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Short Communication

Cadmium stress in rice plants: The effect of cadmium on seed germination and seedling growth of rice plant (Oriza sativa L.)

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Abstract:

Cadmium (Cd) non-essential, but toxic, element for animals and plants is frequently present in paddy fields. Oryza sativa L., a staple food for at least the half of world population, also aquatic plants are known to accumulate heavy metals, easily absorbs Cd by the root, and in this organ the pollutants evoke consistent damages and reducing the root system. In this study the effects of different cadmium chloride concentrations (0 ,15, 25, 35, 45 and 55 ?M) on some physiological and biochemical processes including seed germination, root and shoot fresh and dry weight in rice were investigated. The results showed that after treated, seed germination rate was less affected, but root growth was restrained evidently. It affected the subsequent growth rate in these plants. Higher cadmium concentrations specially at 45 and 55 ?M reduced plant growth significantly. Leaf chlorosis, wilting and leaf abscission were observed in plants treated with cadmium. Also Cd treatment reduced the germination percentage 6.9%, root and shoots length 68.9% and 85.6%, respectively. The decrease of 42.3% in fresh weight was noticed following the treatment with 45, and 55 ?M cadmium doses compared with control treatment, respectively.Based on the results we concluded that, these traits of rice plant are seriously affected by Cd treatment and also these are symptoms of toxicity of Cd element. Our results demonstrate that Cd affect rice root system, by interfering with the formation of the roots and their development. This results into an important change in the root system architecture, which may negatively affect plant survival in highly polluted paddy soils. Therefore, less amount of reduction in a special genotype is referred to the index of tolerance to Cd. Finally, in the metal contaminated areas, further research is needed to determine different levels of metals in the environment and various parts of the plants. Having in mind the value of this crop as a food all over the world, the consequences of the reactivity of its root system to these pollutants is very important for evaluating possible economic losses, and for executing repair strategies.

Keywords

Cadmium (Cd), Rice plants, Seed germination

Introduction

Industry proliferates parallel to urbanization but increased industrialization produced industrial effluent which is hazardous for the environment if not treated. Pakistan is an agricultural country but now it faces acute water shortage therefore farmers look for alternative source of irrigation; in this regard industrial effluent is an attractive option being a cheap and richest source of nutrients. Besides of nutrients, industrial effluents also bring various types of pollutants along themselves like organic, inorganic, radio-active elements and microorganisms which are becoming potential soil contaminants. Among these contaminants heavy metals (Pb, Cd, Hg, As, Ni, Se) are emerging problem all over the world (Bååth, 1989; Zhang et al., 2005a; Ahmad & Ashraf, 2011; Ahmad et al., 2011a). Heavy metals from industries and other sources are deposited in the environment and pose threat to plants, animals and human beings (Jarup, 2003; Azevedo & Lea, 2005). In Pakistan, an area of 0.033 m ha receives industrial effluent (Ensink et al., 2004) and its repeated application may cause metal problem in soil (Ahmad et al., 2007; Hussain et al., 2010). Among these heavy metals Cd is a potential pollutant which can pollute the soil resulting in its accumulation in different parts of plants because it is a very mobile element and can be easily taken up by plants. It is recycled by anthropogenic activities (Kabata-Pendias & Dudka, 1990). In a study, Hussain et al., (2010) reported the presence of ample amount of Cd in the industrial effluent of different locations of Faisalabad and observed more than 200 % increase in Cd contents in soil irrigated with industrial effluent compared to canal water. The Cd accumulated in plants is ultimately taken up by animals and humans. Cheng and his Co-workers have also observed in 2006 that plants are the main pathway for entering toxic elements from soil to humans.

Material and Methods

Effect of Cd on seed germination and seedling growth of four wheat cultivars was investigated in growth room under axenic conditions at the Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad, Pakistan.Seed material: Seeds of four wheat cultivars (Sehar-06,Fareed-06, Inqlab-91, Chakwal-50) were provided by the Cereal Section of Ayub Agricultural Research Institute,Faisalabad, Pakistan. The healthy and robust seeds of each cultivar were surface sterilized with sodium hypochlorite (5%) for ten minutes followed by five washings with de-ionized water.Cadmium treatment: Cadmium chloride (CdCl2.H2O) salt of high purity (98%) was purchased from Merck chemicals,Germany and used to prepare desired cadmium concentrations. Four levels of Cd 5, 20, 50, 80 mg L-1 wereused in the experiment along with control (without Cd).Experimental conditions: Sand was sieved through 2mm sieve before filled in thermophore plates which hasdimensions 4″x4″x2″ length, width and depth, respectively. Each thermophore plate contained 200 g sand and Cd levels were developed in sand by adding 50 mL of each concentration before sowing. Seeds of each cultivar were dipped in distilled water for 24 hours at 28ºC in incubator. Ten imbibed seeds of each cultivar were placed in the sand at uniform depth. These plates were placed in growth room at 25ºC under 14 h photoperiod. The trial was arranged in CRD-factorial and replicated three times.

Results

Effect of cadmium on seed germination: Cadmium had drastic effects on seed germination of wheat but its inhibitory effects varied among cultivars. Inhibition of seed germination, germination energy and germination index were observed at 20, 20 and 5 mg L-1 Cd, respectively (Table 1). Among different cultivars, seed germination, germination energy and index were improved significantly ($p<0.05$) in case of Sehar-06 whereas these parameters were reduced in Inqlab-91 in Cd polluted soil. Inhibitory effect of Cd was more prominent at higher concentration (80 mg L-1 Cd) but it showed a significant ($p<0.05$) reduction at 20 mg L-1 Cd and germination index was found more sensitive in case of main effect while interaction effects were significant at 50 mg L-1 Cd compared to control. Final germination, germination energy and index showed stimulation at 5 mg L-1 Cd, whereas severe inhibition was observed at 20 to 80 mg L-1 Cd .

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Conclusion

In conclusion, germination index, and root, shoot and seedling length were found to be good indicators of Cd toxicity in wheat. Cadmium showed adverse effects on wheat growth indices at low concentration, but maximum inhibition occurred at 80 mg L-1. Tolerance indices forSehar-06, Fareed-06, Inqlab-91 and Chakwal-50 were 80,46, 30 and 33%, respectively. Being a most tolerant-cultivar, Sehar-06 could be successfully grown on Cd contaminated soils