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(An international Journal)

Vol. 4 December 1991 No. 2

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Crop Res. 4 (2) : 199-205 (1991)
With one figure
Printed in India

Effect of cadmium and farm yard manure on the concentration and uptake of zinc by wheat in texturally different soils

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ABSTRACT

A screen house experiment was conducted using sandy loam and clay loam soils to study the effect of varying levels of Cd (0, 10, 20, 40, 80 and 160 μg/g soil) and FYM (0, 0.5, 1.0 and 2.0 per cent on dry weight basis) on the yield of wheat (cv. WH-283) and Zn concentration and uptake by grain and straw. Grain and straw yield of wheat decreased significantly with the increasing levels of Cd in both soils. Application of FYM has resulted in the increased production of grain and straw, however, significant differences were observed at 1 and 2 per cent levels only. Application of FYM also counteracted the adverse effect of Cd on plant growth. The zinc concentration in wheat grain and straw increased significantly with the square root of Cd in the soil (r=0.985 and 0.995). The zinc uptake by wheat grain and straw was found to be inversely correlated with the cube root of the soil added Cd (r=-0.956 and -0.957). Application of FYM increased the zinc concentration and uptake by wheat grain and straw. The plants grown in clay loam soil were containing higher Zn than those in sandy loam soil.

Key words : Cadmium, concentration, farm yard manure, uptake, wheat, zinc

INTRODUCTION

Environmental pollution is increasing due to the increase in the industrialization and urbanization. The heavy metal content of soils is also increasing due to indiscriminate use of contaminated industrial/city wastes for crop production (Gupta *et al*, 1986). Among the metals, Cd is the most mobile in the soil-plant system. Cadmium is also highly toxic to plants and also accumulated in plants in excessive quantities (Singh *et al.*, 1988). Excessive accumulation of Cd in plant tissues may cause nutritional imbalance (John, 1976). Zinc is one of the essential elements related geochemically with Cd. However, contradictory reports are available on the Zn content of plants grown on soils spiked with Cd. Turner (1973) and Cunnigham (1977) observed increased concentration of Zn in plants with the increasing levels of Cd in the growth medium. Bingham *et al.* (1986), however, reported inconsistant effect on Zn due to increasing Cd applications. Present investigation was, therefore, undertaken to study the effect of varying levels of Cd and FYM on the Zn concentration and uptake by wheat in sandy loam and clay loam soils.

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MATERIALS AND METHODS

A pot experiment using sandy loam (Typic Ustipsamment) and a clay loam (Aquic Ustochrept) soil was conducted in the screen house. Some of the physico-chemical chraacteristics of the sandy loam and clay loam soils, as determined by following standard procedures were : pH (1 : 2) 8.3 and 8.5, E.C. (1 : 2) 0.25 and 0.35 dS/m, organic carbon 0.45 and 0.58 per cent, cation exchange capacity 9.4 and 20.6 c mole (p^+)/kg soil, DTPA extractable Zn 1.5 and 3.6 μg/g soil and extractable Cd 0.21 and 0.19 μg/g soil, respectively. Five kg of air dried soil was placed in polyethylene lined earthen pots. Treatments consisted of 6 levels of Cd (0, 10, 20, 40, 80 and 160 μg/g soil as cadmium chloride) and 4 levels of FYM (0, 0.5, 1.0 and 2.0 per cent on dry weight basis) in complete combinations. Each treatment was replicated three times in a randomised design. A basal dose of N, P, K, Zn, Fe, Mn and Cu were applied @ 60, 50, 60, 5, 10, 5 and 5 μg/g soil, respectively through their analytical grade salts in solution form. Nitrogen was also applied in two equal splits after 30 and 45 days of sowing @ 30 μg/g soil through urea. Eight seeds of wheat (cv. WH-283) were sown in each pot and only four plants were maintained upto maturity. The harvested plants were washed first with acidified distilled water and finally with double distilled water. The above ground part was oven dried at 67 ± 2°C for 72 hours and weighed. Thereafter, the grains were separated and weighed. The grain and straw samples were ground in a stainless steel grinder and digested in an acid mixture of HNO_3 and $HClO_4$ (4 : 1). Zinc in the digest was determined by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Yield

The wheat grain and straw yield decreased significantly with the increasing levels of Cd in the soil (Table 1). The increasing levels of FYM increased the yield of grain and straw. However, the significant increase was observed only at 1.0 and 2.0 per cent levels of FYM application. The interaction between Cd, organic matter and texture on grain and straw yield were found to be non-significant.

Increasing levels of Cd in the soil resulted in the decreased yield of wheat grain and straw. Similar results have also been reported by Sameni *et al.* (1987). The reduction in the yield might be due to the toxicity of Cd to the plants because typical toxicity symptoms resembling to iron chlorosis were observed at the higher levels of soil added Cd. Similar toxicity symptoms were also observed by Khan and Frankland (1983). Results further show that the grain and straw yield increased with increasing levels of FYM in the soils. The increase in the yield with the increasing levels of FYM is obvious as it is a store house of plant nutrients apart from improving the physico-chemical processes of the soil (Patil and Patil, 1981).

Table 1. Wheat grain and straw yield (μg pot⁻¹) as affected by Cd and FYM levels

Treatment	Cadmium levels (μgg⁻¹ soil)					
	0	10	20	40	80	160
FYM Levels (%)				**Grain**		
0 0	16.6	13.4	9.3	6.3	3.1	2.2
0.5	17.1	14.2	9.7	6.7	3.2	2.3
1.0	17.9	15.2	10.1	7.1	3.5	2.6
2 0	19.1	16.3	10.8	7.4	3.8	2.7
CD (P=0.05) for : Cd 0.9; FYM 0.7; Cd×FYM NS						
FYM Levels (%)				**Straw**		
0.0	23.1	20.1	13.1	9.2	4.5	3.4
0 5	23.7	20.5	13.6	9.8	4.8	3.5
1.0	24.9	20.9	14.2	10.2	5.0	3.9
2.0	26.7	22.3	15.3	10.8	5.7	4.3
CD (P=0.05) for : Cd 1.3; FYM 1 1; CD×FYM NS						

NS : Not significant

Zinc concentration

The Zn concentration in the wheat grain and straw increased with the increasing levels of Cd and FYM (Table 2). Significant increase in Zn concentration in grain and straw was observed at Cd levels exceeding 10 and 20 μg/g soil, respectively. The interaction between Cd and FYM in relation to Zn concentration in the grain and straw was statistically nonsignificant, however, the Zn concentration increased consistently with the increasing levels of FYM at each level of soil added Cd. The interaction between Cd and FYM was nonsignificant, possibly, due to the masking effect of the main factors. The Zn concentration was significantly higher in the grain and straw of plants grown in clay loam than those grown in the sandy loam soil (Table 3). All other interactive effects were statistically nonsignificant.

The quantitative relationships between the Zn concentration in grain and/or straw and the soil added Cd is shown in Fig. 1A. It is seen that the Zn concentration in the grain and straw was a power function of square root of Cd concentration in the soil ($r = 0.985$ and 0.995). Increased content of Zn in the plant tops with increased Cd levels in the nutrient solution has also been observed by Turner (1973). Jones *et al.* (1973) also reported increased concentration of Zn in the shoots of several plant species. No definite explanation is available for the increase in the Zn concentration due to increasing Cd levels in the soil but Turner (1973) has ascribed it to the possible root damage in the presence of Cd. We have also observed damaged roots of wheat, particularly at 80 and 160 μg/g soil added Cd levels. Another reason for increasing Zn concentration in the plants might be the reduced dry

Table 2. Zinc concentration (μgg^{-1}) in wheat grain and straw as affected by Cd and FYM levels

Treatment	Cadmium levels (μgg^{-1} soil)					
	0	10	20	40	80	160
FYM Levels (%)			**Grain**			
0.0	45.4	46.3	46.9	47.9	48.5	49.5
0.5	48.7	50.8	51.2	51.8	52.4	53.8
1.0	51.8	53.4	54.2	54.7	55.5	56.6
2.0	55.8	58.5	59.3	59.5	59.6	61.9
CD (P=0.05) for : Cd 1.37; FYM 1.12; Cd×FYM NS						
FYM Levels (%)			**Straw**			
0.0	25.0	25.5	25.8	25.9	26.7	27.0
0.5	28.7	29.2	30.0	31.1	31.7	33.5
1.0	32.1	32.3	33.5	34 2	35.2	36.0
2.0	34.6	35.4	35.6	36.0	37.1	38.3
CD (P=0.05) for : Cd 0.92; FYM 0.75; Cd×FYM NS						

NS : Not significant

matter yield as a result of increasing Cd levels in the soil (Table 1). The elevated Zn concentration in wheat grain and straw as a result of organic matter might be due to the production of sequestering agents that aid in the solubilization of Zn compounds in the soil (Stevenson and Ardakani, 1972). Maskina and Randhawa (1983) also observed increased Zn content in rice with the application of organic matter. Hofner *et al.* (1978) also observed increased Zn concentration in maize and sunflower with the application of FYM. The two factors, texture and organic matter interacted significantly in influencing the Zn concentration in wheat. The increased concentration in the plants grown in clay loam soil may be attributed to higher amount of available Zn and organic matter in the soil.

Zinc uptake

The uptake of Zn by wheat grain and straw decreased and increased significantly with the increasing levels of Cd and FYM, respectively (Table 4). The data indicate that the per cent reduction in Zn uptake by wheat straw with soil Cd levels of 10, 20, 40, 80 and 160 $\mu g/g$ was 13.6, 40.9, 56.8, 77.8 and 82.3, respectively. The adverse effect of Cd on Zn uptake by grain and straw was more pronounced at its higher levels i.e. 80 and 160 $\mu g/g$ soil. Application of FYM enhanced the Zn uptake by wheat straw and grain. The per cent increase in Zn uptake by wheat straw was 61.7 with an increase of FYM from 0 to 2 per cent (Table 4). The Zn uptake by wheat grain and straw was significantly higher in clay loam soil as compared to

sandy loam soil. The Zn uptake by wheat grain and straw increased from 431.7 to 533.7 and 391.4 to 424.8 $\mu g/g$ with a change in soil texture from sandy loam to clay loam, respectively.

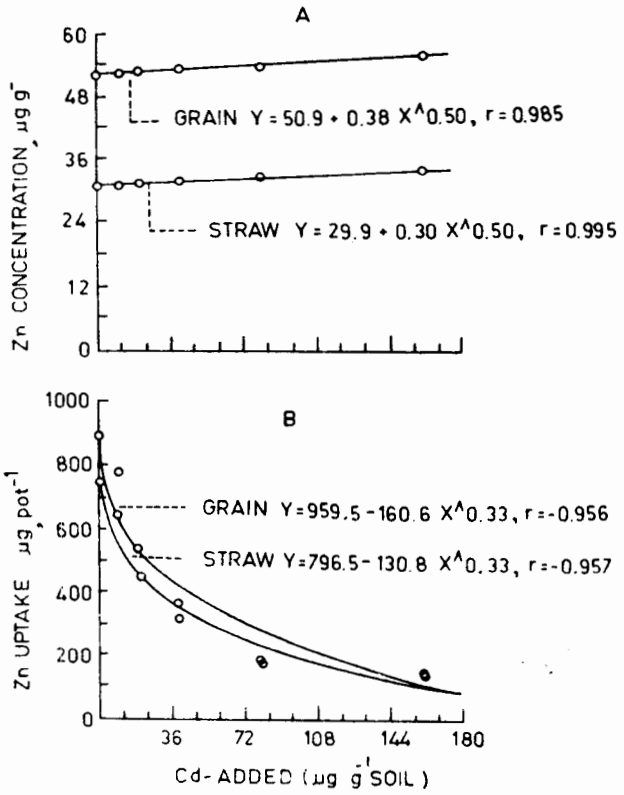

Fig. 1. Zinc concentration in grain and straw and their uptake by wheat as affected by levels of soil added cadmium.

Table 3 Zinc concentration ($\mu g g^{-1}$) in wheat grain and straw as affected by FYM and texture

Treatment	Grain		Straw	
	Sandy Loam	Clay Loam	Sandy Loam	Clay Loam
FYM Levels				
0.0	41.64	53.23	25.64	26.36
0.5	46.68	56.25	30.90	30.55
1.0	48 55	60.23	33.90	33.88
2 0	55.89	62.32	34.53	37 82
CD (P=0 05) for:				
Texture		0.79	0.53	
FYM		1.58	1.06	

Application of FYM enhanced the Zn uptake by wheat grain and straw. The per cent increase in straw was 61.7 with an increase of FYM levels from 0 to 2 per cent (Table 4). The data further indicate that in the absence of Cd, the uptake increased significantly even at 0.5 per cent FYM level but it remained statistically unaffected with increasing FYM levels at 160 $\mu g/g$ soil added Cd level. It is, therefore, evident that the interactive effect was more pronounced at their low levels. The all other interactions were, however, statistically nonsignificant.

Table 4. Zinc uptake (μg pot^{-1}) by wheat grain and straw as affected by Cd and FYM levels

Treatment	Cadmium levels ($\mu g g^{-1}$ soil)					
	0	10	20	40	80	160
FYM Levels (%)			**Grain**			
0.0	755	619	433	302	150	111
0.5	832	720	498	347	168	127
1.0	927	807	551	387	196	152
2.0	1068	952	643	437	228	174
CD (P=0.05) for : Cd 51.6; FYM 42.2; Cd×FYM 103.3						
FYM Levels (%)			**Straw**			
0.0	578	512	337	237	120	91
0.5	680	596	409	308	151	117
1.0	800	676	474	353	176	142
2.0	924	793	541	392	214	167
CD (P=0.05) for : Cd 43.4; FYM 35.4; Cd×FYM NS						

NS : Not significant

The Zn uptake by wheat straw and grain decreased with the increasing levels of Cd in the soil (Fig. 1B). It is seen from the figure 1B that Zn uptake by grain and straw was an inverse function of cube root of the concentration of Cd in soil ($r = -0.956$ and -0.957). The Zn uptake was significantly higher than the straw. The decreased Zn uptake by wheat may be attributed to significant yield reduction with increasing Cd application (Table 1). Khan and Frankland (1983) also reported decreased Zn uptake with increasing Cd application in different crops. The higher uptake of Zn by wheat with increasing FYM levels might be due to the better plant growth and the increase in the solubilization of Zn compounds in the soil (Stevenson and Ardakani, 1972).

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