短篇报道

Cd在水稻植株中的压力：Cd对水稻种子萌发和幼苗生长的影响

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摘要:

Cd (镉) 是非必需但有毒的元素，对动物和植物来说都是有害的。Cd是水稻（Oryza sativa）的主要污染物， Cd通过根系被吸收，在根系中，Cd污染物会引发一致性的损害，并减小根系的生长。在本研究中，我们调查了不同Cd氯化物浓度（0, 15, 25, 35, 45和55 μM）对水稻生理和生物化学过程的影响，包括种子萌发、根和芽的新鲜和干重。结果表明，萌发率受Cd浓度影响较小，但根生长受到明显抑制。Cd浓度超过45和55 μM显著抑制了植物的生长。Cd处理导致叶片黄化、萎蔫和叶片脱落。Cd处理也降低了萌发率6.9%，根和芽的长度分别为68.9%和85.6%，新鲜重量的减少为42.3%。Cd处理显著降低了植物的生长。基于结果，我们得出结论，这些水稻的特征严重受到Cd处理的影响，也是Cd元素毒性的一种症状。Cd影响了水稻根系，干扰了根系的形成和发展。这种结果导致了根系架构的显著改变，可能对在高污染稻田的植物生存产生重要影响。因此，少于特定基因型的Cd耐受指数。最后，在金属污染区域，需要进一步研究来确定环境和植物中不同水平的金属。考虑到这种作物在全世界的经济重要性，对根系对这些污染物的反应性进行评估可能很重要，从而执行修复策略。
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 were used in the experiment along with control (without Cd). Experimental conditions: Sand was sieved through 2mm sieve before filled in thermophore plates which has dimensions 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 dis-
tilled 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 for Sehar-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.