Interactive effects of EDTA and oxalic acid on chromium uptake, translocation and photosynthetic attributes in Indian mustard (*Brassica juncea* L. var. Varuna)

Durga Singh, Ashish Agnihotri and Chandra Shekhar Seth*

Department of Botany, University of Delhi, Delhi 110 007, India

The accumulation and toxicity of chromium (Cr) in Indian mustard (*Brassica juncea* L.) under ethylene diamine tetraacetic acid (EDTA) and oxalic acid (OA) as chelating agents was studied. Plants were exposed to Cr(VI) and chelating agents in four experimental set-ups as Cr(VI), Cr(VI) + EDTA (1 : 1), Cr(VI) + OA (1 : 1) and Cr(VI) + EDTA + OA (1 : 1 : 1), where each set-up comprised of 0, 6.25, 12.5 and 25.0 mg of Cr(VI) and/or chelating agents in 250 g of soil. Results conferred that EDTA augmented bio-concentration factor in all the three doses of Cr(VI), OA considerably increased translocation factor in all the treatments, including control, and the combined application of the two chelates escalated both the aforesaid factors. Moreover, these chelating agents help in ameliorating Cr(VI) toxicity asserted by low degree of lipid peroxidation, insubstantial damage in root and shoot length, fresh and dry biomass, chlorophyll and leaf gas exchange parameters. Besides, plants showed a robust detoxification mechanism primarily by significant ($P < 0.05$) production of reduced glutathione and phytochelatins among other enzymatic and non-enzymatic antioxidants under these chelating agents. The present findings suggest that Indian mustard could be used as a potential phytoremediator of Cr(VI) under the combined application of EDTA and OA.

Keywords: *Brassica juncea* L., chromium uptake, chelating agents, photosynthesis.

ENVIRONMENTAL deterioration by heavy metals is a serious global concern because imbalance caused by their toxicity and harmful nature is an alarming threat to all life forms present on Earth. Among all the heavy metals, chromium (Cr) has a relatively high solubility and mobility and because of excessive anthropogenic activities, particularly tanning and electroplating industries which release large amounts of Cr into the environment, it can easily find its way into the food chain. Chromium has been reported to impart several toxic effects on photosynthetic pigments, chloroplast ultra-structure, electron transport chain and photophosphorylation in plants. It also leads to various deleterious effects on seed germination, membrane integrity, essential nutrient elements, nitrogen and protein metabolism[1] and hence demands urgent attention for its remediation.

Phytoextraction is a cost-effective and eco-friendly approach compared to physical (soil washing, stabilization/solidification, soil flushing, additives/surfactants) and chemical (adsorption using specific media, modified coagulation along with filtration, precipitation, immobilization and complexation reaction) methods, which utilizes plant-mediated clean-up of metal-polluted soil[2]. The success of phytoextraction largely depends on suitable plant species and bioavailability of metals, which can be further enhanced by appropriate use of some chelating agents. Synthetic chelating agents such as ethylene diamine tetraacetic acid (EDTA), diethylene triamine pentaacetic acid (DTPA) and ethylene glycol tetraacetic acid (EGTA) pose environmental risks due to their non-biodegradability, groundwater contamination and toxicity to plants[2]. On the contrary, organic chelating agents such as oxalic acid (OA), citric acid, malic acid, acetic acid, etc. are not reported to show any of these deleterious effects[3,4]. No doubt, synthetic chelating agents pose risks to the environment, but their wide applications cannot be ruled out and they must be used in combination with organic acids under controlled manner for efficient phytoextraction.

Relatively, few reports are available on the combined application of synthetic (EDTA) and natural (OA) chelating agents to understand their usefulness in enhancing Cr uptake, translocation and toxicity amelioration in Indian mustard. Therefore, the present study was performed to investigate the bioconcentration factor (BCF) and translocation factor (TF), whereas toxicity of Cr(VI) was assessed by several indicative parameters, viz. photosynthetic pigments, fresh and dry biomass, lipid peroxidation and leaf gas exchange parameters like net assimilation rate (A), transpiration rate (E), stomatal conductance (G_{H_2O}) and water use efficiency (WUE). Tolerance strategy against Cr(VI)-induced oxidative damage was determined

*For correspondence. (e-mail: seth_bhu@yahoo.co.in)

Declarations regarding ethical issues: The present experiment did not involve any humans or animals, and is in compliance with all ethical issues.