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Citric Acid Assisted Cd Tolerance Mechanism in *Brassica napus*

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[Introduction]
The capacity of plants to accumulate cadmium (Cd) is significant for phytoremediation of Cd-polluted soils. Citric acid (CA) is commonly used chelating agent that desorb metals from soil matrix into soil solution and facilitates their uptake by plants. The role of CA in enhancing phytoremediation of different heavy metals and working against metal-induced oxidative stress has been established in many studies. In this study, we attempted to explore the potential of CA for increasing phytoextraction of Cd contaminated environments and to investigate the effect of CA on growth and physiology of Cd-stress *B. napus* seedlings.

[Materials and Methods]
Mature seeds of *B. napus* L. were surface-sterilized and placed in petri dishes containing two layers of filter papers, and germinated in controlled conditions. Following germination, the morphologically uniform seedlings were transferred to plastic pots and hydroponically grown for 7-days containing Hoagland solution. After one weeks of transplanting, uniform plants were treated with $CdCl_2$ and citric acid as T1: Control, T2: Cd (50 μM), T3: CA (2.5 mM), and T4: Cd (50 μM) + CA (2.5 mM) with three replications. In control plants, no $CdCl_2$ and CA were applied.

[Results and Discussion]
Our investigation was focused on studying the effects of exposing Brassica plants to $CdCl_2$. The metal ion, Cd affected growth parameters and caused morpho-physiological alterations. *Brassica napus* seedlings exposed to different concentrations of $CdCl_2$ for 7 days did not show any leaf chlorosis or withering symptoms. However, Cd stress significantly affects the plant growth characters. A considerable reduction in the shoot and root growth was observed compared with the control. The most significant growth inhibition was observed in plants treated with the highest concentrations of $CdCl_2$ (50 μM). The plant height (Both shoot length and root length) exhibited the largest reduction (8 cm) compared to control plants. Number of leaves per plant and leaf area was found to be decreased when the seedlings were exposed to Cd stress. However, the highest inhibition (4 and 10 cm^2 for leaf number and leaf area respectively) was observed from the highest concentrations (50 μM) compared to the control plants. The reduction in fresh of seedlings because of pronounced initiation of shoot and root growth may probably occur due to metal uptake primarily through roots.

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