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Effect of Zinc on Germination, Seedling Growth and Biochemical Content of Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub)

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Abstract

Cluster bean seeds were grown in the presence of 0, 10, 25, 50, 100,150 and 200 mgl^{-l} of zinc sulphate solution in order to asses the effect of metal on germination, growth and biochemical changes. The results indicated that low level of zinc concentration (10 and 25 mgl^{-l}) showed a significant increase in the germination, seedling growth and biochemical content; whereas the higher concentrations (50-200 mgl^{-l}) decreased the same except for proline content.

Key Words: Biochemical content, cluster bean, germination, Zinc

Introduction

Heavy metals in growth media can function as stresses, causing physiological constraints that decrease plant vigor and inhibit plant growth [1]. Numerous studies conducted on the detrimental effects of metallic pollutants have shown that beyond a particular concentration, the metals can prove to toxic to plants and animals. Heavy metals like zinc are required as structural and catalytic components of protein and enzymes for normal growth and development. But when present in elevated levels in soils, they are toxic and can ultimately cause the death of plants [2]. Hence efforts have been made to establish the toxic level of zinc on seed germination, growth and various biochemical content of cluster bean seedling in the present study.

Materials and Methods

The seeds of Cluster bean Var. CP78 were surface sterilized with 0.2% mercuric chloride and then washed with distilled water. Twenty five seeds were evenly placed in each petri dishes lined with filter paper. The various concentration of zinc sulphate solution (0, 10, 25, 50, 100,150 and 200 mgl^{-l}) were prepared and used for germination studies. Control sets were run with seeds kept in distilled water. Each treatment including the control was replicated five times. The petri plates were kept in seed germinator. The germination percentage, seedling growth, fresh and dry weight (dried at 500C for 24 hours) were recorded after 9 days. The biochemical parameters were estimated as per the method as follows, Chlorophyll [3], Carotenoid [4], Total sugars [5], Starch [6], Amino acids [7], Protein [8] and Proline [9] respectively.

Result and Discussion

Plants treated with low level of zinc (10 and 25 mgl^{-l}) showed a significant increase in germination, seedling growth, fresh and dry weight over the control (Table 1; Figure 1). This value indicates that zinc at lower level had a significant stimulatory, beneficiary and nutritional effect [10]. The growth process beyond these levels (50–200 mgl^{-l}) has an adverse effect. The decrease in seed germination of cluster bean can be attributed to the accelerated breakdown of stored food materials in seed by the application of zinc. Reduction in seed germination can also be attributed to alterations of selection permeability properties of cell membrane. The decrease in seed germination of cluster bean due to zinc treatment is in conformity with the previous findings [11, 12].

The reduced seedling length at higher concentrations of zinc could be the reduction in meristamatic cells present in this region and some enzymes contained in the cotyledon and endosperms. Cells become active and begin to digest and store food which is converted into soluble form and transported to the radicle and plumule tips for enzyme amylase which converts starch into sugar and protease act on protein. So when the activities of hydrolytic enzyme are affected, the food does not reach to the radicle and plumule affecting the seedling length [13]. The reason for different response of seedling and root growth to heavy metals is not known but might be due to rapid accumulation of heavy metals in root than shoot or to faster rate of detoxification in shoot than root.

The total chlorophyll and carotenoid content of cluster bean seedlings increase up to 25 mgl^{-l} of zinc level. Further increase in zinc level significantly decreased the total chlorophyll and corotenoid content (Table 2; Figure 2). The increased chlorophyll and carotenoid content was obviously due to zinc at low level act as a structural and catalytic components of proteins, enzymes and as cofactors for normal development of pigment biosynthesis [14]. The excess zinc treatment brought about a marked depression in photosynthetic pigment in plants. It might be due to excess supply of zinc resulting in interference with the synthesis of chlorophyll. The formation of chlorophyll pigment depends on the adequate supply of iron. Granick [15] has suggested protoporphyrin is a precursor for chlorophyll synthesis. The excess supply of zinc seems to prevent the incorporation of iron in protoporphyrin molecule resulting in the reduction of chlorophyll pigment. This was strengthened by the fact that excessive amounts of a range of heavy metals such as copper

[16], cobalt [17] induced chlorosis in plants which were usually similar to the chlorosis of iron deficiency. Impaired chlorophyll development by heavy metals may be due to the interference to protein, the treatments presumably blocked the synthesis and activities of enzyme proteins responsible for chlorophyll biosynthesis.

Sugar and starch content (Table 2; Figure 2) showed a decreasing trend with progressive increase in zinc content, however 10 and 25 mgl^{-l} of zinc level produced positive effect on the sugar and starch content which is in consonance with previous findings in wheat leaves [18]. The observed decline with respect to the high level of zinc may be due to its role on the enzymatic reactions related to the cycles of carbohydrate catabolism [19]. The decrease in the total carbohydrate content corresponded with the photosynthetic inhibition or stimulation of the respiration rate [20, 22].

Amino acid and protein content (Table 2; Figure 2) were high at lower concentrations of zinc (10 and 25 mgl^{-l}) further the values decreased with an increace in zince level (50–200 mgl^{-l}); this result is an agreement with previous reports [22, 23]. The inhibition of excess zinc in amino acid and protein might be due to binding of metals with the sulfhydryl group of protein and causing deleterious effect in the normal protein form.

The proline content increased with increasing concentration of zinc, maximum proline content was observed at 200 mgl^{-l} and minimum proline content was observed at 10 mgl^{-l} of zinc (Table 2; Figure 2); this would be evident form the previous reports [22, 23]. Proline is known to accumulate under heavy metal exposure and considered to involve in stress resistance. It may also be argued that proline accumulation helps to conserve nitrogenous compounds and protect the plant against heavy metal stress. The accumulation of proline also acts as a membrane stabilizing agent under stress conditions [24].

From these observations it can be concluded that lower level of zinc (10 and 25 mgl^{-l}) had stimulatory effect on germination, seedling growth and biochemical content of cluster bean seedling. Application beyond these levels (50–200 mgl^{-l}), adversely affected the same, except praline and it also indicated that more stimulatory effect could be achieved in 10 mgl^{-l} than 25mgl^{-l} of zinc over the control.

Table 1. Effect of zinc on germination, growth, fresh and dry weight of cluster bean (*Cyamopsis tetragoroloba* (L.) Taub)

Zinc concentrations (mgl^{-1})	Germination percentage	Root length (cm)	Shoot length (cm)	Fresh weight of root (g/seedling)	Fresh weight of shoot (g/seedling)	Root weight (g/seedling)	Shoot dry weight (g/seedling)
0	95	5.86	14.12	0.912	2.172	0.112	0.344
10	98 (+3.15)	6.82 (+16.38)	16.04 (+13.59)	1.089 (+19.01)	2.482 (+14.27)	0.130 (+16.07)	0.401 (+16.56)
25	96 (+1.05)	6.08 (+3.75)	14.95 (+5.87)	0.965 (+5.46)	2.317 (+6.67)	0.121 (+8.03)	0.368 (+6.97)
50	84 (-11.57)	5.05 (-13.82)	13.48 (-4.53)	0.815 (-10.92)	1.967 (-9.43)	0.097 (-13.39)	0.300 (-12.79)
75	72 (-24.20)	4.76 (-18.77)	11.45 (-18.90)	0.708 (-22.62)	1.762 (-18.87)	0.085 (-24.10)	0.259 (-24.70)
100	66 (-30.52)	3.52 (-39.93)	9.26 (-34.41)	0.0617 (-32.56)	1.530 (-29.55)	0.067 (-40.17)	0.223 (-35.17)
200	39 (-58.91)	2.45 (-58.19)	6.78 (-51.98)	0.458 (-49.94)	1.362 (-37.29)	0.051 (-54.46)	0.174 (-49.41)

Figures in parenthesis represent per cent reduction (-) over control

Table 2. Effect of zinc on chlorophyll, carotenoid, sugar, starch, amino acid, protein and proline content (mg g^{-1} fresh weight) of cluster bean (*Cyamopsis tetragoroloba* (L.) Taub)

Zinc concentrations (mgl^{-1})	Total chlorophyll	Carotenoid	Total sugar	Starch	Amino acid	Protein	Proline
0	0.445	0.254	4.125	3.145	2.124	19.234	0.216
10	0.508 (+14.15)	0.291 (+14.56)	4.691 (+13.72)	3.679 (+16.97)	2.427 (+14.26)	22.545 (+17.21)	0.188 (-12.96)
25	0.466 (+4.71)	0.263 (+3.54)	4.445 (+7.75)	3.360 (+6.83)	2.279 (+7.29)	20.314 (+5.61)	0.205 (-5.09)
50	0.405 (-8.98)	0.231 (-9.05)	3.868 (-6.23)	2.910 (-7.47)	1.921 (-9.55)	17.083 (-11.18)	0.234 (+8.33)
75	0.365 (-17.97)	0.207 (-18.50)	3.527 (-14.49)	2.724 (-13.38)	1.755 (-17.37)	15.467 (-19.58)	0.255 (+18.05)
100	0.320 (-28.08)	0.185 (-27.16)	3.145 (-23.75)	2.436 (-22.54)	1.661 (-21.79)	14.159 (-26.38)	0.275 (+27.31)
200	0.279 (-37.30)	0.162 (-36.22)	2.584 (-37.35)	2.090 (-33.54)	1.413 (-33.47)	12.027 (-37.47)	0.287 (+32.87)

Figures in parenthesis represent per cent reduction (-) over control

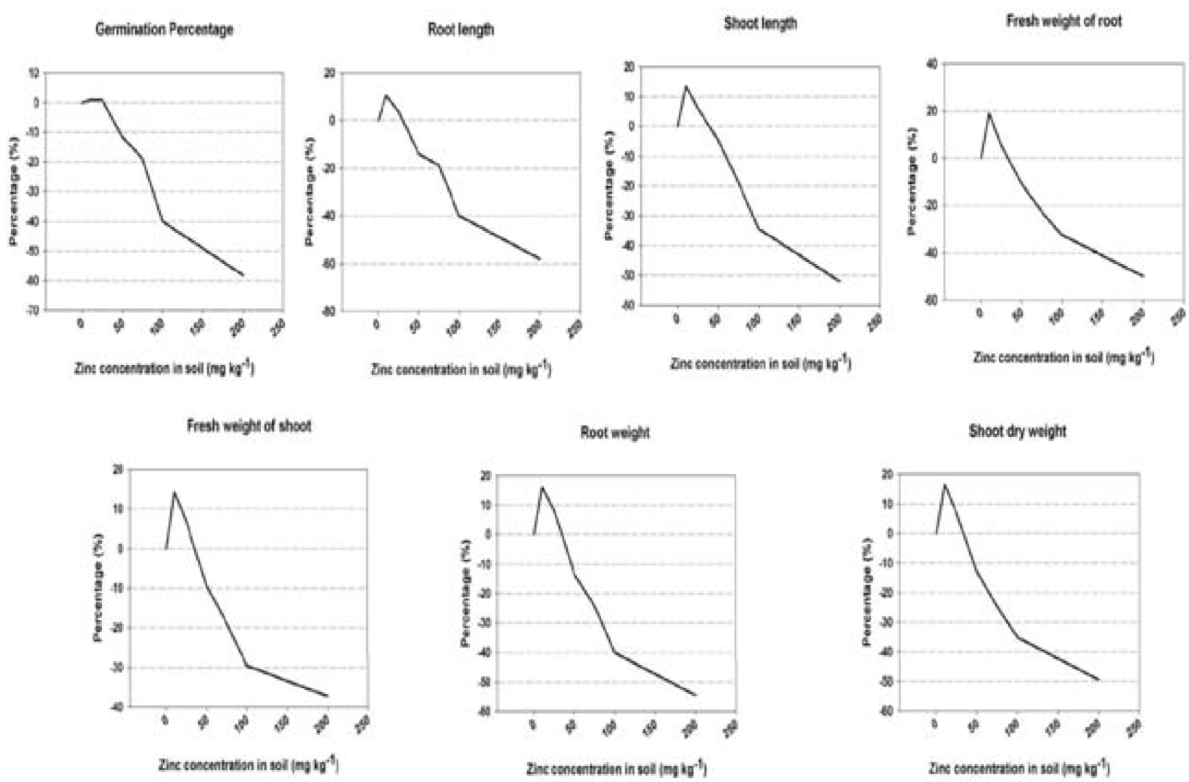

Figure 1. Effect of zinc on germination, growth, fresh and dry weight of cluster bean

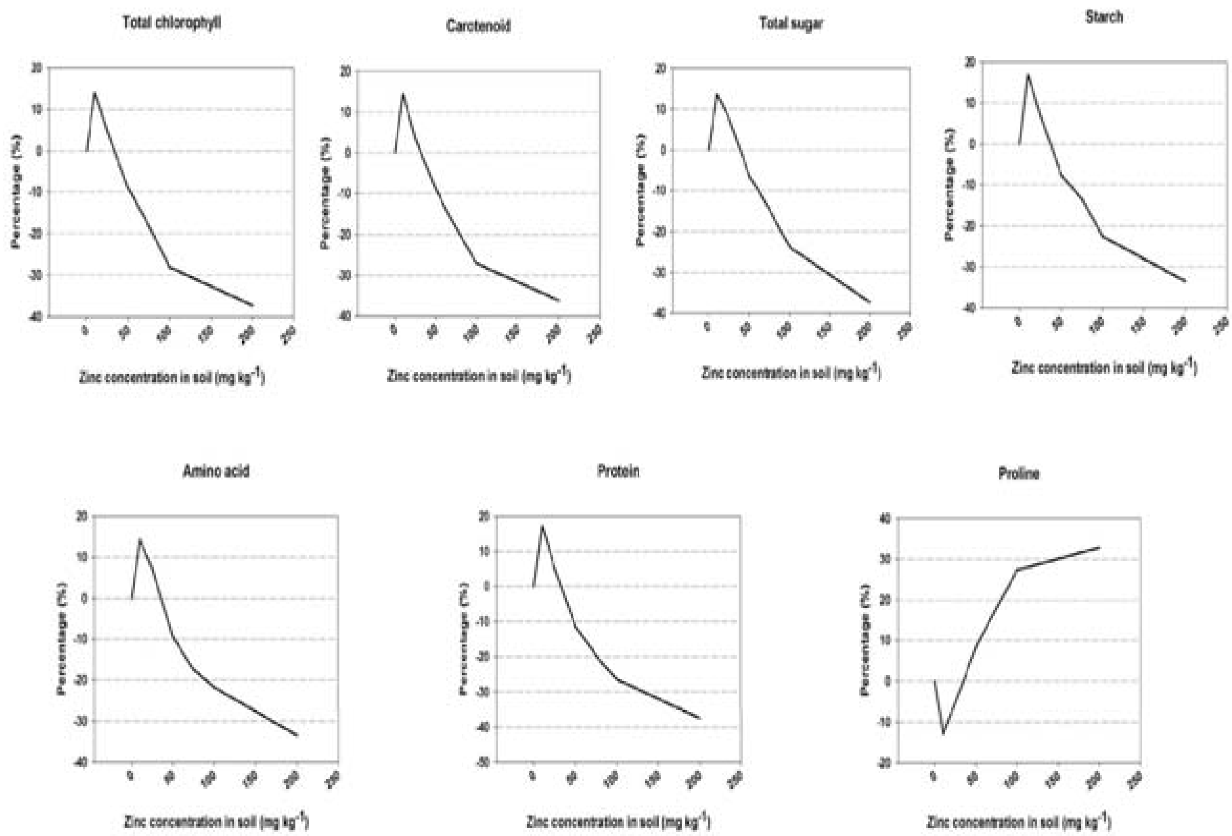

Figure 2. Effect of zinc on chlorophyll, carotenoid, sugar, starch, amino acid, protein and proline content (mg g^{-1} fresh weight) of cluster bean

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