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TOXIC EFFECT OF ZINC ON GROWTH AND NUTRIENT ACCUMULATION OF COW PEA (*Vigna unguiculata* .L)

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ABSTRACT. Zinc is a heavy metal; this element is considered as environmental hazard.Toxicity effects of Zinc on growth and development of plants including inhibition of germination process decrease of growth and biomass of plant. The aim of this research is to study accumulation of Zinc along with nutrients and its effect on the growth of Cow pea plant (*Vigna unguiculata.*L). Thus, cow pea seedlings grown in petriplates lined with filter paper undergoing, different treatments of Zinc (control, 10, 25, 50, 75, 100, 150 and 200 ppm). After one week seedlings were removed and morpho physiological parameters like root length, shoot length and dry weight of plants and accumulation of nutrients along with Zinc in roots and shoots were determined. The results indicated that the concentrations more than Zinc 50 mg/L zinc cause the reduction of morphophysiology parameters in the treatment plants rather than control plant and zinc addition in the cultures caused enhancement of zinc content in roots and shoots of cow pea seedlings. Similarly nutrient accumulation also affected by increasing concentrations of cow pea. It was also noted that accumulation of zinc in the roots was much higher than the shoots of the seedlings under treatment.

1. INTRODUCTION

Environmental pollution is one of the major problems of world and increasing day by day due to urbanization and industrialization. Large amount of industrial effluents discharged due to rapid industrialization is a serious threat to India. Industrial effluents are rich in organic and inorganic matter including heavy metals (Dell and Wilson, 1985; Chang et al .,2007). Major industries in India are electroplating, textile dye, paper mill, tannery, fertilizer industries etc. Among these industries, Zinc electroplating industry effluent plays an important role in water pollution. Zinc electroplating industry effluent is rich in total dissolved solids, total solids, hardness, BOD, COD and contains large quantities of inorganic pollutants like chloride, sulphate, nitrate and organic compounds. The large amount of electroplating industry effluents are discharged in to the river and soil (Marschner and Cakmak 1989). Plants are capable of accumulating heavy metals and so play a significant role in cleaning up the environment. Metals such as Zinc, Sodium, Potassium and Calcium are the best candidates for removal by phytoextraction because it has been shown that it is preferred by the majority of plants that uptake and absorb unusually large amounts of metals and acts as micronutrients for the growth of plants. Zinc is one of the micronutrients essential for normal growth and development of plants as it is known to be required in several metabolic processes (Akay , 2011).

The use of micronutrients in soil nutrition is the pillars of agriculture in developed countries. Proper plant nutrition is one of the most important factors in improving the quality and quantity of plants product. Zinc is required in small but critical concentrations to allow several key plant physiological pathways to function normally (Alloway, 2002; Mousavi et al., 2011; Yosefi et al., 2011). With increasing utilization of chemical fertilizer and on the other hand increasing fertilizer prices due to their dependence on fossil fuels, water, air and soil pollution and ignorance in the use of chemical fertilizers are problems that must be solved with appropriate methods (Alloway, 2008). Zinc is essential element for crop production and optimal size of fruit, also it required in the carbonic enzyme which present in all photosynthetic tissues, and required for chlorophyll biosynthesis (Graham et al., 2000; Ali et al., 2008; Mousavi, 2011; Xi-Wen et al., 2011). In general zinc have main role in synthesis of proteins, enzyme activating, oxidation and revival reactions and metabolism of carbohydrates. By utilizing of fertilizers contain zinc and other micronutrients, performance on quality of crops is increasing and with shortage of this elements due to decline in plant photosynthesis and destroy RNA, amount of solution carbohydrates and synthesis of protein decreased and then performance and quality of crop will be decreased (Mousavi et al., 2007; Efe and Yarpuz, 2011). In plants, zinc plays a key role as a structural constituent or regulatory co-factor of a wide range of different enzymes and proteins in many important biochemical pathways and these are mainly concerned with: carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens (Alloway, 2008).

When zinc amount is excessive, causes toxicity in plants. Leaf and root growth and development decreased by zinc toxicity. Production of NADPH in plant chloroplasts are decreases with increasing zinc concentration. In addition, production of free radicals will increases in plants. Activity of RUBP carboxylase enzyme and Photosystem II decreases by zinc toxicity. Zinc toxicity reduces ATP synthesis and chloroplasts activity and photosynthesis will decline as a result. Also, large amounts of zinc reduces uptake of P and Fe.More than 300 ppm of zinc in plant caused toxicity. (Prasad et al., 1999; Vitosh et al., 1994; Teige et al, 1990; Ruano et al., 1988). Resistance to zinc is differences in various plants, the plants such as beans, corn, onions, sorghum, rice, citrus fruits and grapes have most sensitivity to zinc deficiency, barley, lettuce, potatoes, soybeans, sugar beet and tomato have moderate sensitivity to zinc deficiency and carrots, alfalfa, asparagus, radish, and forage plants are resistance to zinc deficiency (Vitosh et al., 1994).With these aspects in view, the present investigation was made to study the effect of different concentrations of zinc on the growth, mineral nutrients and accumulation of zinc in cowpea.

2. MATERIALS AND METHODS

The Cow pea (*Vigna unguiculata* L.) seeds were obtained from Tamilnadu Agricultural University, Vamban, Pudukkottai District,Tamil Nadu. The seeds are uniform size; colour was selected for the experimental purpose. Zinc sulphate was used as the source of preparation of stock solution of Zinc. From this stock solution different concentrations (Control, 10, 25, 50, 75,100,150,200 and 300 ppm) of Zinc solution were prepared freshly at the time of experiments. The selected cow pea seeds were sown in the petriplates lined with filter paper. The seed irrigated with normal tap water was maintained as the control. Three replicates were maintained. Plant Growth were measured by using centimeter scale and recorded. The same plant samples were taken for morphological studies were also used for the determination of dry weight by using electrical single pan balance. Their dry weights were determined by keeping the plant materials in a hot air oven at 80 °C for 24 hrs and recorded. The mineral elements such as Total nitrogen (Jackson, 1958), Phosphorus (Black, 1965), Potassium (Williams and Twine, 1960), Calcium and magnesium (Yoshida *et al.,* 1972), manganese, iron, copper and zinc accumulation was also measured by using the method of Pipper, 1966.

3. DISCUSSION

In this experiment, the percentage of germination increase up to 50 ppm of zinc concentrations when compared to control. Similarly higher concentrations of Zinc reduce drastically the germination (Table -1). Similar inhibition of germination percentage at higher concentrations of Zinc was observed by Moniruzzaman et al., 2008 and Vijayarengan, 2012. The improvement in the germination and growth efficiency of plant organ might also be due to beneficial effects of zinc treatments on the physiological activities and other enzyme reaction in the transformation of carbohydrates and activities of hexokinase of plants which were responsible in improving the growth of plant and its component organs ultimately influencing the relative development of plant parts and their growth efficiency (Vijayarengan and Mahalakshmi., 2013).The reduction in germination percentage of plants at higher zinc concentrations may be attributed to the interference of metal ions, which may inhibit seed germination by exerting unfavourable effect on the activities of hydrolytic enzymes involved in the mobilization of major seed reservoirs such as starch, protein, RNA and phytin (Dua and Sawhney, 1991).

The Root length and shoot length and dry weight of cow pea are gradually decreased with the increase in zinc concentrations (Table -1). While the lower concentrations of zinc (up to 50 ppm) increase the growth and dry weight of cow pea seedlings. The inhibition of root growth was influenced by the concentration of heavy metals because of the surface accumulation and sensitive to root primordia. It was more pronounced at higher concentrations of zinc (Bitell *et al.,* 1974).In this experiment; there was a gradual decrease in seedling dry weight with the progressive increase in zinc concentrations above 50 ppm (Table -1). The lowest dry weight of cow pea seedlings was recorded in seedlings treated with 200 ppm zinc concentrations and the highest dry weight was registered at 50 ppm. The reduction in seedling dry weight was observed from 75 ppm zinc concentrations onwards. A decrease in biomass productivity might be attributed to a disruption in nitrogen metabolism of seedlings under heavy metal stress (Chatterjee and Chatterjee, 2000).

The mineral elements such as nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron and copper content of cow pea increased upto 50 ppm and are gradually decreased with the increase in zinc concentrations (Table-2). It may be due to competition of zinc ions with potassium, which in turn exercised a regulatory control on potassium uptake (Lanoreaux and Chaney, 1978).While the zinc accumulation increased gradually with the increase in zinc concentrations. Among treatments, a higher zinc content of cow pea was observed in 200 ppm zinc concentrations when compared to other zinc treatments. Similarly root accumulate higher amount of zinc than in shoot. It could be due to immobilization of zinc in the vacuoles of the root cells, thus rendering it less toxic, which may be a natural toxicity response of the plant (Shanker *et al.,* 2004).

Table 1. Seed germination, Seedling growth (cm /seedling) and Seedling dry weight (g/seedling) of Cow pea (*Vigna unguiculata* L.) as influenced by different concentrations of Zinc

Zinc Concentrations (ppm)	Germination percentage	Root length (cm/seedling)	Shoot length (cm/seedling)	Dry weight (g/seedling).
Control	84.0	9.2 ± 0.424	11.2 ± 0.71	0.156 ± 0.0128
10	90.0 (-4.08)	9.5 ± 0.415	12.5 ± 0.65	0.223 ± 0.0126
25	94.0 (-8.16)	10.4 ± 0.325	13.5 ± 0.60	0.243 ± 0.120
50	98.0 (-14.28)	10.6 ± 0.462	14.2 ± 0.07	0.272 ± 0.0116
75	82.0 (-16.32)	9.0 ± 0.423	10.6 ± 0.60	0.143 ± 0.0114
100	74.0 (-24.48)	8.5 ± 0.315	8.7 ± 0.55	0.128 ± 0.0042
150	68.0 (-30.61)	8.0 ± 0.40	7.5 ± 0.45	0.113 ± 0.0038
200	58.0 (-40.81)	5.6 ± 0.315	7.2 ± 0.014	0.098 ± 0.0049

± Standard deviation.

Table 2. Nutrient composition and Zinc accumulation of Cow pea (*Vigna unguiculata* L.) under different concentrations of Zinc

Zinc concentrations (ppm)	N (µg/g)	P (µg/g)	K (µg/g)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)
Control	60.1 ± 3.6	15.2 ± 0.91	47.0 ± 2.0	25.0 ± 1.2	17.0 ± 1.0	25.5 ±1.62	23.0 ±1.44	13.3 ± 0.85	34.0 ± 1.8
10	66.5 ± 3.2	16.0 ± 0.88	48.0 ± 2.4	26.0 ± 1.2	18.5 ± 1.0	26.5 ±1.60	25.5 ±1.40	14.0 ± 0.80	42.5 ± 1.8
25	70.3 ± 3.3	16.5 ± 0.85	49.5 ± 2.37	27.5 ± 1.3	20.0 ± 0.9	27.6 ±1.55	27.2 ± 1.5	15.5 ± 0.72	44.2 ± 1.6
50	72.1 ± 3.0	18.3 ± 0.80	57.0 ± 2.2	30.5 ± 1.2	22.5 ± 0.82	32.2 ±1.40	29.2 ± 1.5	16.5 0.65	48.5 ± 1.6
75	48.5 ± 2.8	12.2 ± 0.70	43.5 ± 2.0	25.0 ± 1.2	16.2 ± 0.80	26.2 ±1.31	30.5 ± 1.4	13.0 ± 0.60	35.0 ± 1.7
100	43.2 ± 2.5	11.5 ± 0.65	35.2 ± 1.8	23.5 ± 1.1	15.0 ± 0.75	24.5 ±1.30	32.5 ± 1.4	12.5 ± 0.55	33.5 ± 1.5
150	36.5 ± 2.5	10.2 ± 0.63	30.2 ± 1.6	22.0 ± 1.1	14.0 ± 0.70	22.0 ±1.25	34.5 ± 1.3	12.2 ± 0.50	30.2 ± 1.6
200	28.2 ± 2.3	9.5 ± 0.66	28.6 ±1.5	20.2 ± 1.0	12.2 ± 0.60	20.5 ±1.20	36.2 ± 1.2	10.00 ± 0.50	28.6 ± 1.2

± Standard deviation.

4. CONCLUSION

It can be concluded that the level of zinc above 200 ppm is proved to be lethal to cow pea crop. However, zinc contaminated water can be properly treated and then discharged into nearby water bodies in order to prevent water pollution. Both government and public sector should join hands in the creation of a clean and green environment.

Reference

[1] Akay A, 2011. Effect of zinc fertilizer applications on yield and element contents of some registered chickpeas varieties. African Journal of Biotechnology. 10: 13090-13096.

[2] Ali S, Riaz KA, Mairaj G, Arif M, Fida M, Bibi S, 2008 Assessment of different crop nutrient management practices for yield improvement. Australian Journal of Crop Science, 2(3):150-157.

[3] Alloway BJ, 2002 Zinc-the vital micronutrient for healthy, high-value crops. International Zinc Association (IZA). University Extension.

[4] Alloway BJ, 2008. Zinc in soils and crop nutrition. Second edition, published by IZA and IFA, Brussels, Belgium and Paris, France.

[5] Bitell, J.E., D.E. Koeppe and R.J. Miller, 1974. Sorption of heavy metal cations by corn mitochondria and the effects on electron and energy transfer reactions. *Physiol. Plantarum,* 30: 226-230.

[6] Black, C.A., 1965. *In:* Methods of Soil Analysis Part 2. Chemical and Microbiological Properties, American Society of Agronomy, Inc., Madison, Wisconsin, p. 242.

[7] Cakmak I, 2008. Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? Plant Soil, 302:1-17.

[8] Chang WY, Lu BY, Yun JJ, Ping YL, Zheng Y, Xin XS, An LG, Wei S, Chun Z, 2007. Sufficiency and deficiency indices of soil available zinc for rice in the alluvial soil of the coastal yellow sea. Rice Science, 14(3):223-228.

[9] Chatterjee, J. and Chatterjee, C. (2000). Phytoxicity of cobalt, chromium and copper in Cauliflower. *Environ. Pollut*., 109:69-74.

[10] Dell B, Wilson, A.S., 1985. Effect of zinc supply on growth of three species of eucalyptus seedling and wheat. Plant Soil, 88:377-384.

[11] Dua, A. and S.K. Sawhney, 1991. Effect of chromium on activities of hydrolytic enzymes in germinating pea seeds. *Environ. Exp. Bot.,* 31: 133-139.

[12] Efe L, Yarpuz E, 2011. The effect of zinc application methods on seed cotton yield, lint and seed quality of cotton (*Gossypium hirsutum* L.) in east Mediterranean region of Turkey. African Journal of Biotechnology. 10: 8782-8789.

[13] Graham RD, Welch RM, Bouis HE, 2000. Addressing micronutrient nutrition through enhancing the nutritional quality of staple foods. Advances in Agronomy 70:77-161.

[14] Jackson, M.L., 1958. Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi, pp. 22-31

[15] Lanoreaux, R.J.W.R. and S. Chaney, 1978. The effect of cadmium on net photosynthesis, transpiration and dark respiration of excised silver maple leaves. *Plant Physiol.,* 43: 231-236.

[16] Marschner H, Cakmak J, 1989. High light intensity enhances chlorosis and necrosis in leaves of zinc, potassium, and magnesium deficient bean (*Phasseolus vulgaris*) plants. Journal of Plant Physiology, 134:924-934.

[17] Moniruzzaman M, Mozumder SN, Islam MR, 2008. Effects of Sulfur, Boron, Zinc and Molybdenum on Yield and Profitability of Broccoli (*Brassica oleracea* L. Var. italica). J Agric Rural Dev., 6 (1&2): 55-61.

[18] Mousavi SR, 2011. Zinc in crop production and interaction with phosphorus. Australian Journal of Basic and Applied Sciences. 5: 1503-1509.

[19] Mousavi SR, Galavi M, Ahmadvand G, 2007. Effect of zinc and manganese foliar application on yield, quality and enrichment on potato (*Solanum tuberosum* L.). Asian Journal of Plant Sciences, 6:1256-1260.

[20] Mousavi SR, Shahsavari M, Rezaei M, 2011. A general overview on manganese (Mn) importance for crops production. Australian Journal of Basic and Applied Sciences. 5: 1799-1803.

[21] Piper, C., 1966. Soil and plant analysis. Asian Hans Publishers, Bombay, pp. 11-36.

[22] Prasad K, Saradhi PP, Sharmila P, 1999. Concerted action of antioxidant enzymes and curtailed growth under zinc toxicity in *Brassica juncea*. Environmental and experimental Botany, 42:1- 10.

[23] Ruano A, Poschenrieder CH, Barcelo I, 1988. Growth and biomass partitioning in zinc toxic bush beans. Journal of Plant Nutrient, 11:577-588.

[24] Shanker, A.K., M. Djanaguiraman, R. Sudhagar, C.N. Chandrashekar and G. Pathmanabhan, 2004. Differential antioxidative response of ascorbate glutathione pathway enzymes and metabolites to chromium speciation stress in greengram (*Vigna radiata* (L.) R. Wilczek, cv. CO 4) roots. *Plant Sci.,* 166: 1035-1043.

[25] Teige M, Huchzermeyer B, Sehultz G, 1990. Inhibition of chloroplast ATPsenthease\ATPase is a primary effect of heavy metal toxicity in spinach plants. Biochemie und Physiologie der Pflanzen, 186:165-168.

[26] Vijayarengan, P., 2012. Growth and biochemical variations in radish under zinc applications. Intern. J. Res. Plant Science, 2(3): 43-49.

[27] Vijayarengan.P and G.Mahalakshmi,2013.Zinc Toxicity in Tomato Plants, World Applied Sciences Journal 24 (5): 649-653.

[28] Vitosh ML, Warncke DD, Lucas RE, 1994. Zinc determine of crop and soil. Michigan State

[29] Williams, C.H. and V. Twine, 1960. *In:* Peach, K. and M.V. Tracey (eds.), Modern Methods of Plant Analysis, Vol. 5, Springer Verlag, Berlin, pp. 3-5.

[30] Xi-Wen Y, Xiao-Hong L, Xin-Chun T, William GJ, Yu-Xian C, 2011. Foliar zinc fertilization improves the zinc nutritional value of wheat (*Triticum aestivum* L.) grain. African Journal of Biotechnology.10: 14778-14785.

[31] Yosefi K, Galavi M, Ramrodi M, Mousavi SR, 2011. Effect of bio-phosphate and chemical phosphorus fertilizer accompanied with micronutrient foliar application on growth, yield and yield components of maize (Single Cross 704). Australian Journal of Crop Science, 5(2):175-180.

[32] Yoshida, S., D. Fordo, J. Cork and K. Gomez, 1972. Laboratory manual for physiological studies of rice, 3rd edn., The International Rice Research Institute, Philippines, pp. 11-23.