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Differential toxicity of cadmium to mustard (*Brassica juncia* L.) genotypes under higher metal levels

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Abstract

Cadmium application inhibited various growth and biochemical parameters in seedlings of five cultivars of *Brassica juncia* L. with different magnitude at lower Cd supply, however, at higher metal applications the variation in Cd toxicity ranged with minor differences. The seedling vigour index (SVI) was inhibited more severely in Gangotri (62.25% over control) and least in Pusa Jai Kisan (8.95%) at 1.0 mM $CdCl_2$. The SVI of all five mustard cultivars, however, severely inhibited (84.29-91.80%) at 5.0 mM Cd. The root and shoot elongation in 7 days old seedlings were inhibited by 32.39-40.38 and 11.83-56.40% respectively at 1.0 mM $CdCl_2$ whereas the varietal differences in root and shoot elongation were 76.71-82.47 and 71.57-78.91 respectively at 5.0 mM $CdCl_2$. The genotypic differences at lower Cd level were more pronounced in shoot elongation than that in the root elongation. The dry weight and moisture content of the seedlings, however, does not show much varietal differences even at lower Cd level, though the Cd toxicity increased at higher level of Cd application. The metal tolerance index (MTI) and % phytotoxicity of 3 days old seedlings ranged between 43.30-98.37 and 1.63-56.70% respectively at 1.0 mM $CdCl_2$ for different mustard genotypes, whereas at 5.0 mM $CdCl_2$ these factors ranged between 12.26-20.92 and 80.08-87.74% respectively. The varietal differences of MTI and % phytotoxicity was, however, less pronounced at all the metal levels when the seedling attained an age of 7 days. A similar trend of genotypic variation was noticed in Cd accumulation in the seedlings at lower and higher levels of Cd supply to the seedlings. Amongst some biochemical parameters *e.g.* photosynthetic pigments, carbohydrates and proteins in the leaves, the photosynthetic pigments *i.e.* chlorophylls and carotenoids were decreased more drastically. The carbohydrate content of leaves, however, was the least affected component. Our data indicate that the differential toxicity of cadmium to Indian mustard genotypes was dependent on the level of contamination and growth phases.

Key words

Brassica, Germination, Cadmium toxicity, Metal tolerance index, Seedling vigour index

Introduction

Heavy metal contamination of soil and water is one of the most serious environmental problem across the world due to their toxicity to human, animals, plants and microbes (Singh *et al.,* 1997; Meagher, 2000; Chandra *et al.,* 2009). Cadmium is released into the biosphere naturally by volcanoes, weathering of rocks (Mahmood *et al.,* 2005) as well as anthropoegenically through various urban/industrial wastes such as mining and metal refining (Fialkowski *et al.,* 2003; John *et al.,* 2007; Pandey *et al.,* 2007), compost application (Ramos and Lo´pez-Acevedo, 2004), cadmium rich phosphate fertilizers (Jiang *et al.,* 2005) and waste water irrigation (Chandra *et al.,* 2009). Like other toxic metals, Cd is also taken up by the plants and gets accumulated in various plant parts as free metal which may adversely affect the plant growth and metabolism (Choudhary and Singh, 2000; Hasan *et al.,* 2009; Sylwia *et al.,* 2010). In case, plant tolerate high level of the metal and get survived in the metal rich environment, it may enter in to the food chain and can cause serious health hazards to animals and human (Munzuroglu and Geckil, 2002).

Cadmium decreases activities of various enzymes (Gouia *et al.,* 2003; Mishra *et al.,* 2006; Khan *et al.*, 2006 and 2007; Singh *et al.*, 2008) and interfere with general and membrane physiology such as oxidative reactions and nitrogen metabolism(Hasan *et al.,* 2009). Indian mustard (*Brassica juncia*), a high biomass producing plant, has been one of the most studied terrestrial plants for its potentiality to extract heavy metals including Cd from soils, fly ash and sediments (Singh *et al.,* 2007; Qadir *et al.,* 2004; Marchiol *et al.,* 2006; Gasic and Korban, 2007; Simnova *et al.,* 2007; Tickoo *et*