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INTER-RELATIONSHIP BETWEEN CADMIUM TOXICITY AND FARMYARD MANURE AS SOIL CONDITIONER UNDER DESERT SOIL CONDITIONS

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A pot experiment was carried out in the greenhouse in 1998 to study the effect of Cd and soil application of a natural soil conditioner on the growth and Cd uptake of barley and sorghum plants under the conditions of Maryut and Nubaria desert areas to the depth of 30cm. Cadmium was applied to the soil at the rates of 0, 10, 20 and 30mg $Cd.kg^{-1}$ soil either alone and with 50g organic soil conditioner/pot.

The pots were cultivated to barley then to sorghum plants. Plant and soil samples were collected at the harvest of barley and at the three cuts of sorghum to follow up growth and Cd uptake. Grain and straw yields of barley and the dry matter of sorghum were recorded. Cadmium uptake was calculated.

Dry matter decreased significantly in retard to increased Cd level. But, Cd content in both straw and grains of barley and in the dry matter of sorghum increased as soil cadmium increased. Farm Yard Manure (FYM) conditioner decreased the depressive effect of Cd on dry matter production at all Cd levels. Fine-textured soil of Maryut was significantly better than the coarse soil of Nubaria. This points to the essence of applying greater amounts of FYM to the coarse textured soils than to the fine ones in case of pollution with Cd. The lowest Cd uptake was found in barley grains as compared with that in straw. For sorghum, the roots retained an appreciable amount of Cd.

The tolerance and mobility indexes were calculated and proved to be good tools for evaluating Cd effects on plant performance. Also, EDTA-extractable Cd was measured, but was not found to be a good vehicle to assess total Cd in the soil.

Keywords: cadmiun toxicity, farmyard manure, soil conditioners, calcareous soil.

Soil and water pollution degrades the resources that support life. Prosi and Van Lierde (1983) stated that mercury is the most toxic metal followed by cadmium, though there is no rigid order of toxicity. Abd El-Aziz (1983) reported that the first symptoms of toxicity start at 50ppm Cd for both corn and wheat.

Concerning sources of Cd pollution, the amount of Cd ranges from 10 to 91ppm depending on the source of rock phosphate (Schroeder *et al.*, 1967). In addition, Abdel-Shakour (1982) showed that the arable soils at Shoubra El-Kheima contain 1.2ppm Cd and 25ppm near the factories and smelters complex. He added that the level of Cd depends on the distance of the soil from the industrial areas and the amount of precipitation.

Staher *et al.* (1980) found that cadmium was not highly adsorbed in mineral soil. The adsorption of cadmium by soils is important in determining its availability to the plant and its movement through the soil profile. Tyler and McBride (1982) mentioned that high pH, CEC and exchangeable base content are among the factors that enhance Cd mobility in the soil. Cd was reported to be of lower mobility as compared to Cu, Zn and Ni. So, Cd exists predominantly in the surface soil. Jauregui and Reisenauer (1982) found that $CaCO_3$ had a negative effect on the uptake of Cd by plant. Cadmium was bound to humidified organic matter in the soil as soluble or insoluble organo-mettalic complexes (Stevenson and Fitch, 1986).

Sorteberg (1976) found that barley plants grown in normal soil contained 0.25mg $Cd.kg^{-1}$ straw and 0.08mg $Cd.kg^{-1}$ grain. Jarvis *et al.* (1978) stated that, in general, Cd content of roots was much greater than that of shoots, and that older plants contained more Cd than younger ones. Hofer (1980) reported that the application of 6-12ppm Cd reduced wheat grain yield by 10% and straw yield by 12-17%. However at 48ppm Cd, wheat grain yield was reduced by only 6% compared to the control. Webber (1981) reported that cadmium concentration ranges from 2 to $150mg.kg^{-1}$ dry matter.

The aim of the present investigation was to study the effect of Cd level in soil as well as with the application of organic amendment on the growth of barley and sorghum plants under the conditions of desert soils; a calcareous soil at Maryut and a sandy one at Nubaria.

MATERIALS AND METHODS

Representative soil samples (0-30 cm) were collected from a non-calcareous soil at Nubaria (150km by the Cairo-Alex desert road) and from a calcareous soil from parcel 13 of the Maruyt experimental research station of the Desert Research Centre (200km by the desert road). Soil samples were air-dried, crushed, sieved through a 2-mm sieve and stored for chemical and physical analyses.

The experimental unit in this study was a plastic pot containing five kg of the soil from both locations under investigation. Calcium super phosphate was thoroughly mixed with the soil in each pot at the rate of

30kg/fed (fed = 0.42 ha). Cadmium sulfate was applied at the rates of 0, 10, 20 and 30 ppm either alone or with 50 g farm yard manure, FYM/pot. Each of the eight treatment combinations, for both soils, was assigned three pots in factorial arrangement in a completely randomized statistical design.

Fifteen seeds of barley (Giza 126) were planted in each pot. After germination, all pots received N at 40 kg/fed as ammonium nitrate and K at 50 kg/fed as potassium sulfate, both in two equal doses; after 20 and 50 days from sowing. Other practices were the same for all pots.

Plant samples were collected at three stages; tillering, before earing and at harvesting, weighed, washed with dilute HCl then with redistlled water, dried at 70°C, ground and stored. Dry weight of each plant sample was recorded as g/pot.

After barley harvest, the soil in each pot was loosened and treated with 0.1g N/pot. Twenty seeds of sorghum were sown per pot. Three cuts of sorghum were obtained at 45-day intervals. Samples were treated same as with barley ones, in addition to that after the third cut the roots were collected, cleaned from the soil particles, washed with redistilled water then dried at 70°C and the root dry weight was recorded.

Soil samples were taken from each pot at plant sampling, air-dried and sieved through a 2-mm sieve. Soil mechanical composition was carried out by the pipette method without removal of $CaCO_3$ (Kilmer and Alexander, 1945). EC, soluble cations and anions, total carbonate, pH and organic matter were determined according to Jackson (1958). CEC and exchangeable cations were determined according to Richards (1954) using $NaOAc$-NH_4OAc and NH_4Oac, respectively. Total and NH_4Ac-EDTA extractable Cd were determined as described by Cottenie *et al.* (1982) using an atomic absorption spectrophotometer Perkin Elmer 2380 to investigate the availability of Cd in the Nubaria and Maryut soils after barley harvesting as well as after the third cut of sorghum.

Dry plant samples of both crops were ground and wet-digested using ternary acid mixture of concentrated HNO_3, H_2SO_4 and $HCLO_4$ as described by Hess (1971). Cd content was determined in the digest as above.

The tolerance index (Ti) was calculated according to Camerlynck and Velghe (1979) to evaluate cadmium effect on plant growth.

Ti = (Dry weight of enriched soil) / (Dry weight of normal soil)

When: Ti = 1 (no effect), Ti > 1 (favourable) and Ti < 1 (unfavourable)

Also, the mobility index was calculated according to Tallab (1994):

Mi = (Concentration of Cd in shoots) / (Concentration of Cd in roots)

RESULTS AND DISCUSSION

The two studied soils are mildly alkaline with the Nubaria soil being sandy, non-saline, non-calcareous and dominated by soluble ions of calcium and sulphate, while Maryut soil is calcareous, sandy clay loam, salt affected and dominated by sodium and chloride (Table 1). Total Cd content in both soils is nearly the same. Table (2) shows the properties of the applied FYM.

TABLE (1). Chemical and physical properties of the studied soils.

Soil	Soluble cations (me/L):				Soluble anions (me/L):		
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Nubaria	4.55	4.1	1.94	2.21	4.89	4.56	3.35
Maryut	19	10.6	27.5	2.12	6	36.5	16.72
	pH	EC (dS/m)	CEC (me/100g soil)	$CaCO_3$ (%)	O.M. (%)	Total Cd ($mg.kg^{-1}$)	Exch. Cd ($mg.kg^{-1}$)
Nubaria	7.7	1.28	3.48	3.88	0.05	0.15	0.04
Maryut	7.8	7.4	10.4	27.27	1.48	0.2	0.04
	Mechanical analysis (%):				Textural class		
	C S	F S	Silt	Clay			
Nubaria	66.34	23.76	3.06	5.94	Sand		
Maryut	0.84	43.75	26.26	29.15	Sandy clay loam		

C.S.=Coarse Sand F.S.=Fine Sand

TABLE (2). Chemical analysis of the organic conditioner Farm Yard Manure applied in this study.

Organic C (%)	Total N (%)	C:N	Total P (%)	Total K (me. kg^{-1})	Total Cd ($mg.kg^{-1}$)	Exch. Cd ($mg.kg^{-1}$)
19.34	1.45	13 : 1	0.25	1.4	0.2	0.08

Generally, the tables (3,4,5 and 6) depict the achieved effects in the form of three interactions; namely cadmium x soils, cadmium x FYM and soils x FYM, on the different measurements of both barley and sorghum plants.

Dry matter production of barley and sorghum plants

Data in table (3) show that the grain and straw yields of barley were significantly and consistently decreased by the increase in soil pollution with cadmium in both studied soils either without or with FYM application. However, this depressive effect was more pronounced in the sandy soil of Nubaria than in the heavy-textured soil of Maryut. This can be referred to higher buffering action in the latter soil of hindering the toxic effect of Cd on barley growth. From another point of view, the application of FYM helped greatly and significantly in decreasing the toxic effect of cadmium pollution in both soils, with a greater significant role in the heavy-textured soil. Table (4) exhibits the above-mentioned trends on the accumulative (sum of 3 cuts) dry weight of shoots and the final dry weight of sorghum roots. Generally, sorghum was more prominent in depleting cadmium from the soils compared with barley owing to the greater dry matter production of the former.

This agrees firmly with the findings of Stevenson and Fitch (1986), who found that Cd is bond by humidified organic matter in the soil as soluble or insoluble organo-metallic complexes.

From the above-mentioned results, combating soil pollution with toxic elements, such as cadmium in this study, requires providing a surfaceactive material as FYM. Consequently, counterbalancing the toxic effect in light-textured soils necessitates the application of greater amount of FYM compared with that in the heavy textured ones. Planting the soil to a more capable crop is an efficient tool in combating pollution, hence reclaiming such soils and rendering them good for safe crop production.

TABLE (3). The main effect of Cd pollution, soil type and FYM conditioner and their interactions on grain and straw yields (g/pot) of barley.

Cd level (mg/kg)	Soil		FYM		Mean	Soil	FYM	
	Nubaria	Maryut	Without	With			Without	With
Grain								
0	2.84 a	3.08 a	2.59 a	3.33 a	2.96 a	Nubaria	1.42 b	2.14 b
10	2.07 b	2.02 b	1.68 b	2.41 b	2.05 b	Maryut	1.55 a	2.26 a
20	1.26 c	1.61 c	0.94 c	1.94 c	1.44 c			
30	0.95 d	0.90 d	0.73 d	1.12 d	0.93 d			
Mean	1.78 b	1.90 a	1.48 b	2.20 a				
Straw								
0	11.26 a	17.66 a	13.84 a	15.09 a	14.46 a	Nubaria	9.57 b	9.65 b
10	9.71 b	15.49 b	12.56 b	12.64 b	12.60 b	Maryut	14.35 a	15.42 a
20	9.08 c	13.99 c	11.47 c	11.60 c	11.54 c			
30	8.37 d	12.40 d	9.97 d	10.80 d	10.39 d			
Mean	9.61 b	14.88 a	11.96 b	12.53 a				

Values in the same column sharing an alphabet are not significantly different at 5% level.

TABLE (4). The main effect of Cd pollution, soil type and FYM conditioner and their interactions on cumulative shoot (sum of 3 cuts) and root dry weights (g/pot) of sorghum.

Cd level (mg/kg)	Soil		FYM		Mean	Soil	FYM	
	Nubaria	Maryut	Without	With			Without	With
Cumulative shoot (3 cuts)								
0	25.90 a	30.52 a	27.54 a	28.89 a	28.21 a	Nubariya	17.03 b	20.17 b
10	21.68 b	22.68 b	20.80 b	23.56 b	22.18 b	Maryut	21.03 a	23.20 a
20	16.68 c	19.45 c	16.77 c	19.36 c	18.07 c			
30	10.16 d	17.61 d	12.82 d	14.95 d	13.88 d			
Mean	18.60 b	22.12 a	19.03 b	21.69 a				
Root								
0	4.31 a	5.70 a	4.70 a	5.32 a	5.01 a	Nubariya	3.00 b	3.51 b
10	3.86 b	3.64 b	3.39 b	4.11 b	3.75 b	Maryut	3.54 a	4.07 a
20	3.01 c	3.17 c	2.90 c	3.28 c	3.09 c			
30	1.86 d	2.72 d	2.12 d	2.45 d	2.29 d			
Mean	3.26 b	3.81 a	3.27 b	3.79 a				

Values in the same column sharing an alphabet are not significantly different at 5% level.

Tolerance index of plants to cadmium

Tolerance index values calculated from the obtained dry matter production of barley grains and straw are depicted in table (5), while those concerned with sorghum accumulative shoots (sum of 3 cuts) and roots are in table (6). Tolerance index of barley decreased by increasing Cd level in the soil. Generally, the lowest tolerance index was recorded in Nubaria soil pointing to its low buffering action to combat Cd effect compared with that of Maryut soil. Soil conditioner enhanced dry weight production of barley (grains and straw) at every Cd level of application in both soils. Regarding sorghum (Table 6), approximately the same trends of tolerance index on barley could be seen on the accumulative shoots and roots dry weights.

Generally, tolerance index emphasized the results observed above and proved to be a good tool of exhibiting such depressive effects of pollutants, such as Cd, for discussion and evaluation.

TABLE (5). The main effect of Cd pollution, soil type and FYM conditioner and their interactions on tolerance index of barley in grain and straw yields.

Cd level (mg/kg)	Soils x Cd		FYM x Cd		Mean	Soil	FYM x Soils	
	Nubaria	Maryut	Without	With			Without	With
Grain								
0	1.000 a	1.000 a	1.000 a	1.000 a	1.000 a	Nubariya	0.582 a	0.660 a
10	0.727 b	0.650 b	0.652 b	0.725 b	0.688 b	Maryut	0.565 b	0.661 a
20	0.433 c	0.508 c	0.361 c	0.580 c	0.471 c			
30	0.326 d	0.294 d	0.282 d	0.338 d	0.310 d			
Mean	0.621 a	0.613 b	0.574 b	0.661 a				
Straw								
0	1.000 a	1.000 a	1.000 a	1.000 a	1.000 a	Nubariya	0.842 b	0.864 a
10	0.863 b	0.882 b	0.899 b	0.846 b	0.872 b	Maryut	0.880 a	0.811 b
20	0.807 c	0.797 c	0.823 c	0.781 c	0.802 c			
30	0.743 d	0.703 d	0.722 d	0.724 d	0.723 d			
Mean	0.853 a	0.846 b	0.861 a	0.838 b				

Values in the same column sharing an alphabet are not significantly different at 5% level.

Table (6). Effect of Cd pollution, soil type and FYM conditioner and their interactions on tolerance index of sorghum accumulative shoots (sum of 3 cuts) and roots dry weight.

Cd level (mg/kg)	Soils x Cd		FYM x Cd		Mean	Soil	FYM x Soils	
	Nubaria	Maryut	Without	With			Without	With
Cumulative shoot (3 cuts)								
0	1.000 a	1.000 a	1.000 a	1.000 a	1.000 a	Nubariya	0.718 a	0.739 b
10	0.790 b	0.785 b	0.796 b	0.779 b	0.788 b	Maryut	0.707 b	0.751 a
20	0.641 c	0.640 c	0.626 c	0.654 c	0.640 c			
30	0.485 d	0.491 d	0.429 d	0.547 d	0.488 d			
Mean	0.729 a	0.729 a	0.713 b	0.745 a				
Root								
0	1.000 a	1.000 a	1.000 a	1.000 a	1.000 a	Nubariya	0.756 a	0.668 a
10	0.767 b	0.747 b	0.808 b	0.706 b	0.757 b	Maryut	0.697 b	0.712 b
20	0.627 c	0.617 c	0.658 c	0.586 c	0.622 c			
30	0.454 d	0.456 d	0.441 d	0.469 d	0.455 d			
Mean	0.712 a	0.705 a	0.727 a	0.690 b				

Values in the same column sharing an alphabet are not significantly different at 5% level.

Cadmium concentration and uptake in barley and sorghum plants

Cadmium concentration in barley plants grown on Nubaria soil was higher than that in plants grown on Maryut soil, which reflects slower diffusion of Cd to plant roots in the latter soil (Fig. 1). Increasing the level of Cd application to the soil led to increasing its concentration in plants, but this was not in a linear mode (Fig. 1). This suggests that the available soil Cd is controlled by biological metabolic processes and/or chemical reactions that take place in different soil systems (Tallab, 1994). This explains, in addition, the greater toxic effect of Cd on barley growth in Nubaria soil compared with that in Maryut soil.

Concerning Cd uptake in barley grains and straw (Table 7) increased as soil Cd level increased. The application of soil conditioner decreased Cd content in grains. This is mainly referred to the greater dry matter production than to the concentration of cadmium in the plants. Analogously, FYM enhanced dry matter production, but significantly decreased cadmium concentration in plant parts. This led conclusively to greater Cd uptake by plants. Greater depletion of cadmium from the soil took place, but in a safe mode, where the pollutant cadmium was distributed into a large amount of plant tissue, i.e. low concentration.

Table (7). Effect of Cd pollution, soil type and FYM conditioner on Cd uptake in barley grains and straw.

Cd level (mg/kg)	Soils x Cd		FYM x Cd		Mean	Soil	FYM x Soils	
	Nubaria	Maryut	Without	With			Without	With
Cadmium uptake in grains (µg/pot)								
0	7.17 d	15.76 d	9.75	13.19 d	11.47 d	Nubariya	20.00 b	95.71 a
10	51.96 c	88.43 c	56.92	83.47 c	70.20 c	Maryut	102.48 a	87.27 b
20	69.08 b	118.96 b	71.28	116.76 b	94.02 b			
30	103.22 a	156.35 a	107.01	152.56 a	129.78 a			
Mean	57.86 b	94.87 a	61.24 b	91.49 a				
Cadmium uptake in straw (µg/pot)								
0	12.34 d	15.76 d	14.92 d	13.19 d	14.05 d	Nubariya	113.27 a	95.71 a
10	89.80 c	88.43 c	94.76 c	83.47 c	89.11 c	Maryut	102.48 b	87.27 b
20	132.46 b	118.96 b	134.66 b	116.76 b	125.71 b			
30	183.37 a	156.35 a	187.16 a	152.56 a	169.86 a			
Mean	104.49 a	94.87 b	107.87 a	91.49 a				

Values in the same column sharing an alphabet are not significantly different at 5% level.

Cadmium contamination of soil influenced its concentration in sorghum plant tissues. Data shown in figure (2) demonstrate that Cd concentration in shoots increased by increasing the Cd level in the soil. The highest Cd was recorded in plants grown on Nubaria soil. This is reflected on the dry weight of plants grown on the two soils; the dry weight of plants on Maryut soil was greater than that on the other soil. This also suggests that Cd in the soil is controlled by biological metabolic processes and/or chemical reactions (Tallab, 1994).

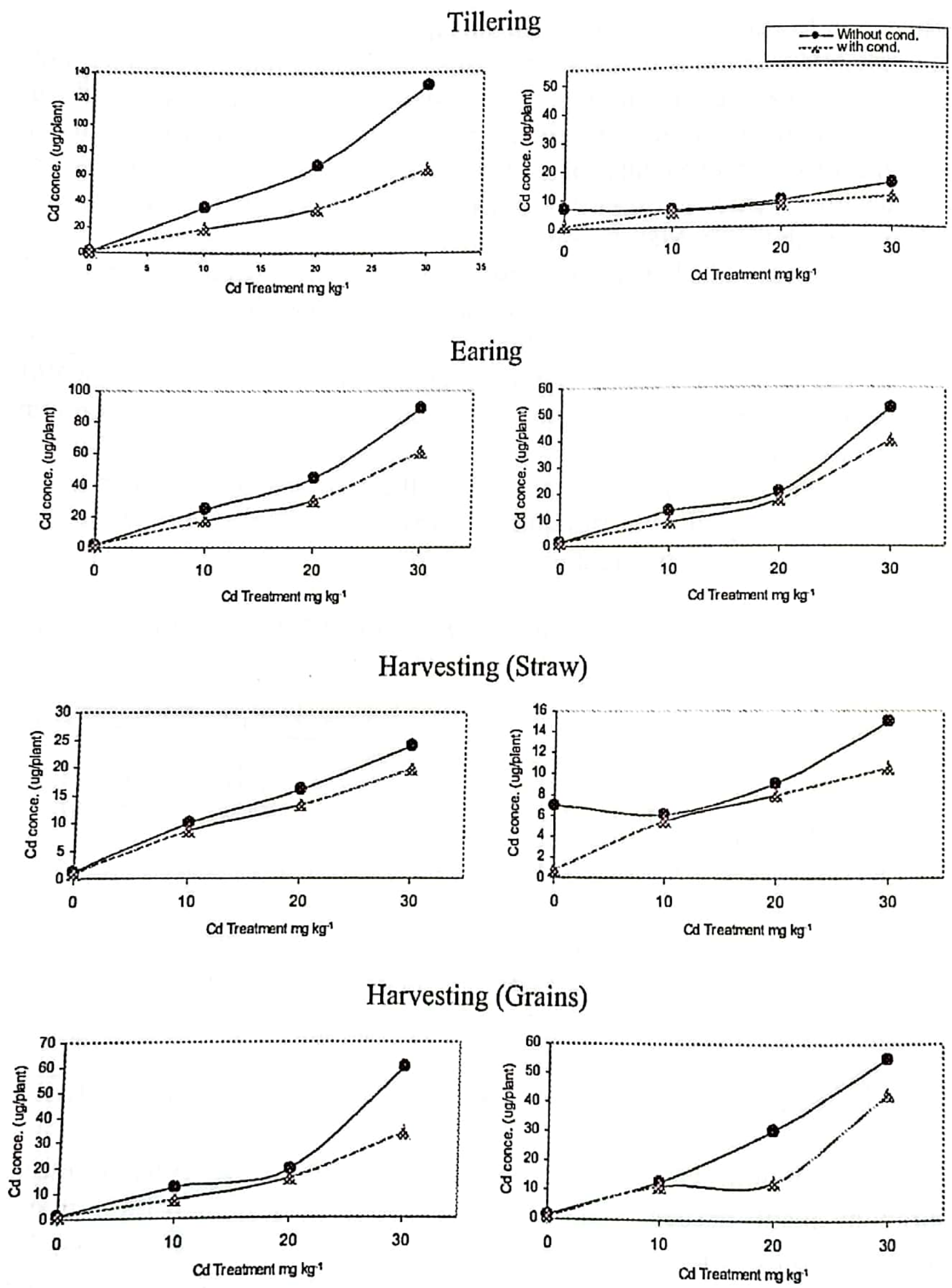

Fig. (1). Change of Cd concentration on barley plant with Cd applied level in soil.

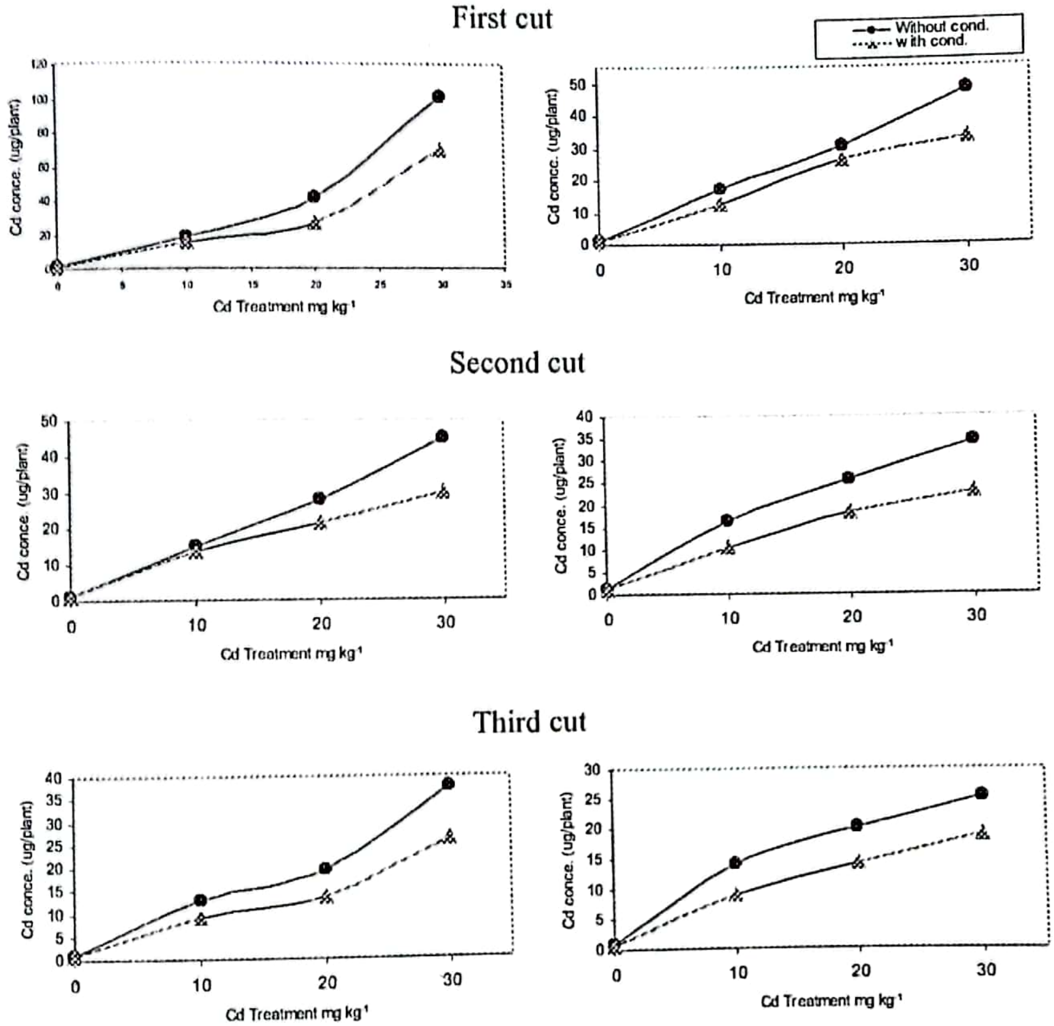

Fig. (2). Change of Cd concentration on sorghum shoots with Cd applied level in soil.

Data in table (8) show that the amount of Cd taken up by sorghum plants increased by increasing the Cd contamination. The accumulative uptake of Cd in shoots was greater than that in roots. However, the amount of cadmium restricted in sorghum roots points to its possible precipitation in the roots. From another point of view, application of FYM significantly decreased\Cd uptake at all levels of Cd contamination in both soils.

Translocation of cadmium in sorghum plants

Owing to the equilibrium between cadmium concentration in roots and shoots at any time during plant lifetime, the mobility index (Mi) was calculated based on cadmium concentration in sorghum roots and shoots at the third cut. Table (9) depicts the Mi values for the different treatments. Cadmium concentration was greater in sorghum roots than shoots at all levels of applied Cd for the two studied soils. This indicates that the roots of sorghum plant have the ability to accumulate relatively higher amounts of Cd per unit weight than shoots. Also, root tissues of sorghum control cadmium concentration in shoots. The highest Mi values were found in Nubaria soil. This reflects the low control of light-textured soil on cadmium mobility in the soil solution, which is contrary to Maryut soil. Generally, Mi increased as cadmium pollution increased. Anyhow, the application of FYM resulted greater Mi values compared with no application treatments at all levels of cadmium pollution. This reflects higher mobility of cadmium from roots to shoots with FYM, which is enhanced by higher cadmium concentration in the soil solution.

In conclusion, greater portion of the adsorbed Cd onto the roots moved to shoots when FYM was applied. Yet, FYM was shown to enhance shoots and roots dry weights of sorghum and decrease Cd concentration in both tissues. The dilution effect can explain the promotional effect of FYM towards greater dry matter production.

Table (8). Effect of Cd pollution, soil type and FYM conditioner on Cd uptake in sorghum shoots (three cuts) and roots.

Cd level (mg/kg)	Soils x Cd		FYM x Cd		Mean	Soil	FYM x Soils	
	Nubaria	Maryut	Without	With			Without	With
Cumulative shoot (3 cuts) (µg/pot)								
0	1.29 d	1.51 d	1.45 d	1.35 d	1.40 d	Nubariya	13.76 b	12.37 b
10	13.92 c	14.46 c	15.66 c	12.72 c	14.19 c	Maryut	16.77 a	13.04 a
20	17.56 b	19.99 b	20.39 b	17.16 b	18.78 b			
30	19.49 a	23.68 a	23.58 a	19.59 a	21.58 a			
Mean	13.06 b	14.91 a	15.27 a	12.70 b				
Root (µg/pot)								
0	0.51 d	0.75 d	0.68 d	0.58	0.63 d	Nubariya	5.66 b	4.00 b
10	5.41 c	5.96 c	6.50 c	4.88	5.69 c	Maryut	6.22 a	5.04 a
20	6.22 b	7.56 b	7.93 b	5.85	6.89 b			
30	7.18 a	8.25 a	8.66 a	6.77	7.71 a			
Mean	4.83 b	5.63 a	5.94 a	4.52 b				

Values in the same column sharing an alphabet are not significantly different at 5% level.

TABLE (9). Mobility index of Cd in sorghum plant under two soil types.

Cd level (mg/kg)	Soils x Cd		FYM x Cd		Mean	Soil	FYM x Soils	
	Nubaria	Maryut	Without	With			Without	With
0	0.366 d	0.338 d	0.338 d	0.366 d	0.352 d	Nubariya	0.363 a	0.423 a
10	0.391 c	0.348 c	0.354 c	0.385 c	0.369 c	Maryut	0.348 b	0.352 b
20	0.402 b	0.354 b	0.360 b	0.396 b	0.378 b			
30	0.413 a	0.360 a	0.370 a	0.403 a	0.387 a			
Mean	0.393 a	0.350 b	0.355 b	0.387 a				

Values in the same column sharing an alphabet are not significantly different at 5% level.

Soil extractable cadmium

Data in table (10) indicate that increasing the level of Cd increased the EDTA-extractable Cd in all cases. Values associated with Maryut soil were greater than those with Nubaria soil. So, Cd ions are more adsorbed onto soil particles of Maryut soil than of the other one. Regardless of Cd-level, the EDTA-extractable Cd slightly decreased by the conditioner application, which reflects the competition between FYM and the extracting solution for Cd in the soil solution. This also infers that the application of conditioner decreased availability of Cd in both soils.

Soil total cadmium

Data in table (10) show also the total Cd in the soil followed approximate the same trends of EDTA-extractable Cd. The percentage of extractable Cd increased with the increase in total Cd content in both soils, but such relation was not linear in all cases. Therefore, the EDTA-extractable Cd does not fully represent the total Cd level in the soil.

Table (10). Effect of treatments on total and EDTA-extractable Cd in the studied soils (mg/kg).

Cd level (mg/kg)	Soils x Cd		FYM x Cd		Mean	Soil	FYM x Soils	
	Nubaria	Maryut	Without	With			Without	With
			Soil total Cd after barley harvest (mg/kg)					
0	0.07 d	0.06 d	0.11 d	0.02 d	0.07 d	Nubariya	14.53 a	6.64 a
10	6.80 c	6.31 c	9.50 c	3.61 c	6.56 c	Maryut	14.38 b	6.11 b
20	14.08 b	13.76 b	19.35 b	8.49 b	13.92 b			
30	21.39 a	20.85 a	28.85 a	13.38 a	21.12 a			
Mean	10.58 a	10.24 b	14.45 a	6.37 b				
			Soil EDTA-extractable Cd after barley harvest (mg/kg)					
0	0.08 d	0.08 d	0.12 d	0.04 d	0.08 d	Nubariya	13.83 b	7.95 a
10	6.65 c	7.15 c	9.15 c	4.65 c	6.90 c	Maryut	14.26 a	7.32 b
20	15.10 b	14.33 b	19.15 b	10.28 b	14.71 b			
30	21.73 a	21.60 a	27.75 a	15.58 a	21.66 a			
Mean	10.89 a	10.79 b	14.04 a	7.63 b				
			Soil total Cd after the 3[rd] cut of sorghum (mg/kg)					
0	0.06 d	0.04 d	0.09 d	0.02 d	0.05 d	Nubariya	14.19 a	6.46 a
10	6.71 c	5.72 c	8.87 c	3.56 c	6.21 c	Maryut	13.81 b	5.78 b
20	13.79 b	13.31 b	19.09	8.01 b	13.55 b			
30	20.75 a	20.10 a	27.95 a	12.90 a	20.43 a			
Mean	10.33 a	9.79 b	14.00 a	6.12 b				
			Soil EDTA-extractable Cd after the 3[rd] cut of sorghum (mg/kg)					
0	0.06 d	0.05 d	0.09 d	0.03 d	0.06 d	Nubariya	13.83 b	6.74 a
10	6.63 c	6.53 c	9.23 c	3.94 c	6.58 c	Maryut	13.97 a	6.34 b
20	14.24 b	13.84 b	19.08 b	9.00 b	14.04 b			
30	20.20 a	20.20 a	27.20 a	13.20 a	20.20 a			
Mean	10.28 a	10.15 b	13.90 a	6.54 b				

FYM=farm yard manure

Values in the same column sharing an alphabet are not significantly different at 5% level.

In conclusion, the application of soil conditioner is important to combat soil pollution with Cd for better crop performance, because Cd pollution decreases dry weight of plants. Fine-textured soils (Maryut) are more resistant to pollution than coarse-textured ones (Nubaria). Cadmium uptake in barley straw was greater than in grains owing to the greater straw yield. Sorghum roots retain appreciable amount of Cd, thus decrease its hazard on shoots. Finally, extracting Cd with EDTA did not prove to be an efficient tool for the assessment of total content in the soil, while tolerance and mobility indexes proved to be valuable tools in evaluating plant performance towards pollution.

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العلاقة بين سمية الكادميوم والسماد العضوي كمحسن للتربة تحت ظروف الأراضي الجيرية

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أجريت تجربة في أصص لدراسة تأثير الكادميوم والإضافة الأرضية لمحسن تربة طبيعي على النمو والمحتوى من الكادميوم للشعير والسورجم تحت ظروف المناطق الصحراوية بمريوط والنوبارية لعمق ٣٠ سم، وقد أضيف الكادميوم للتربة بمعدلات صفر، ١٠، ٢٠، ٣٠مجم كادميوم/كجم تربة إما على حدة أو مع ٥٠ جم من محسن التربة لكل أصيص.

زرعت الأصص بالشعير ثم بالسورجم، وأخذت عينات نبات وتربة عند حصاد الشعير والحشات الثلاث للسورجم لمتابعة النمو ومحتوى النباتات من الكادميوم، وقد قدر محصول الحبوب والقش للشعير وكذلك المادة الجافة للسورجم، كما تم قياس تركيز الكادميوم وحساب محتوى النباتات من الكادميوم.

وتشير النتائج إلى أن إنتاج المادة الجافة قد نقص معنوياً بزيادة مستوى الكادميوم في التربة ولكن الامتصاص الكلي قد زاد في كل من القش والحبوب للشعير وأيضاً في المادة الجافة للسورجم، هذا وقد أدت إضافة مخلفات المزرعة (محسن التربة) إلى تخفيف الفعل المدمر للكادميوم على إنتاج المادة الجافة عند جميع مستويات إضافة الكادميوم، وقد ثبت أن قوام التربة الناعم لأرض مريوط كان أفضل معنوياً من القوام الخشن لأرض النوبارية، ويشير هذا إلى ضرورة إضافة كميات أكبر من مخلفات المزرعة إلى الأراضي الخشنة عنها للأراضي الناعمة في حالات التلوث بالكادميوم، وكان أقل امتصاص للكادميوم قد لوحظ في حبوب القمح بالمقارنة بذلك في القش، وبالنسبة للسورجم فقد لوحظ أن الجذور قد احتجزت كمية لا بأس بها من الكادميوم.

تم أيضاً حساب دليل المقاومة ودليل الحركية وثبت أنهما أداتان جيدتان لتقييم تأثيرات الكادميوم على أداء النبات، كما وقد تم استخلاص الكادميوم بمحلول EDTA ووجد أنه ليس دليلاً جيداً للتنبؤ بالكادميوم الكلي في التربة حيث أن العلاقة بينهما ليست خطية دائماً.