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CADMIUM CONTENT OF PLANTS AS AFFECTED BY SOIL APPLICATION OF CADMIUM AND FARM YARD MANURE

Heavy metals in soils and plants have received increasing attention in recent years because of the harmful health effects of their dietary intake. Toxic heavy metals in high concentrations are infrequently found in soil. Their accumulation reduces soil fertility, soil microbial activity, plant growth and quality of agricultural products. Cadmium is a toxic heavy metal and is a recognized contaminant in the environment. Sources of contamination are fossil fuels, metal industry, mining wastewater, paints, rubber, plastics, batteries and catalysers.

Plant species differ greatly in their ability to take up and transport metals within the plant. The retention of Cd in root varies from 34 per cent to 97 per cent of the total plant Cd (Jarvis *et al.*, 1976). High retention of heavy metals in roots is particularly desirable in forage, cereals and vegetable crops where the roots are not utilized, thus reducing the heavy metal burden to animals and man. To investigate the extent of Cd accumulation in different crop species, and its retention pattern in various plant parts, as influenced by application of farm yard manure, pot culture experiments were conducted with graded levels of Cd in rice, sesame and cowpea. The soils used were lateritic alluvium (Aquic Ustipsamment), sandy Onattukara (Oxyaquic Quartzipsamment) and Vellayani red loam (Rhodic Haplustox) for rice, sesame and cowpea respectively.

Table 1. Content (mg kg^{-1}) of cadmium in soils, manures, fertilizers and lime used in pot culture studies

Samples	Total	Extractable
Lateritic alluvium	2.9	0.08
Sandy Onattukara	5.0	0.10
Red soil	2.3	0.06
Farm yard manure	1.8	—
Urea	0.9	—
Superphosphate	20.4	—
Factamphos	18.2	—
Muriate of potash	1.7	—
Burnt lime	Traces	—

The soils were air-dried, powdered and filled in earthern pots of 30 cm diameter @ 8 kg per pot. The total and DTPA extractable Cd contents in the soils used in pot culture studies were given in Table 1. The treatments were given as given in Table 2 in a completely randomized design with three replications.

Table 2. Details of treatments

T0	Absolute control
T1	Fertilizers + farm yard manure + lime
T2	Fertilizers + lime
T3	T1 + Cd 5 mg kg^{-1} soil
T4	T1 + Cd 15 mg kg^{-1} soil
T5	T1 + Cd 25 mg kg^{-1} soil
T6	T2 + Cd 5 mg kg^{-1} soil
T7	T2 + Cd 15 mg kg^{-1} soil
T8	T2 + Cd 25 mg kg^{-1} soil

Fertilizers, farm yard manure and lime were given as per the package of practices recommendations of the Kerala Agricultural University (KAU, 1993).

Manure, fertilizers and lime used in pot culture studies were initially analyzed for their content of cadmium (Table 1). A stock solution of $CdCl_2\ 2H_2O$ was prepared in water and the quantity required to provide the prescribed level in each treatment was applied in soil contained in pots before transplanting rice and sowing of sesame and cowpea. In the experiment with rice, three seedlings (18 days old) of the variety Jyothi were transplanted in each pot and water level was maintained at 5 cm after two days. In the experiment with sesame, 10 seeds of the variety Thilak were sown in each pot and population thinned to two plants. In the experiment with cowpea, two plants of the variety C-152 were grown in each pot. Light irrigation was given to sesame and cowpea.

At the time of harvest, the entire plants along with roots in each pot were carefully removed, washed free of adhering soil particles with water and air-dried. Plants were separated into root, straw/haulm and grain/pod. The air-dried samples were oven dried, powdered and analyzed for the content of Cd following

Table 3. Cadmium concentration (mg kg^{-1}) in different parts of rice, sesame and cowpea as influenced by treatments

Plant species	Plant parts	Treatments									CD (0.05)
		TO	Tl	T2	T3	T4	T5	T6	T7	T8	
Rice	Grain	1.0	2.1	1.7	2.4	2.8	6.3	2.2	2.7	3.2	0.71
	Straw	1.2	2.7	2.2	4.7	6.8	9.3	2.7	4.2	7.8	0.93
	Root	2.8	6.2	5.2	24.2	49.0	91.2	11.0	23.3	51.7	1.29
Sesame	Pod	3.2	4.7	3.5	8.8	12.5	13.7	8.3	9.8	10.7	1.58
	Haulm	4.0	5.3	5.0	19.2	31.5	31.8	20.0	22.3	22.8	4.57
	Root	7.0	7.8	8.0	52.0	101.3	108.0	97.0	126.7	134.7	31.9
Cowpea	Grain	1.2	1.7	1.3	1.7	2.3	2.8	1.7	1.7	2.0	0.50
	Haulm	1.3	2.2	2.1	2.5	3.3	7.0	3.3	4.0	5.5	1.12
	Root	3.8	6.5	4.3	11.7	21.3	38.8	8.1	18.8	21.0	3.99

standard procedures outlined by AOAC (1980). The Cd concentration in different plant parts of rice, sesame and cowpea are presented in Table 3. A gradient of Cd concentration was found in different plant parts of all the three crops in the order of roots > straw/haulm > grain/pod. Such a gradation in Cd content has been reported by Culter and Rains (1974). Complexation of heavy metals by phytochelators and metallothionines in roots as observed by Guo and Marschner (1995) explains these results. Differences between plant species were found in Cd concentration. Among the three crops studied, accumulation of Cd was the highest in sesame and the least in cowpea. A differential capacity of plant species and genotypes in their adsorption and translocation of heavy metals has been reported by Petterson (1977). It may be seen from Table 3 that cadmium contents in grains of rice and cowpea and pod of sesame in the control treatments (TO, Tl and T2) were in the range of 1.0 to 2.1, 1.2 to 1.7 and 3.2 and 4.7 mg kg^{-1} respectively. Cd content in rice grain from absolute control pot (TO) alone appears to be in the food safety level of 1.0 mg kg^{-1}, suggested by Ito and Iimura (1976). Higher concentrations of Cd noted in Tl and T2 than in TO indicate that fertilizers and farm yard manure are sources of Cd contamination as reported by Mathew and Abraham (2000). When graded levels of Cd were applied along with farm yard manure in T3, T4 and T5, Cd content in the edible parts of cowpea, rice and sesame ranged from 1.7 to 2.8, 2.4 to 6.3 and 8.8 to 13.7 mg kg^{-1} respectively. While at varying levels of Cd in T6, T7 and T8 in the absence of farm yard manure, contents of Cd in the edible parts of cowpea, rice and sesame were in the range of 1.7 to 2.0, 2.2 to 3.2 and 8.3 to 10.7 mg kg^{-1} respectively. It was clear that Cd content in all the plant parts of the three crops increased with increasing levels of Cd in soil. The increase was more appreciable in the presence of farm yard manure than without it. The humified organic matter in farm yard manure might have chelated Cd as soluble complexes and permitted a higher intake of Cd by plants that have received Cd along with farm yard manure.

Among the three crops studied, sesame was found to be the highest accumulator of Cd. In Cd treated plants, accumulation of Cd in roots was nearly ten fold higher than the amount of Cd translocated to the above ground edible plant parts. In control treatment, content of Cd in roots was almost double its content of edible portions.

Considering the enhancing effect of farm yard manure in promoting plant intake of Cd, application of farm yard manure cannot be recommended as an ameliorative measure in heavy metal polluted soils.

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