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SELECTIVE RETENTION OF CADMIUM AND LEAD IN DIFFERENT PARTS OF CHILLI *(CAPSICUM ANNUUM* L.)

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Abstract: To assess the selective retention of cadmium in chilli (*Capsicum annuum* L.), a pot culture experiment was conducted at the College of Horticulture, Vellanikkara, Trichur during kharif 1996. Cadmium and lead were supplied through water soluble salts viz. $CdCl_2$ and $Pb(NO_3)_2$ respectively. Requirements of N, P and K were met through chemically pure sources of urea, KH_2PO_4 and KCl. It was observed that in general, shoot portion of chilli plant maintained highest cadmium uptake followed by root and least uptake of cadmium was noted in fruit portion. This indicated a more selective retention of cadmium in the shoot portion. Similarly, in the same study, it was noted that lead was more selectively retained in the root portion than the other parts of the plant. Application of organic matter in conjunction with heavy dose of these heavy metals to soil resulted in the enhanced uptake of cadmium and lead in all the plant parts analyzed.

Keywords: Cadmium, chilli, heavy metal, lead, selective retention.

INTRODUCTION

The concern of increasing heavy metal concentration in the environment and its adverse effect on human health has created global awareness especially when inhalation and ingestion have been identified as the most important modes of entry. The bioavailability of heavy metals is regulated mostly by the physical and chemical characteristics of soil (Eriksson, 1988). Heavy metals enter food chain mainly through root (Haghiri, 1973) and will be selectively retained in the different plant parts, which may vary with variations in plant type. Such selective retention in the different plant parts open up the necessity to identify the exact plant part for each crop where such accumulation occurs and the concern attains global dimension when such accumulation confines to the economic plant parts. In the present study with chilli *(Capsicum annuum* L.) as the test crop, emphasis is placed on the selective retention of cadmium and lead in the root, shoot or fruit portion of the crop.

MATERIALS AND METHODS

A pot culture experiment was conducted at the Vegetable Research Farm, College of Horticulture, Vellanikkara, Trichur during the kharif season of 1996 to assess the selective retention of heavy metals viz. cadmium and lead in chilli plants from the application of different rock phosphate sources, besides their partially acidulated forms. To have meaningful comparison of heavy metal uptake direct application of water-soluble heavy metal salts were also tried. The design of the experiment was completely randomized with 29 treatments and three replications. However, in this paper selective retention of cadmium and lead in the root, shoot and fruit portions of the chilli from the application of water soluble sources of heavy metals viz. $CdCl_2$ and $Pb(NO_3)_2$ are highlighted. A uniform quantity of soil (5 kg pot^{-1}) that maintained a pH of 5.3 was used in the study. A high yielding variety of chilli (Ujwala) was selected as test crop. The details of initial characterization of the soil are presented in Table 1.

Table 1. General characteristics of the soil used for pot culture experiment

Characteristics	Value
Coarse sand (%)	8.9
Fine sand (%)	50.1
Silt (%)	34.6
Clay (%)	6.4
pH (1:2.5)	5.3
EC (1:2.5) (dS m^{-1})	0.13
Av. N (mg kg^{-1})	110.0
Av. P_2O_5 (mg kg^{-1})	19.7
Av. K_2O (mg kg^{-1})	120.0
Av. Cd (mg kg^{-1})	0.04
Total Cd (mg kg^{-1})	0.79
Av. Pb (mg kg^{-1})	0.13
Total Pb (mg kg^{-1})	1.2

The fertilizer recommendation based on the package of practice for chilli (KAU, 1993) provided NPK @ 70-40-25 kg ha^{-1}. In this study, the required doses of N, P and K were maintained in pots through chemically pure sources of N, P, K (urea, KH_2PO_4 and KC1) to which heavy metal cadmium and lead were added through $CdCl_2$ and $Pb(NO_3)_2$ at two levels viz. 2.5 and 5.0 mg per pot either alone or in combination with organic matter (@ 5 t ha^{-1}). Healthy seedlings were identified from the nursery and transplanted to experimental pots at the rate of one seedling per pot. All through the period of growth, only distilled water was provided to maintain sufficient soil moisture (field capacity). At maturity, carefully uprooted plant samples were cleaned and separated for root, shoot and fruit portions. Further, they were dried and analyzed for Cd and Pb status using di-acid mixture as per procedure outlined by Jackson (1958) and determined directly using Perkin Elmer atomic absorption spectrophotometer. N content was determined by the micro-kjeldahl digestion method as described by Jackson (1958), P content determined colorimetrically by developing the phospo-molybdo-vanadate yellow complex in nitric acid system and K content using EEL flame photometer. Post-harvest soil samples (87 numbers) were also analyzed for assessing both available (DTPA extractable) Cd and Pb (Lindsay and Norvell, 1978) and total Cd and Pb (Page *et al.*, \ 982).

RESULTS AND DISCUSSION

Table 2 shows the uptake of Cd by root, shoot and fruit portions of chilli plant from the direct application of water-soluble Cd at two levels. From this it is clear that Cd uptake by chilli root, shoot and fruit portion was signifi-

Table 2. Cd uptake by chilli root, shoot and fruit from direct application of heavy metals in pots with and without organic mater ($\mu g\ pot^{-1}$)

Source	Level	Root			Shoot			Fruit		
		Without OM	With OM	Mean	Without OM	With OM	Mean	Without OM	With OM	Mean
$CdCl_2$	L1	42.8	43.2	43.0	77.2	79.4	78.3	24.1	24.9	24.5
$Pb(NO_3)_2$	L1	1.1	1.3	1.2	1.5	1.7	1.6	0.5	0.5	0.5
$CdCl_2$	L2	91.2	93.5	92.4	137.1	140.4	138.8	45.7	47.6	46.7
$Pb(NO_3)_2$	L2	1.1	1.2	1.2	1.5	1.7	1.6	0.6	0.6	0.6
Control	-	-	-	0.8	-	-	0.5	-	-	0.2
Mean	-	34.1	34.8	-	54.3	55.8	-	17.7	18.4	-
CD (0.05) for source and level are 0.94 and 0.66 respectively			CD (0.05) for source and level are 0.83 and 0.63 respectively					CD (0.05) for source and level are 0.36 and 0.25 respectively		

Table 3. Pb uptake by chilli root, shoot and fruit from direct application of heavy metals in pots with and without organic mater ($\mu g\ pot^{-1}$)

Source	Level	Root			Shoot			Fruit		
		Without OM	With OM	Mean	Without OM	With OM	Mean	Without OM	With OM	Mean
$CdCl_2$	L1	12.0	12.2	12.1	6.0	6.2	6.1	1.9	2.2	2.1
$Pb(NO_3)_2$	L1	107.1	108.4	107.6	57.1	58.4	57.8	22.4	23.6	23.0
$CdCl_2$	L2	12.1	12.2	12.2	6.1	6.2	6.2	2.2	2.3	2.3
$Pb(NO_3)_2$	L2	172.6	174.1	173.4	72.6	73.1	72.9	34.1	35.3	2.3
Control	-	-	-	2.9	-	-	1.5	-	-	0.5
Mean	-	75.9	76.7	-	35.5	36.0	-	15.1	15.9	-
CD (0.05) for source and level are 0.21 and 0.15 respectively			CD (0.05) for source and level are 0.21 and 0.15 respectively				CD (0.05) for source and level are 0.26 and 0.18 respectively			

Table 4. DTPA extractable Cd and Pb in post-harvest soil samples from direct application of heavy metals in pots with and without organic matter (mg kg^{-1})

Source	Level	DTPA extractable Cd			DTPA extractable Pb		
		Without OM	With OM	Mean	Without OM	With OM	Mean
$CdCl_2$	L1	0.37	0.37	0.37	0.13	0.13	0.13
$Pb(NO_3)_2$	L1	0.04	0.04	0.04	0.49	0.50	0.49
$CdCl_2$	L2	0.53	0.58	0.55	0.13	0.13	0.13
$Pb(NO_3)_2$	L2	0.04	0.04	0.04	0.64	0.64	0.64
Control		-	-	0.04	-	-	0.12
Mean	-	0.24	0.26	-	0.35	0.35	-
CD (0.05) for source is 0.04 and level is non-significant					CD (0.05) for source and level is 0.003		

Table 5: Total Cd and Pb in post-harvest soil samples from direct application of heavy metals in pots with and without organic matter (mg kg^{-1})

Source	Level	Total Cd			Total Pb		
		Without OM	With OM	Mean	Without OM	With OM	Mean
CdCl,	L1	1.3	1.3	1.3	1.2	1.2	1.2
$Pb(NO_3)_2$	L1	0.8	0.8	0.8	1.7	1.7	1.7
CdCl,	L2	1.6	1.7	1.7	1.2	1.2	1.2
$Pb(NO_3)_2$	L2	0.8	0.8	1.8	2.1	2.1	2.1
	Control	-	-	0.8	-	-	1.2
Mean	-	1.1	1.1	-	1.6	1.6	-
CD (0.05) for source is 0.02 and level is non-significant					CD (0.05) for source is 0.02 and level is non-significant		

Table 6. Dry matter yield of chilli root, shoot and fruit from direct application of heavy metals in pots with and without organic mater (g pot^{-1})

Source	Level	Root			Shoot			Fruit		
		Without OM	With OM	Mean	Without OM	With OM	Mean	Without OM	With OM	Mean
$CdCl_2$	L1	1.23	1.43	1.33	14.0	17.4	15.7	3.43	3.43	3.43
$Pb(NO_3)_2$	L1	1.17	1.27	1.22	14.1	17.2	15.7	3.37	3.53	3.45
$CdCl_2$	L2	1.03	1.53	1.28	14.8	15.3	15.1	3.47	3.60	3.53
$Pb(NO_3)_2$	L2	1.30	1.50	1.40	15.1	15.9	15.5	3.20	3.53	3.37
Control		-	-	0.87	-	-	4.7	-	-	1.57
Mean	-	1.18	1.43	-	14.5	16.5	-	3.37	3.53	-
CD (0.05) for source and level are 0.09 and 0.07 respectively			CD (0.05) for source and level are 0.52 and 0.37 respectively					CD (0.05) for source and level are 0.12 and 0.08 respectively		

cantly higher at higher levels of application of Cd. Addition of organic matter had also resulted in marginal but significant enhancement of the Cd uptake in all the plant parts, which might have been due to the marginal contribution of heavy metals from organic matter, under favourable condition. Anderson (1976) reported the possibility of an annual contribution of heavy metals especially Cd to the extent of 1-4 kg ha^{-1} under normal application of organic matter which supports the above observation. The very low content of Cd in the fruit portion suggests that the edible part of plant was relatively free from Cd, making it absolutely safe for human consumption. The low Cd retention in the fruit portion of chilli might be due to a possible redistribution of heavy metals within the plant or a possible failure to translocate the heavy metal to the fruit portion, which formed and developed towards the final stages of crop growth.

Similarly, maximum uptake of Pb was noted in the root portion and least in fruit portion (Table 3) indicating that the edible portions of the plant are relatively free from this metal, when compared to other plant parts. Khan and Frankland (1983) in a study on radish reported that Cd was selectively retained in the plant shoot while Pb was retained in plant root. The uptake of Pb through roots and the subsequent retention by the different plant parts at higher levels of heavy metal (Pb) application were found to be significantly higher especially when organic matter addition was combined with such additions.

It has been noted in the post-harvest soil samples that at increasing levels of application of Cd and Pb [through $CdCl_2$ and $Pb(NO_3)_2$], the DTPA extractable Cd and Pb registered significant increase which probably could be a reflection of the enhanced heavy metal load in such soils after reasonable uptake by the test crop (Table 4).

Application of organic matter @ 5 t ha^{-1} in pots along with water-soluble heavy metal salts did not have any additive effect in increasing the availability of both heavy metals viz., Cd and Pb from post-harvest soil samples especially when such an availability of heavy metals is compared from pots where there had been no addition of organic matter. The availability of Cd and Pb from the control pots was quite insignificant.

While assessing the total Cd and total Pb status in the post-harvest soils (Table 5), it is seen that wherever higher loads of Cd and Pb had been provided in soil through $CdCl_2$ and $Pb(NO_3)_2$ there had been higher heavy metal load in post-harvest soil sample. However, the states of such heavy metal in the control pots were quite significant.

The dry matter yields of root, shoot and fruit portions (Tables 6) indicate that the root portion recorded least dry matter yield compared to shoot or fruit portion of the plant. However, when organic matter was applied to chilli plant especially in conjunction with the application of heavy metals, the relative dry matter yields of root, shoot and fruit portions of the plant were significantly higher indicating the positive influence of organic matter not only in promoting the dry matter yield but also in retarding the ill effects of heavy metals in suppressing dry matter yield.

The failure of heavy metals to retard dry matter yield even at higher doses might have been due to a possible chelation of heavy metals by organic matter or due to the locking up of the heavy metals in the roots. Under such a situation, organic matter or its decomposed fractions might have favoured an enhanced dry matter production, through better utilization of soil nutrients. Haghiri (1973) had similar observations in soybean and wheat, when high doses of heavy metal addition and organic matter were combined.

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