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Citric Acid (CA) and Glutathione (GSH) Mediated Alleviation of Cadmium (Cd) Stress in *Brassica napus*

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[Introduction]

Cadmium (Cd), a kind of nonessential and toxic metal that is very much harmful for both human and animal. The accumulating capacity of Cd is significant for phytoremediation of Cd-polluted soil environment. Citric acid (CA) as an organic chelator plays a vital role in alleviating Cd stress through more uptake of Cd by plants whereas Glutathione (GSH) significantly decreased the translocation of Cd from root to shoot, ultimately decreased Cd accumulation in shoots. From many previous studies it has been established that the CA and GSH enhance phytoremediation of different heavy metals and working against metal-induced oxidative stress. In this study, we attempted to discover the capability of CA for increasing phytoextraction of Cd contaminated environments and to know the capability of GSH for retaining the Cd in the plant roots, and to examine the comparative effect of CA and GSH on growth and physiology of the seedlings of Cd-stressed *Brassica napus*.

[Materials and Methods]

Healthy seeds of *B. napus* L. were 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 (30 μM), T3: Cd (30 μM) + CA (1.0 mM), and T4: CA (1.0 mM) and; $CdCl_2$ and Glutathione as T1: Control, T2: Cd (30 μM), T3: Cd (30 μM) + GSH (0.5 mM), and T4: GSH (0.5 mM) with three replications. The control plants were free from $CdCl_2$, CA and GSH.

[Results and Discussion]

The research was focused on studying the effects of revealing 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 and plants become more yellowish in CA treated plants than GSH treated plants. A considerable reduction in the shoot and root growth was observed compared with the control in both CA and GSH treated plants. The most significant growth inhibition was observed when plants are treated with $CdCl_2$ (30 μM). The plant height (Both shoot length and root length) exhibited the largest reduction (14.40 cm in CA treated plants and 15.30 cm in GSH treated plants) compared to control plants respectively. Number of leaves per plant and leaf area (size) was found to be decreased when the seedlings were exposed to Cd stress. However, the highest inhibition (5 and 10 cm^2 for CA treated and 5 and 12 cm^2 for GSH treated leaf number and leaf area respectively) was observed in 30 μM concentrations compared to the control plants. The reduction of shoot and root growth may be occurred due to metal uptake primarily through roots. From previous studies as the Cd is retained in the root of plants for application of GSH, so it may be the environment friendly and promising strategy to decrease Cd concentration in edible parts of plants that may helpful for reducing the health hazard for both human and animals.

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