Shoot And Root Phytotoxicity By EDDS In Relation To Dose And Application Time In *Brassica carinata* A. Braun And *Raphanus sativus* L. var. *oleiformis*

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ABSTRACT

This study examines the effects of the chelator EDDS on plant growth and phytoextraction of *Brassica carinata* A. Braun (Ethiopian mustard) and *Raphanus sativus* L. var. *oleiformis* (fodder radish) grown in metal(loid)-polluted pyrite wastes (As, Co, Cu, Pb, Zn). Plants were cultivated for 75 days in pots. Four EDDS treatments were tested: 2.5 and 5 mmol EDDS kg^{-1} soil applied one week before harvest and 1 mmol kg^{-1} soil repeated five times at 5- and 10-day intervals. Fodder radish treated with 1 mmol at the 5-day interval was also added with 1 mg IBA (indole-3-butyric acid) kg^{-1} soil to prevent root phytotoxicity.
EDDS caused shoot and root phytotoxicity in both species, especially when it was applied earlier (repeated treatments). Ethiopian mustard was less sensitive than radish to EDDS application. EDDS enhanced metal concentrations in shoots at any dose in both species, but not metal removal, except for dose 2.5 mmol in mustard.
KEYWORDS: EDDS, root and shoot phytotoxicity, *Brassicaceae*.

INTRODUCTIONS

Soil application of metal chelators can improve the efficiency of phytoextraction, by enhancing metal availability. However, this practice should be carefully evaluated, as chelators cause metal leaching and toxicity to plants and soil organisms (Meers et al., 2005). This study examines the effects of EDDS, a more easily biodegradable and low-toxic chelant than the widely used EDTA, on plant growth (shoot and root) and phytoextraction of Ethiopian mustard and fodder radish grown in metal-polluted pyrite wastes.

METHODS

A pot experiment was carried out in greenhouses cultivating fodder radish (*Raphanus sativus* L. var. *oleiformis,* cv Siletta nova) and Ethiopian mustard (*Brassica carinata* A. Braun, cv 079444) for 75 days (from the end of May to early August). One plant per pot was grown on PVC tubes filled with a mixture of pyrite cinders and sand (1:1 w/w). The pyrite cinders had been dumped in the past as waste from sulphur extraction and were severely polluted by As, Co, Cu, Pb, and Zn (886, 100, 1735, 493, and 2404 mg kg^{-1} soil, respectively). Untreated controls (C) were compared with plants grown on cinders treated with: 2.5 or 5 mmol EDDS kg^{-1} soil applied one week before harvest (called 2.5 and 5, respectively), 1 mmol EDDS kg^{-1} soil repeated five times at 5- and 10-day intervals (1x5-5d and 1x5-10d, respectively), starting from 48 and 28 days after sowing, respectively. Aiming at reducing metal phytotoxicity and increasing metal uptake, fodder radish treated with 1 mmol EDDS at the 5-day interval was also added with 1 mg IBA (indole-3-butyric acid) kg^{-1} soil at 10-day intervals (EDDS+IBA). Leaf growth and chlorophyll content (SPAD values) and root activity (EC, root electrical capacitance) were recorded weekly. At harvest, root length was assessed by automatic analysis of root digital images acquired through a flatbed scanner. Shoot biomass and its metal(loid) concentrations (through ICP-OES) were also revealed.

RESULTS AND DISCUSSIONS

In general, EDDS caused phytotoxicity both above- and below-ground, especially when applied repeatedly, resulting in a decrement in shoot biomass and root length (Figure 1). As regards roots, in radish EDDS applied close to harvest at half dose only (2.5 mmol kg^{-1}) did not cause root phytoxicity, whereas mustard was sensitive exclusively at 1x5-10d (Figure 1). At shoot level, mustard was also less affected by the chelator than radish, showing a smaller biomass decrease (average of all EDDS treatments: -42% vs. -61%) compared with controls. In radish, there was a slight (not significant) positive effect of IBA on root growth and a fairly negative effect on shoot growth. Root activity, estimated through the electrical capacitance method, was well correlated to final root length, suggesting its profitable use in non-destructive root measurements.

Metal concentrations (i.e., Cu, Zn, Pb, and Ni) were generally enhanced by the addition of EDDS in the soil, as described by Luo et al. (2005), whereas As was not influenced. Concentrations of various metal(loi)s (summation) in shoots due to EDDS were lower in *Brassica carinata* than in *Raphanus sativus* (3.5 vs. 4.9 mmol kg^{-1}, average of EDDS treatments), but the greater biomass of mustard allowed better offtakes (3.3 vs. 1.9 mmol per plant). Mustard treated with 2.5 mmol of chelator only achieved higher contaminant removals than controls through the harvestable biomass.

Similar to results on other chelators, ours indicate that EDDS can increase metal concentrations in biomass and only occasionally metal offtake due to biomass reduction. The extent of phytotoxicity depends on dose and application time – the earlier the application the stronger the effect – but great attention should be paid to interspecific variability.

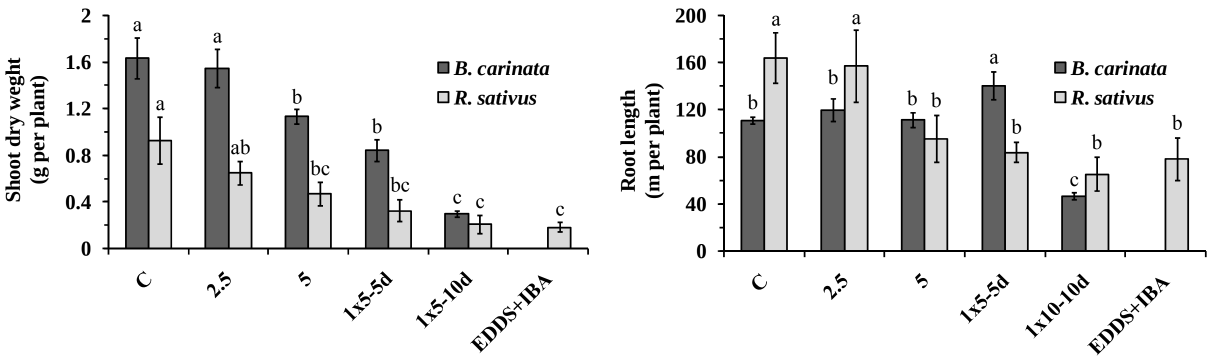

Figure 1. Shoot biomass (left) and total root length (right) at harvest (± S.E.). Letters: differences among treatments within same species (LSD test, P≤0.05).

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