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Full Length Research Paper

Germination and seedling growth of maize (Zea mays L.) seeds in toxicity of aluminum and nickel

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Effect of Nickel and Aluminum toxicity on root, shoot and seedling length, seed germination and seedling dry biomass of maize was studied, compared to control values. Nickel and Aluminum treatments at 0, 50, 100, 150 and 200mg/L affected on seed germinaton and seedling growth of maize as compared to control. Nickel treatments at 0, 50, 100, 150 and 200mg/L concentrations produce significant ($p<0.05$) effects on seed germination and seedling length of maize while nickel treatment at 150mg/L significantly affected root growth and seedling dry biomass as compared to control. Similarly Aluminum treatment from 50 to 200 mg/L affected the root, shoot and seedling length, seed germination and seedling dry biomass of maize as compared to control. Aluminum treatments revealed adverse effects on seedlings of maize as compared to Nickel. Nickel and Aluminum treatment at 200mg/L showed lowest percentage of tolerance in seedlings of maize as compared to control.

Keywords: Nickel, Aluminum, Zea mays, Seedling, Germination

INTRODUCTION

Heavy metals a group of density higher than 5.0 g cm^3 such as cadmium (Cd), chromium (Cr), mercury (Hg), Nickel (Ni), aluminium (Al), silver (Ag), etc., are important environmental pollutants, particularly in areas where there is high anthropogenic pressure. Their presence in the atmosphere, soil and water even in trace concentrations can cause serious problems to all organisms, and heavy metal bioaccumulation in the food chain can be highly dangerous. Heavy metals can enter plants via up take systems for essential cations, including different metal transporters (Eide, 2004; Guerinot, 2000; Perfus Barbeoch et al., 2002; Shenker et al., 2001). Another very important role is that heavy metals up take is enabled by low molecular weight compounds that are actively secreted by the roots of plants and serve as chelators (Shenker et al., 2001).

Al toxicity is the major agriculture problem in several countries over the world. The inhibition of root elongation is a general and very sensitive response of several plant species to the presence of soluble forms of Al. Numbers of hypotheses for Al toxicity mechanism have been proposed, including inhibition of cell division, disjunction of cell wall (CW), inhibition of ion fluxes, disruption of plasma membrane integrity, failure in Ca homeostasis, inhibition of signal transduction pathway and alteration in cytoskeleton structure (Kochian, 1995; Matsumoto, 2000; Rout et al., 2001; de Campos et al., 2003; Ma et al., 2004). Aluminium is the most abundant metal in the earth's crust. It is approximately 7% of crust's mass, and occurs mainly as oxides and aluminosilicates. To plants, aluminium is a major growth imiting factor. Abundant aluminium ions in soil can inhibit plant growth and decrease crop production because of its toxicit. The primary response of plants to aluminium stress occurs in the plant roots. Those roots affected by aluminium ions are inefficient in the absorption of nutrients and water.

Table1. Effect of Nickel on seed germination, Root , shoot and seedling length, seedling dry biomass and Root/Shoot ratio of maize (Zea mays L.)

Ni concentration (Mg/L)	Seed Germination%	Root length(cm)	Shoot length(cm)	Seedling lenght(cm)	Seedling dry biomass(mg)	Root/shoot Ratio
0	94±5.1	5.0±.04	8.6±.11	13.2±.02	39.40±.28	.59±.04
50	83±5.1	4.3±.16	8.0±.06	13.1±.13	38.01±.02	.45±.02
100	76±5.0	4.1±.03	7.6±.06	12.5±.08	36.70±.08	.38±.02
150	73±4.8	3.5±.09	7.3±.14	11.4±.10	35.07±.06	.29±.01
200	67±4.7	3.1±.10	7.1±.15	11.1±.14	33.18±.09	.20±.01

Table 2. Effect of Aluminum on seed germination, Root , shoot and seedling length, seedling dry biomass and Root/Shoot ratio of maize (Zea mays L.)

Al concentrateion (Mg/L)	Seed Germination%	Root length(cm)	Shoot length(cm)	Seedling lenght(cm)	Seedling dry biomass(mg)	Root/shoot Ratio
0	95±3.0	5.1±.03	7.8±.07	13.4±.12	39.20±.30	.60
50	82±2.8	4.2±.03	7.2±.05	12.4±.08	38.1±.31	.42
100	65±5.1	3.7±.03	7.1±.06	11.1±.07	36.00±.31	.22
150	53±5.3	3.1±.02	6.0±.04	9.3±.06	36.1±.34	.12
200	36±3.5	2.6±.04	4.7±.03	7.1±.05	30.10±.11	.07

As a result, plant growth is rapidly inhibited (Li et al. 2000).

High levels of Ni in plants growth media are phytotoxic. Slight increases in the growth of a number of plants species were attributed to low levels of Ni, but its function is not known. Possible benefitic effects of Ni on plant growth are poorly defined and not understood. Some studies have confirmed that the nickel is essential for activation of urease, an enzyme involved with nitrogen metabolisam that is required to process urea. Possibly urease and, therefore, Ni might be required for the mobilization of stored seed-nitrogen through ureides or arginin during early stage of seedlig growth. Without Ni, toxic levels of urea accumulate, leadind to the formation of necrotic lesions (Barker and Pilbeam, 2007; Baccouch et al., 2001). The present manuscript reports results of the percentage of germinated seeds, the root and shoot length of seeds which were treated with different concentration of $NiCl_2$ and $Alcl_3$.

MATERIALS ANDMETHODS

The healthy seeds of maize were collected randomly from from Agricultural Research Center of Karaj were sterilized with 1% Hgcl2 for 15 min, then washed several times with distilled water and germinated for 4 day in the dark on floating plastic net. 15 seeds were placed in Petri dishes on filter paper (Whatman No. 42). Metal treatments of Ni and Al were prepared using $Nicl_2$ and $Alcl_3$ with concentrations of (0, 50, 100,150 and 200 mg/L) respectively. At the start of experiment, 3 ml of respective treatment was added to each set of Petri dish and at every third day, the old solution were replaced with 3 ml of new solution .Add 3 ml of distilled water in control. There were 5 replicates per treatment and the Petri dishes were kept at room temperature (25℃) with 4 hourly light periods provided by 100 watt bulb and the experiment lasted for 14 days.

The experiment was completely randomized. Germination was recorded and seedling dry biomass was determined by placing the seedling in oven at 85℃ for 24 hours. The numbers of germinated seeds were counted after 14 days of treatment. Seedling dry biomass was measured with electrical balance (Metler) with 0.001 g sensitivity, Maximum shoot, root and seedling length were also obtained. The seed germinationand seedling growth data were statistically analyzed by Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) to determine the level of significance at $p<0.05$.

RESULTS

Seed germination, root, shoot and seedling length, root shoot ratio and dry biomass of maize were highly decreased with the treatment of Ni and Al at (0,50, 100, 150, and 200 mg/L). (Tables 1 and 2) Nickel treatments at 50 mg/L concentration produced significant ($p<0.05$) effects on seed germination and seedling length as compared to control. Increase in concentration of Nickel to 100mg/L significantly affected seedling dry biomass of maize as compared to control. Further increase in the concentration of Nickel upto 150 mg/L produced toxic effects on root growth. Similarly, Aluminum treatment at low concentration of 50 mg/L significantly ($p<0.05$) decreased seed germination, seedling and root length as compared to control (Table 2). Aluminum treatment at 100 mg/L produced significant ($p<0.05$) effects on root length of maize as compared with control (Table 2). The tolerance of maize seedlings to Nickel and Aluminum gradually decreased with the increasing concentrations of Nickel and Aluminum as compared to control. Nickel treatments at 50, 100, 150 and 200 mg/L produced 94.12, 82.35, 74.51, 72.56 and 27.45% of tolerance in maize, respectively. Aluminum treatment at similar range of treatments produced 92.15, 80.39, 64.7, 41.18 and 11.76% of tolerance in maize respectively. According to tolerance indices, lead and cadmium treatments at 200 mg/L showed lowest percentage of tolerance in maize seedlings as compared to control. Aluminum treatment produced more toxic effects on maize seedlings than Nickel treatment at all concentrations.

DISCUSSION

Heavy metals have been widely recognized as highly toxic to plants. Plants can be affected directly by air pollutants, as well as indirectly through the contamination of soil and water. At the same time, plant is a part of food chain and may create a risk for man and animals through contamination of food supplies (Farga Šová 1994). Nickel and Aluminum toxicity have become an important issue due to their constant increase in the environment. In the present investigation, seed germination and seedling growth of maize (Zea mays L.) gradually decreased with the increase in concentration of Nickel and Aluminum. Nickel and Aluminum treatments significantly ($p<0.05$) decreased seed germination as compared to control. Seed germination and seedling growth inhibition by heavy metals has also been reported by many other workers (Morzek and Funicelli, 1982; Al-Helal, 1995; Azmat et al., 2005; Shafiq and Iqbal, 2005). The decrease in seed germination of maize (Zea mays L.) can be attributed to the accelerated breakdown of stored food material in seed by the application of Nickel and Aluminum. (Baccouch et al, 2001; Pandey and Sharma, 2002) Some elements such as Cu, Co, Fe, Mo, Mn, Ni and Zn are essential mineral nutrients. Others, such as Al and Pb, however have no known physiological activity (Lasat; 2002). Significant reduction in root growth of maize (Zea mays L.) with the increase in concentration of Aluminu treatment was also observed as compared to control. Aluminum is a highly toxic contaminant that affects many plant metabolic processes. Aluminum can also affect root metabolism, which shows sensitivity to Al^{3+} toxicity by a reduction in lateral root size. This is due to reductions in both new cell formation and cell elongation in the extension region of the root (Desnos 2008; Aremu and Meshitsuka (2005). The effects of heavy metals on plant depend on the amount of toxic substance taken up from a given environment. The seedlings of maize (Zea mays L.) also showed a gradual decrease in dry biomass as concentrations of Nickel and Aluminum increased. Similar observations in crops had been observed by Barceló and Poschenrieder (2002). The toxicity of some metals may be so severe that plant growth is reduced before large quantities of the element can be translocated (Bowman and Floyd 2008). According to the tolerance test, tolerance to Nickel and Aluminum treatments in maize (Zea mays L.) was lower as compared with control. This information can be considered a contributing step in exploring and finding of the tolerance limit of maize (Zea mays L.) at different concentrations of treated metal. Aluminum is found highly toxic to seedling growth of maize (Zea mays L.) as compared to Nickel. Results of the findings can be useful indicator of metal tolerance to some extent for plantation of this species in metal contaminated area. How fairly low amounts of Nickel and Aluminum absorbed over many years could lead to extinction of such an important plants species is unknown. In the metal contaminated areas, further research is needed to determine different levels of metals in the environment and various parts of the plants.

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