Zinc-Cadmium Interaction in Soil and Plant System

S. K. Patra[1], S. S. Das[2] , D. Majumdar[3] and A. Zaman[4]

[1, 2] Department of Agricultural Chemistry and Soil Science, [3] Department of Agricultural Statistics, [4] Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

INTRODUCTION

Cadmium is highly phytotoxic and hazardous to mammals and human health. It adversely affects crop yield due to its high mobility and translocation in soil-plant continuum (Panwar and Morvai, 1999). The incorporation of adequate amount of organic matter and/or counter ion Zn in soil depresses soil-Cd toxicity and prevents its accumulation in plants (Das and Kumar, 1996; Zhang *et al.,* 2001). The present experiment aimed to assess the direct and residual effects of Zn, either alone or in conjunction with organic matter, on depression of soil-Cd and consequent biomass yields and uptake of Cd by plants in a rice-palak cropping sequence.

METHODS

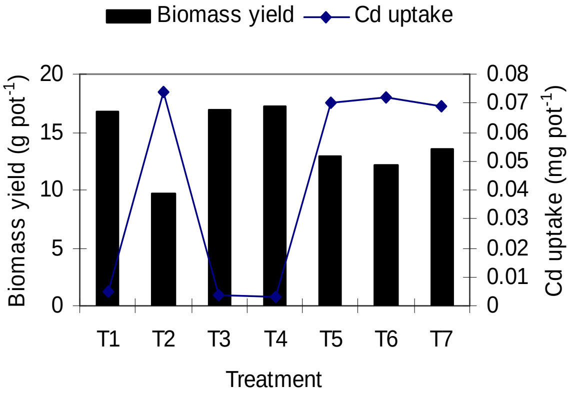
Several 2-kg portions of processed soil samples were filled in polythene sheet-lined 3-kg capacity earthen pots. Soil was a clay loam with pH 7.5, EC 0.61 dS m^{-1}, CEC 17.9 cmol (p^+) kg^{-1}, organic C 12.8 g kg^{-1}, available N 240 kg ha^{-1}, P 25.4 kg ha^{-1}, K 237 kg ha^{-1}, DTPA-Cd 0.12 mg kg^{-1} and DTPA-Zn 1.07 mg kg^{-1}. The experiment was laid in a randomized block design with three replications and seven treatments, viz. T_1: untreated control, T_2: Cd @ 10 mg kg^{-1}, T_3: Zn @ 15 mg kg^{-1}, T_4: organic matter@10 t ha^{-1}, T_5: Cd @ 10 mg kg^{-1} + organic matter@10 t ha^{-1}, T_6: Cd @ 10 mg kg^{-1} + Zn @ 15 mg kg^{-1}, T_7: Cd @ 10 mg kg^{-1} + Zn @ 15 mg kg^{-1} + organic matter @10 t ha^{-1}. Rice (*Oryza sativa* Linn cv. IET 4786) and palak (S*pinacia oleracia* L. cv. Banerjee giant) were grown in sequence. Rice plants were raised in submerged conditions at 5±0.5 cm depth throughout the physiological stages. Zinc as $ZnSO_4$ and Cd as 3 $CdSO_4$, 8 H_2O were applied as per treatments. Standard agronomic and management practices were followed. The crops were harvested at 65-70 days after sowing. Soil-Cd was extracted with DTPA-$CaCl_2$ solution at pH 7.3 (Lindsay and Norvell, 1978). Plant samples were digested in tri-acid (HNO_3:$HClO_4$:H_2SO_4: 10:4:1) mixture, cooled, filtered and analyzed for Cd content with using an atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Application of soluble Cd in soil resulted in the lowest dry matter yields of both rice and palak crops (Figs. 1 and 2). However, incorporation of Zn and/or organic matter increased biomass yields of crops in normal and Cd-enriched soils. Similarly, Cd uptake by crops in control soil as well as Cd-enriched soil was significantly reduced by addition of Zn or organic manure, or both. The relative effect was more pronounced with combined application of Zn and organic matter than their sole application. Addition of Zn or organic matter depressed the extractable soil-Cd concentration by 12.5 and 20.0 per cent or 37.5 and 40.0 per cent after rice and palak harvest, respectively (Table 1). The suppression of toxic soil-Cd concentration by organic matter was likely due to the formation of an insoluble Cd-organic matter complex (He and Singh, 1993) and the suppressing or antagonistic effect of Zn on soil-Cd (Gupta and Potalia, 1990). These resulted in less Cd mobility in soil and consequently lower bioavailability of Cd to plants leading to higher biomass yields of both crops.

CONCLUSIONS

Organic matter is considered a cost-effective absorbent of toxic heavy metals like Cd in metal- contaminated soil. Alternatively, higher doses of Zn might be incorporated in mitigating the adverse effects of Cd. These appeared to be useful in depressing soil-Cd toxicity and uptake by plants for optimizing yields of rice and leafy vegetable palak crops.



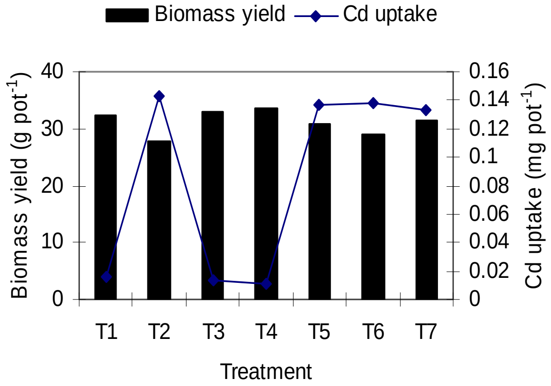


Fig. 1. Biomass yield and uptake of Cd by rice as influenced by Zn and/or organic matter addition

Fig. 2. Biomass yield and uptake of Cd by palak as influenced by Zn and/or organic matter addition

Table 1. Periodic changes in DTPA extractable soil-cadmium as influenced by different treatments

Treatment	Soil-Cd content (mg kg^{-1})		
	Before cropping	After rice harvest	After palak harvest
T_1	0.12	0.08	0.05
T_2	0.12	1.33	0.94
T_3	0.12	0.07	0.04
T_4	0.12	0.05	0.03
T_5	0.12	0.87	0.52
T_6	0.12	1.19	0.67
T_7	0.12	0.98	0.59

T_1: untreated control, T_2: Cd @ 10 mg kg^{-1}, T_3: Zn @ 15 mg kg^{-1}, T_4: organic matter@10 t ha^{-1}, T_5: Cd @ 10 mg kg^{-1} + organic matter@10 t ha^{-1}, T_6: Cd @ 10 mg kg^{-1} + Zn @ 15 mg kg^{-1}, T_7: Cd @ 10 mg kg^{-1} + Zn @ 15 mg kg^{-1} + organic matter @10 t ha^{-1}

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