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Morpho-Physiological Insights into Citric Acid-Induced Copper Tolerance using *Brassica napus* L.

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[Introduction]

Recently, phytoremediation, plants for remediation of heavy metal has become popular various reason such as cost and environment friendly nature. However, the efficiency of phytoremediation varies among plant species, soil types, and environmental conditions. Different Brassica species can do phytoremediation of heavy metals, among them, *Brassica napus* has more tolerant to excessive Cu concentration than other Brassica species. Citric acid (CA) that is organic chelating agents and has more biodegradability and environment friendly nature as compared to inorganic chelating agents. Organic chelating agent is a commonly used chelating agent that desorbs metals from soil matrix into soil solution and facilitate their uptake by plants. In this study, we attempted to explore the potential role of CA in increasing phytoremediation of Cu contaminated plants, and to investigate the effect of CA-induced Cu on morpho-physiological characteristics in Brassica.

[Materials and Methods]

The seeds (Jungmo 7001) collected from Mokpo, Korea were germinated in growth chamber at 25ºC for one week. After one week of germination, the uniformed seedlings were transferred into a box containing Hoagland solution. After two weeks, the plants were treated various concentration of Cu and CA for 5 days. Two weeks after transplanting into the nutrient solution, the plants were exposed to various treatments of CuSO4 and citric acid as Cu (25 μM), Cu (50 μM), CA (1.0 mM), CA (1.0 mM) + Cu (25 μM), and CA (1.0 mM) + Cu (50 μM). After treatment, the plants were harvested and measured morpho-physiological characteristics including, shoot length, root length, plant height, proline contents, protein contents, and chlorophyll contents.

[Results and Discussion]

Cu stress caused a significant inhibition of plant growth characteristics. The significant inhibition in plant height was recorded when the plants were subjected to Cu stress. However, the maximum growth reduction was recorded under the highest Cu (50 μM) treatment. Addition of CA into Cu-contaminated nutrient solution significantly ameliorated Cu toxicity in the *B. napus* by promoting plant growth. Cu stress had a negative impact on chlorophyll content in leaf tissue in *Brassica*. However, chlorophyll contents were increased under CA application. Proline accumulation was increased when exposed to Cu stress but especially it was increased in CA application. The highest proline content was obtained from the CA (1.0 mM) + Cu (50 μM) treatment compared with the untreated plants. The findings suggest that application of CA may increase the proline so that plant can be more tolerant towards heavy metal stress. In protein concentration, concentration was decreased when treated Cu of any level. On the other hand, in CA application, protein concentration was increased than untreated seedlings. The present findings reveal that CA helps Brassica to enhance proline contents, chlorophyll contents, and protein contents that may provide essential insights in tolerating Brassica in response to Cu stress.

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