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EFFECTS OF ZINC SUPPLY ON ITS UPTAKE, GROWTH AND BIOCHEMICAL CONSTITUENTS IN LENTIL

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SUMMARY

The effects of five levels of Zn, viz. 0.0, 0.25, 1.0, 25.0 and 100.0 ppm on growth, yield, biochemical changes and its uptake in lentil (*Lens culinaris* Medic) plants, grown in loamy-sand alluvial soil were examined. Soil used in the experiment was highly deficient in Zn (0.46 ppm). The maximum increase of 20.5% and 52.7% in the height and dry matter was obtained at 25 ppm Zn supply. Protein and chlorophyll a content were also significantly increased by 25 ppm Zn. Excess Zn of 100 ppm however, reduced all the growth and biochemical responses. Zn-toxicity symptoms, viz. stunted plant growth and chlorosis followed by necrosis in lentil leaves were observed. The uptake of Zn was found to be dose dependent. Accumulation of Zn was more in root than the shoot at all Zn applications.

***Key words*: Zn, growth, biochemical changes, lentil.**

INTRODUCTION

Zinc forms a structural component of a large number of proteins with catalytic or regulatory functions. Over three hundred enzymes are known to contain Zn as a cofactor (Valee and Auld 1990).Widespread deficiency of Zn has been recorded in several states of India (Agarwala *et al*. 1970, Malewar and Randhawa 1978) including alluvial soils of the plains of Uttar Pradesh (Agarwala and Sharma 1979). The uptake of Zn in plants is mostly in the toxic form, as free Zn^{2+}, it is concentration dependent and saturable (Hart *et al*. 1998). A large agricultural area in the vicinity of industrial set up or irrigated with water containing heavy metals including Zn, is affected and rendered infertile (Pandey *et al*. 2008). Despite the beneficial role of Zn in high levels are toxic and reduce crop yield. Excess Zn can change the certain physiological equilibrium by competition with other bivalent cations (De Fillipps and Ziegler 1993). Lentil (*Lens culinaris* Medic.) is widely cultivated in temperate, subtropical and tropical climate, as a winter crop. It can be grown on a wide range of soils from light loams to black cotton soils. The present study aimed at analysing the effects of Zn-stress on its uptake, growth and biochemical responses in lentil.

MATERIALS AND METHODS

A pot culture experiment was conducted using a uncontaminated loamy - sand alluvial soil collected from Badshahbagh area of Lucknow in Uttar Pradesh. Top (20 cm) soil was collected, air dried, sieved, weighed and mixed thoroughly. The soil contained 0.46 $\mu g\ g^{-1}$ DTPA extractable Zn at pH 7.3 estimated following Lindsay and Norvell (1978). The soil $CaCO_3$ was 1.63 %, organic matter 0.44 %, pH 6.8 and E.C. 0.48 m mhos/cm (Table 1). NPK fertilizers at the rate 50 mg kg^{-1} soil each, were added to the soil as a basal dose. Clay pots (10L), lined with a polythene sheet, were filled up with soil and 6 pots were used for each treatment. The pots were placed in a glass top wire house. Ten seeds of lentil were sown in

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Table 1. Physico-chemical properties of composite sample collected from Badshabagh area, in Lucknow district used for the experiment.

Parameter	Texture	pH	O.M (%)	$CaCO_3$ (%)	E.C (m mhos/cm)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Ni (ppm)
Average value	Loamy sand	6.8	0.44	1.63	0.48	0.46	0.32	2.28	0.008

OM= organic matter; E.C.= electrical conductance.

each pot. Thirty days after emergence, plants were thinned to three per pot and irrigated with distilled water according to need. At 30 days growth stage, plants were irrigated with graded Zn (as $ZnSO_4$) levels (0.0, 0.25, 1.0, 25.0 and 100.0 ppm). Plant samples for yield parameters, dry matter, catalase activity, chlorophyll and protein contents were taken at different days of Zn treatment. Biochemical parameters were determined in young leaves (3rd to 4th leaf from the top). Chlorophyll and protein contents were estimated by the method of Lichtenthaler and Wellburn (1983) and Lowry *et al*. (1951), respectively. Data presented in the tables are mean values of five replicates and statistically tested by the least significant difference test (L.S.D.).

RESULTS AND DISCUSSION

The Gomti upland alluvial soil (Entisol) used to grow lentil plants was mild calcareous and low in Zn (DTPA extractable Zn, 0.46 ppm). Agarwala and Sharma (1979) reported DTPA extractable 0.8 ppm Zn is critical deficiency limit for most of the crops in alluvial soils of UP. Visual Zn deficiency symptoms, such as reduction in the shoot growth and reduced size of leaf lamina were observed in plants grown in untreated soil (control). The middle leaves of these plants developed mild chlorosis, first at the base of the leaflets, later spreading to the apex. Some visible symptoms of Zn toxicity at excess Zn (100.0 ppm) namely stunted growth and leaf chlorosis were observed. At early growth stage, Zn supply increased the dry matter production of lentil with increase in Zn concentration from 0.25 to 100.0 ppm, but Zn at 100 ppm decreased the plant growth at later stage (Table 2).

Accumulation of Zn in lentil was found to be dose dependent, as shown by increased uptake and translocation with increase in the Zn supply (Veltrup 1978). Hart *et al*. (1998) also showed Zn^{2+} uptake by wheat seedling to be concentration dependent. We found that Zn amount was higher in root than in shoot. Maximum dry matter yield was obtained in plants irrigated with 25.0 ppm Zn, twice in a week, at 85 days after the treatment (Table 2). Zinc supply led to increase in number and weight of pods, indicative of the importance of Zn in grain yield. Plants grown in soil supplied with 25.0 ppm Zn, that produced maximum dry matter yield had a shoot tissue concentration of 35.7 µg

Table 2. Effects of Zn supply on growth and yield of lentil

Parameters	DAS	Zn supply (ppm)					LSD
		0	0.25	1.0	25	100	P=0.05
Shoot length (cm)	25	30.43	30.81	30.67	31.87	30.31	0.733
	75	35.28	39.13	37.46	42.51	30.71	5.463
Dry weight (g $plant^{-1}$)	30	0.41	0.46	0.48	0.65	0.66	0.131
	85	0.78	1.40	1.56	1.65	1.04	0.45
Number of pods $plant^{-1}$	85	7	8	11	7	5	
Weight pod^{-1} (g)	85	0.026	0.029	0.029	0.026	0.021	0.004

DAS= Days after treatment

Table 3. Effects of Zn supply on some biochemical constituents of lentil 55 days after treatment.

Parameters	Zn supply (ppm)					LSD
	0	0.25	1.0	25	100	P=0.05
Chlorophyll a (mg/g fw)	1.15	1.48	1.87	2.24	1.52	0.15
Chlorophyll b (mg/g fw)	0.92	1.38	1.16	1.09	0.73	0.30
Total Chlorophyll (mg/g fw)	2.68	3.40	2.52	2.31	2.25	0.57
Sugar (mg g^{-1} fw)	15.07	16.21	18.30	14.71	13.42	2.28

- Significant at P=0.05 level.

Zn g^{-1} dry weight which was higher than in control soil (without any Zn supply). The control plants had low Zn of 18.15 µg g^{-1} dry weight (deficient range). In most plants, the critical level deficiency of Zn ranges between 15 to 20 µg g^{-1} dry weight (Sharma 1996). Increase in dry matter and reproductive yield was also reported in chickpea grown in 5 mg Zn kg^{-1} amended alluvial soil and accumulated 30 µg Zn g^{-1} dry weight (Sharma *et al*. 1987). Plants grown with 100.0 ppm Zn retarded growth and reproductive yield (number and weight of pods) and these plants had accumulated 68 µg Zn g^{-1} dry weight in shoot and 170.3 µg Zn g^{-1} dry weight in root. Inhibition of uptake of essential metals in plants under zinc toxicity have been reported (Sresty *et al*. 1999).

Chlorophyll content in leaves was significantly increased with the increase of Zn concentration upto 25.0 ppm, while it decreased at excess (100.0 ppm) Zn supply. But chlorophyll b and total chlorophyll contents were not affected at Zn above 0.25 ppm. The maximum increase in sugar content was obtained at 1.0 ppm and 25.0 ppm Zn at the tissue concentration of 33.6 and 36.5 µg Zn g^{-1} dw, respectively, (Fig. 1). The growth and biochemical responses of lentil were suppressed at 100.0 ppm Zn wherein, tissue concentration of Zn increased to 170.9 µg Zn g^{-1} dw in root and 68.43 µg Zn g^{-1} dw in shoot. Generally, tissue concentrations in the order of 150-200 µg Zn g^{-1} dw are reported to be toxic (Sauerebed 1982). The decrease in dry weight at high Zn level may be attributed to failure of oxidative system, inhibition of photosynthesis and metabolism involved in starch formation in leaves (Jyung *et al*. 1975, Sharma 2006). Zinc nutrient status of plants plays role in plant reproduction, tryptophan dependent of biosynthesis of auxin (Sharma 2006).

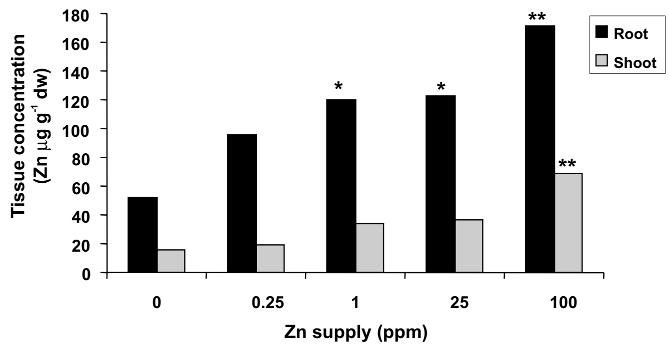

Fig. 1. Effect of Zn application on uptake of Zn in lentil. Data are mean value (N=5) and statistically tested by the LSD. *, ** indicate value that differ significantly from control at P< 0.05 and P< 0.01, respectively.

The present study revealed that low Zn (below 25.0 ppm) in irrigation water stimulates growth, biochemical

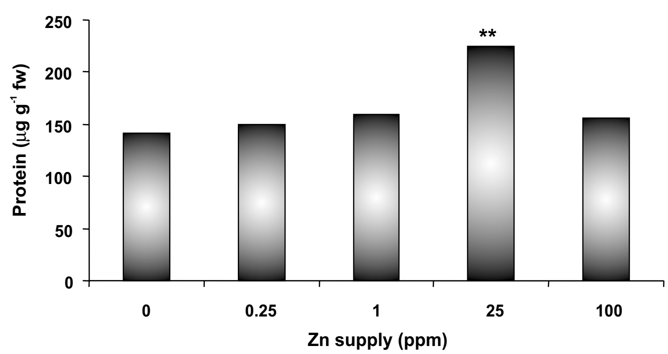

Fig. 2. Effect of Zn application on protein content (µg/g fw) in lentil. Data are mean value (N=5) and statistically tested by the LSD. *, ** indicate value that differ significantly from control at P< 0.05 and P < 0.01, respectively.

responses (chlorophyll, sugar and protein content) and reproductive yield of lentil grown in calcareous, Zn-deficient and coarse textured alluvial soil. The uptake and translocation of Zn was found to be dose dependent, and its translocation to shoot is slow as compared to the uptake by roots of lentil plants.

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