1970) and 526 μg/g for tomatoes (Lyon et al., 1943). Assuming that the Zn requirements of soybeans are similar to those of navy beans and tomatoes, the upper critical level of Zn of 502 μg/g for soybeans observed in this study is therefore a resonable estimate.

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REFERENCES

CARROLL, M. D. and J. F. LONERAGAN. 1968. Response of plant species to concentrations of zinc in solution. I. Growth and zinc content of plants.—Aust. J. agric. Res. 19: 859-868.

CHAPMAN, H. D. 1960. Leaf and soil analysis in citrus orchards. Univ. Calif. Div. Agric. Sci Ext. Serv. Manual 25.

LONERAGAN, J. F. 1968. Nutrient requirements of Plants. -Nature,220: 1307-8.

MELSTED. S. W., H. L. MOTTO and T. R. PECK. 1969. Critical plant nutrient composition values useful in interpreting plant analysis data.—Agron. J. 61: 17-20.

NELSON, W. L. and S. A. BARBER. 1964. Nutrient deficiencies in legumes for grain and forag e.-In Hunger Signs in Crops (H. B. SPRAGUE-ed.). pp. 143-79. David Mckay Co., New York.

OHKI, K. 1975. Lower and upper critical Zinc levels in relation to cotton growth and development —Physiol. Plant, 35: 96-100.

POLSON, D. E. and M. W. ADAMS. 1970. Differential response of navy beans *Phaseolus vulgaris* L.) to zinc. I. Differential growth and element composition at excessive Zn levels.—Agron' J. 62: 557-60.

ROSELL. R. A and A. ULRICH. 1964. Critical Zn concentrations and leaf minerals of sugar beet plants.—Soil Sci, 97: 152-67.

SHUKLA, U. C. and Hans Raj. 1980. Zinc response in Pigeon pea as influeced by genotyple variability.—Plant and Soil,57: 323-33.

ULRICH, A. and F. J. HILLS. 1973. Plant analysis as an aid in fertilizing sugar crops. Part I. Sugar Beets.—In Soil Testing and Plant Analysis (L. M. WALSH and J. D. BENTON, eds.) pp. 271-88. Soil Sci. Soc. Am. Madison, Wis

VIETS, F. G. L. C. BOAWN, C. L. CRAWFORD, and C. E. NELSON. 1954. Zinc content of bean plants in relation to deficiency symptoms and yield. Plant Physiol. 29: 76-9.

TABLE 1. Effect of Zn concentration on root and top dry weight and Zn content in tops soybean plants.

Zn concentrations μM/1	Dry weight g/5 plants		Zn content in
	Root	Top	tops (μg/g)
0	0.105	1.05	10
0 01	0.107	1.14	12
0.05	0r112	1.27	13
0.10	0.141	1.57	15
0.20	0.152	1.74	18
0 30	0.165	1.82	20
0.50	0.174	1.97	25
1.00	0.178	2.04	37
2.00	0.189	2.08	53
3.00	0.168	2.05	171
5.00	0.164	2.00	400
10.00	0.125	1.75	602
50.00	0 105	1.66	805
75.00	0.092	1.54	920
100.00	0.083	1.50	1050
C.D. at 0.05	0.013	0.30	16