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PHYTOTOXICITY OF Zn AMENDED SOIL TO *SPINACIA* AND *CORIANDRUM*

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Zn (2×10^{-3} M Zn/l soil) amendment to the soil inhibited growth and yield of *Spinacia oleracea* cv All Green and *Coriandrum sativum* cv Selhari. The levels of chlorophyll components and Hill activity were also lower in plants grown on Zn amended soil. The uptake and translocation of nitrogen and phosphate were inhibited and the uptake and translocation of total heavy metal was promoted.

Our previous work on the effects of irrigation with polluted municipal waste water, rich in industrial effluents and sewage sludge, on total heavy metal content in soil and plants indicated high accumulation of total heavy metals, including zinc by soil and plants (Veer and Lata 1987). Therefore, it was of interest to investigate effects of Zn amendment in soil on growth, yield, levels of chlorophyll components, Hill activity and uptake and translocation of phosphate, nitrogen and total heavy metals in *Coriandrum sativum* cv Selhari and *Spinacia oleracea* cv All Green.

MATERIALS AND METHODS

Soil was amended with zinc sulphate to give Zn concentration of 2×10^{-3} M Zn/l soil. Seeds of *Coriandrum sativum* cv Selhari and *Spinacia oleracea* cv All Green were sown in the amended soil in polythene bags. Two plants/bag in case of *Spinacia* and four plants/bag in case of *Coriandrum* were allowed to grow up to sampling stage. Plants were sampled on 30th and 60th day from emergence. The data are averages of 15 samples and statistically analysed. For chlorophyll estimation 200 mg fresh leaves (3rd leaf from the apex) were homogenized in 80% acetone with a pinch of sodium bicarbonate. The homogenate was centrifuged at 4000 rpm for 5 minutes and final volume of supernatant was made to 10 ml with 80% acetone. Optical density of the extract was read at 645 and 665 nm. The amount of chlorophyll *a* and *b* were calculated according to Arnon (1949). Chloroplast isolation and Hill activity determinations were done following Banerji and Kumar (1975) and Banerji and Rauf (1977). Phosphate was determined by a modified Allen's method (Allen 1940) with metol reagent. Digestion was done by microkjeldahl method, with H_2SO_4 : H_2O_2 (Snell and Snell 1954) and estimation of digest for nitrogen was done with Nessler's reagent of Koch and McMeekin's formula (Oser 1965). For total heavy metals digestion was done with 60% $HClO_4$ and HNO_3, the residue was dissolved in ammonium citrate buffer, pH 8·5. Total heavy metal content was determined by dithizone method (Sandell 1950).

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RESULTS AND DISCUSSION

In general, growth and yield of both the crops were inhibited by Zn amendment in soil (Figs. 1, 2). Growth inhibition by Zn has also been reported by Rauser

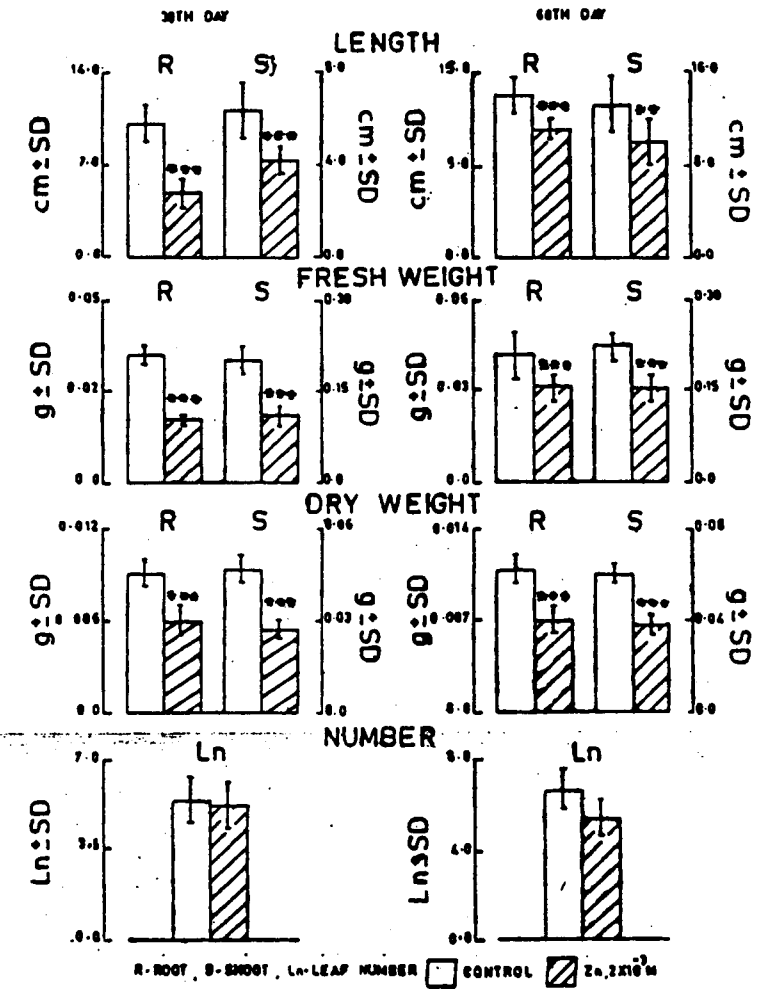

Fig. 1. Effects of Zn amendment in soil (2×10^{-3} M Zn/l soil) on growth and yield of *Spinacia oleracea* cv All green.

(1973) in bean and soybean and Dogar and Vanhai (1979) in *Oryza sativa*. The leaf number was not affected significantly but the leaf area was severely affected, being 55% of the control. The fresh weight of shoot was also reduced considerably being 81% of control. In general, levels of chlorophyll components and Hill activity of chloroplasts isolated from treated plants, were lower (Table 1). These observations are in agreement to those of Hampp *et al.* (1976), Rai and Kumar (1980) and Nag *et al.* (1981). Hill activity was 72% of control in treated plants. Uptake and distribution of phosphate and nitrogen were inhibited by Zn in both the crops (Table 2). Oberlaender and Roth (1978) also reported reduction in uptake and distribution of phosphate from the soil into the roots and shoots of young barley plants. Hunter and Vergnano (1953) observed that toxic effects of heavy metals are associated with reduced nitrogen contents in plants.

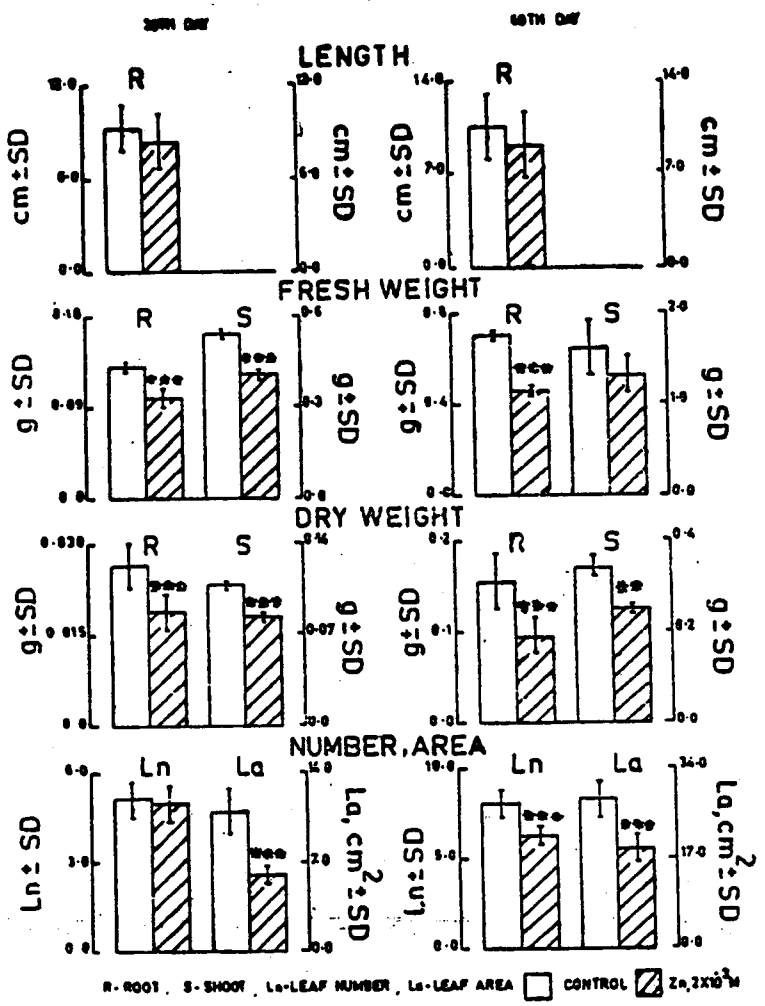

Fig. 2. Effects of Zn amendment in soil (2×10^{-3} M Zn/l soil) on growth and yield of *Coriandrum sativum* cv Selhari.

**Significant at 0·01% probability, ***Significant at 0·001% probability.

TABLE 1. Levels of chlorophyll components and Hill activity in leaves (3rd leaf from apex) of control and Zn treated *Spinacia oleracea* cv All Green and *Coriandrum sativum* cv Selhari.

Parameter	Control	Zn (2×10^{-3} M)
	Spinacia oleracea cv All Green	
Chlorophyll *a*	0·34 ± 0·02	0·27** ± 0·01
Chlorophyll *b*	0·30 ± 0·04	0·17* ± 0·04
Total chlorophyll mg/gfw±S.D.	0·64 ± 0·06	0·44** ± 0·04
Hill activity µM DCPIP red./h/mg Chl.±S.D.	7·32 ± 0·12	5·12*** ± 0·07
	Coriandrum sativum cv Selhari	
Chlorophyll *a*	0·35 ± 0·02	0·26*** ± 0·01
Chlorophyll *b*	0·30 ± 0·04	0·22* ± 0·02
Total chlorophyll mg/gfw±S.D.	0·65 ± 0·07	0·48* ± 0·04
Hill activity µM DCPIP red./h/mg Chl.±S.D.	6·63 ± 0·07	4·27*** ± 0·09

*Significant at 0·05% probability, **Significant at 0·01% probability, ***Significant at 0·001% probability.

In contrast to phosphate and nitrogen the levels of total heavy metal was much higher in treated plants (Table 2).

TABLE 2. Effects of Zn (2×10^{-3} M) amendment of soil on uptake and translocation of nitrogen (N), phosphate (P) and total heavy metals (tHm) in *Spinacia oleraeea* cv All Green and *Coriandrum sativum* cv Selhari.

Plant parts	Days from emergence: 30 Control N	30 Control P	30 Control tHm	30 Treated N	30 Treated P	30 Treated tHm	60 Control N	60 Control P	60 Control tHm	60 Treated N	60 Treated P	60 Treated tHm
	mg gm^{-1} dw±SD						mg gm^{-1} dw±SD					
Spinacia oleracea cv All Green												
Root	36·28 ±1·21	3·57 ±0·12	0·16 ±0·006	19·44*** ±0·89	2·38*** ±0·09	0·25*** ±0·009	38·88 ±1·31	2·08 ±0·09	0·25 ±0·10	24·62*** ±1·01	1·49*** ±0·06	0·30*** ±0·013
Shoot	37·58 ±1·27	4·58 ±0·16	0·12 ±0·003	23·32*** ±0·90	3·57*** ±0·12	0·19*** ±0·008	51·85 ±1·59	3·27 ±0·013	0·19 ±0·009	38·88*** ±1·21	2·32*** ±0·10	0·25*** ±0·010
Coriandrum sativum cv Selhari												
Root	36·28 ±1·20	0·42 ±0·014	0·24 ±0·008	22·03*** ±1·01	0·24*** ±0·009	0·29*** ±0·009	24·88 ±1·10	0·18 ±0·009	0·28 ±0·009	19·44*** ±1·02	0·09*** ±0·003	0·35*** ±0·012
Shoot	32·40 ±1·10	0·36 ±0·011	0·15 ±0·007	20·73*** ±0·93	0·24*** ±0·008	0·21*** ±0·008	23·32 ±1·17	0·42 ±0·013	0·16 ±0·008	12·96*** ±1·05	0·30*** ±0·011	0·23*** ±0·310

***Significant at 0·001% probability.

Reduction in growth and fresh weight of shoot in treated plants may be due to low levels of chlorophyll components, Hill activity and low uptake of phosphate and nitrogen from soil. Further, the edible parts of treated plants are not only nutritionally of poorer quality but also create a hazard due to higher heavy metal content.

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REFERENCES

ALLEN R J L 1940 The estimation of phosphorus. *Biochem J* 34 858–865

ARNON D I 1949 Copper enzyme in isolated chloroplast. Polyphenol oxidase in *Beta vulgaris*. *Plant Physiol* 24 1–15

BANERJI D AND KUMAR N 1975 Partial inhibition of Hill activity in isolated chloroplasts by kinetin. *Biochem Biophys Res Commun* 65 940–944

BANERJI D AND RAUF A 1977 Higher than half leaf Hill activity in cotyledonary chloroplasts in certain legumes. *Biochem Biophys Res Commun* 85 921–926

DOGAR M A AND VANHAI M A 1979 Effects of increasing zinc concentrations in nutrient solution on growth and kinetics of zinc uptake by rice (*Oryza sativa*). *Z Pflanzenphysiol* 93 207–218

HAMPP R, BEULICH K AND ZIEGLAR H 1976 Effects of zinc and cadmium on photosynthetic CO_2–fixation and Hill activity of spinach chloroplasts. *Z Pflanzenphysiol* 77 336–344

HUNTER J G AND VERGNANO O 1953 Trace element toxicities in oat plants. *Ann Appl Biol* 40 761–777

NAG P, PAUL A K AND MUKHERJI S 1981 Heavy metals effects in plant tissues involving chlorophyll, chlorophyllase, Hill activity and gel electrophoretic patterns of soluble proteins. *Ind J Exp Biol* 19 702–706

OBERLAENDER H AND ROTH K 1978 Effects of heavy metal chromium, nickel, copper, zinc, cadmium, mercury and lead on uptake and translocation of K and P by young barley plants. *Z Pflanzenerachr Rodenkd* 141 107–116

OSER B L 1965 *Hawk's Physiological Chemistry*. New Delhi : McGraw Hill Publ Co Ltd

RAI L C AND KUMAR A 1980 Effects of certain environmental factors on the toxicities of Zn to *Chlorella vulgaris*. *Microbios Lett* 13 79–84

RAUSER W E 1973 Zinc toxicity in hydroponic culture. *Can J Bot* 51 301–304

SANDELL E B 1950 *Colorimetric Determination of Traces of Metals*. 2nd ed. New York : Interscience Publ Inc

SNELL F D AND SNELL C T 1954 *Colorimetric Methods of Analysis*. New York : D Van Nostrand Company Inc

VEER B AND LATA K 1987 Effects of polluted municipal waste water on growth, yield and levels of some biochemical components of *Triticum aestivum* L. cv SD-2204. *Acta bot Indica* 15 242–246