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Influence of cadium on yield and its uptake by chickpea, wheat and nutrient status of soils

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ABSTRACT

The pot culture experiment was conducted during *Kharif*, 1999 by growing chickpea upto flowering and wheat upto maturity stage in a clay and a loamy sand soils of Karvan and Anand with five levels of Cd (0, 2.5, 5.0, 10.0 and 20.0 ppm). The pot culture study indicated a significant reduction in the dry weight of both crops. Wheat plant did not show any visual toxic symptoms, whereas chickpea plants showed visual symptoms for Cd toxicity at elevated Cd level even after the crop harvest. About 22 to 27 per cent of the total applied Cd remained in available form, indicating possible residual effect also. Particularly at Cd_4 level it crossed the critical level of 3.0 mg kg^{-1} suggested for Cd.

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Key words : Yield, Uptake, Nutrient status of soil, Cadium

INTRODUCTION

Cadmium is one of the most important potential bio-toxic heavy metal encountered in soil and water pollution. Though it occurs naturally in soil, its addition as a pollutant has increased in recent times causing concern in the field of agriculture. This has necessitated research on Cd added to soil. It is naturally found in soil as mineral combined with other elements such as oxygen, chlorine or sulphur. In India Cd toxicity has also been reported from the rice growing area and other agricultural lands, near by industrial estates.

Cadmium is added to the soil as a contaminant in fertilizer, manure, municipal wastes, sewage sludge and also from aerial deposition. The amount of Cd contributed from each source varies with location due to difference in soil formation, management practices and exposure to pollution sources (Jones *et al.*, 1992). Among the different sources of Cd pollution, commercial fertilizers particularly phosphatic fertilizers contain a great range of heavy metals including Cd. In some phosphatic fertilizers 9-156 mg Cd kg^{-1} is reported (Williams and David, 1976). In case of manures, both composted and uncomposted municipal wastes may have about 2 mg Cd kg^{-1} dry weight (Purves, 1977). Sewage sludge, which is the most important source of Cd dissemination, may contain 2-1500 mg Cd kg^{-1} dry weight (Webber *et al.*, 1983). Generally much more Cd is added in one application of sewage sludge than in a normal application of fertilizer.

The critical content of Cd in soil is 3 ppm. Plants can tolerate Cd toxicity to a greater extent as compared to animals and human. The critical concentration of Cd is reported to be 5-10ppm in the dry matter of plants. Differential uptake of Cd was observed by different crop species. Plants of gramineae family like wheat, rice, oat etc. were reported to accumulate more Cd than leguminous plants.

MATERIALS AND METHODS

A pot experiment was conducted to study the effect of varying level of Cd on yield and nutrient uptake of chickpea and wheat grown on a loamy sand and a clay soils. The details of the treatments are as under

(a) Cd levels Five	(b) Type of soil : Two
0 ppm Cd (Cd_0)	Clay soil (S_1)
2.5 ppm Cd (Cd_1)	Loamy sand soil (S_2)
5.0 ppm Cd (Cd_2)	(c) Crops : Two
10.0 ppm Cd (Cd_3)	Chickpea (C_1)
20.0 ppm Cd (Cd_4)	Wheat (C_2)

The experiment was conducted in FCRD with three repetitions. The total numbers of pots were sixty. Ten kg capacity polythene lined earthen pots were filled with 8 kg soil. Before transferring the soil to pots calculated recommended doses of fertilizers were added through urea and DAP solution. Cd was applied as $3CdSO_4 8H_2O$ in form of solution. The pots were brought to field capacity and 10 seeds of chickpea and 15 seeds of wheat were sown in each pot. After sprouting, chickpea and wheat plants were thinned to keep 6 and 10 plants per pot,

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respectively. Irrigation and plant protection measures were taken as per the need. Chickpea was allowed to grow upto flowering whereas wheat was grown upto maturity stage after which the plants were uprooted carefully and after oven drying at 65^{0}C. The soil sample after harvest of crop were air dried for chemical plant and soil analysis as per below standard methods.

Chemical analysis				
		Anand	Karvan	Reference
1	Available N (kg ha^{-1})	125	203	Subbiah and Asija (1956)
2	Available P_2O_5 (kg ha^{-1})	164	217	Olsen *et al.* (1954)
3	Available K_2O (kg ha^{-1})	778	953	Jackson (1973)
4	Available S (kg ha^{-1})	96	127	Chaudhary and Cornfield (1966)
5	Available Cd (ppm)	0.02	0.04	Lindsay and Norvell (1978)
6	Available Zn (ppm)	10.5	18.6	Lindsay and Norvell (1978)
7	Available Fe (ppm)	16.1	21.6	Lindsay and Norvell (1978)

RESULTS AND DISCUSSION

Application of Cadium significantly reduced the total dry matter yield of wheat. The total dry matter yield decreased to 49.6 per cent at Cd_4 levels as compared to Cd_0. In present study wheat plants did not show any visual Cd toxicity symptoms but chickpea plants showed the toxic symptoms (Table 1). The reduction in dry matter yield due to increasing Cd application rates was reported by several workers (Haghiri, 1973; Bingham *et al.*, 1975; Khan and Khan, 1983; Valdares *et al.,* 1983; Dahiya *et al.*, 1987; Gupta and Disal, 1992; Sarkunan *et al.*, 1995; Gupta *et al.,* 1997; Ramchandran and D'souza, 1999). The yield reduction was also correlated with photosynthetic processes. The net photosynthesis and chlorophyll content in general decreased with Cd concentration. The inhibition may primarily be attributed to the closure of stomata (Huang *et al.*, 1974). The application of 0, 2.5, 5.0, 10.0 and 20.0 ppm Cd to both the soils significantly increased the Cd uptake by chickpea and wheat. These findings are in confirmation with those Dahiya *et al.* (1987); Singh and Singh (1994); Sankenan *et al.* (1995). The availability of N, P, K, S and Zn was noticed significantly higher at harvest under clay soil (S_1) than loamy sand soil (S_2). However, the available Cd (1.98 mg kg^{-1}) and Fe (8.23 mg kg^{-1}) were significantly more in loamy sand soil after harvest of crops.

Application of Cd enhanced significantly its availability and reduced the concentration of N,P,K, S, Zn and Fe in soils. The highest Cd availability (4.96 mg kg^{-1}) was noticed under Cd_4 level, which is more than maximum (2.30 mg kg^{-1}) concentration in soils permitted under European Community Regulations (Wild, 1998). Cd may reach to hazardous level in the soil if it will be incorporated in the soil through any means. Availability

Table 1 : Effect of cadmium on yield and its uptake by chickpea and wheat and nutrient status of soils

Treatments	Grain (g pot^{-1})	Cd uptake (mg pot^{-1})	Available nutrient status (mg kg^{-1})						
			N	P	K	S	Zn	Fe	Cd
C_1	16.86	8.97	879	293	1789	292	3.22	8.23	1.86
C_2	28.91	23.12	799	309	1734	255	4.50	7.73	1.90
S.E. ±	0.051	0.158	8.65	5.42	14.50	6.49	0.033	0.036	0.006
C.D. (P=0.05)	0.147	0.452	27.74	NS	41.44	18.56	0.096	0.103	0.017
S_1	27.21	17.80	870	376	2730	299	4.36	7.59	1.78
S_2	18.56	14.29	808	226	794	247	3.36	8.36	1.98
S.E. ±	0.051	0.158	8.65	5.42	14.50	6.49	0.033	0.036	0.006
C.D. (P=0.05)	0.147	0.452	24.74	15.48	41.44	18.56	0.096	0.103	0.017
Cd_0	30.21	0.53	943	411	1768	285	5.50	10.15	0.002
Cd_1	26.64	9.70	873	359	1812	294	4.61	9.22	0.55
Cd_2	23.04	15.83	845	305	1772	283	3.88	8.22	1.15
Cd_3	19.29	22.42	798	273	1762	267	3.07	6.95	2.74
Cd_4	15.24	31.74	737	192	1694	237	2.23	5.35	4.96
S.E. ±	0.081	0.250	13.69	8.56	22.92	10.27	0.053	0.057	0.009
C.D. (P=0.05)	0.233	0.714	39.11	24.78	65.51	29.34	0.152	0.162	0.027
CV %	1.23	5.39	5.65	9.86	4.51	13.01	4.78	2.47	1.76

of all nutrients was significantly reduced under 20.0 ppm of applied Cd.

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