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EFFECT OF CADMIUM ON GROWTH OF SUNFLOWER PLANT GROWN IN CALCAREOUS SOIL

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Abstract

A pot experiment was conducted to evaluate the effect of Cd and P levels on growth and yield components of sunflower(*Helianthus annuus L.Meak*). The dry weight yields of leaves , stems, and roots after 35 days from sowing and weight of seeds. Plant at harvest were reduced by cadmium application. Dry weight of stems , seed oil percentage, plant height and leaf area at harvest were not affected. Phosphorus application as superphosphate fertlizer had no significant effect on the studied growth parameters. Cadmium content in leaves of sunflower increased by cadmium application while cadmium content of seeds was not affected.

DTPA-Extractable Cd in soil, and Cd content in leaves of plants were increased by adding cadmium to soil than the impurities from superphosphate fertilizer.

INTRODUCTION

In recent years, there are many reports dealing with the effect of Cd (as a potential hazard) on growth of different plant species and its content in the different plant organs. Plant growth reduction due to Cd concentration in the growth medium is documented by Iwai *et al.* (1975) and others.The available data on Cd uptake ini-

cated that Cd is strongly retained in roots (Cabrera *et al.*, 1988 and Cataldo *et al.*, 1981). Furthermore, William and David (1973) found that less than 0.2% of the added cadmium was found in grains of oats, wheat and rice.

Cadmium impurities in superphosphate fertilizer might accumulate in the soil and increase the supply of available Cd to plants (Williams and David, 1973). The application of cadmium to soil alone as $CdCl_2$ or as impurities in superphosphate fertilizer was found to increase Cd levels in the edible portion of some species of vegetables (Schroeder *et al*, 1976; Williams and David, 1973).

The present paper aims to study Cd accumulation in soil as a result of $CdCl_2$ and /or superphosphate fertilizer application and its effect on growth and yield components of sunflower.

MATERIALS AND METHODS

Experimental Procedure

Greenhouse pot experiment was conducted in the Salinity and Alkalinity Lab, Alexandria in 1990. The pots used were 30cm in diameter and 50cm in depth and were filled with 20kg soil. The soil used was calcareous, sandy clay loam with 34.4 meq/l total soluble salts, 34.4% total carbonate, 1ppm NaHCO3 extractable P, 0.04 ppm DTPA extractable Cd and pH 8.35. Five seeds of sunflower (*Helianthus annuus L.meak*) were planted in each pot. Two weeks later, the seedlings were thinned to 2 plants/pot. Treatments comprised 4 levels of cadmium in irrigation water added as $CdCl_2$ in rates of 0,5,10 and 20 mg/L and 3 levels of phosphorus added as superphosphate before planting at the rates of 6, 12 and 24 mg P/kg soil. Twelve treatments were laid out in a complete block design with three replicates. The irrigation water was applied weekly to the pots and was continued to the end of experiment (12 weeks). A basal application of nitrogen as ammonium nitrate and potassium as potassium sulfate fertilizer were applied to all pots at the rate of 45 and 20 mg/kg soil of N and K, respectively. Nitrogen and potassium were added 15 days after sowing .

After 35 days of planting one plant from each pot was pulled out while the remaining plant was left to grow to maturity . Leaf area index, and dry matter of leaves, stems and roots were determined . At maturity plant height and the weight of seeds/ plant were measured. Leaves at harvest were removed, washed by tap water, distilled water, then glass redistilled water and dried at 70C for 24 hr. The dried leaves and seeds were ground in stainless steel mill and kept for analysis . Soil samples were taken at depth 0-15 cm, air dried, allowed to pass through 2 mm sieve and kept for analysis.

Analytical method

A known weight of the dry plant materials (leaves and seeds) was digested with HNO_3 / $HCLO_4$ as described by Oien and Kjerdingen (1977). The oil content of the seeds was determined according to Comstoc and Culbertson (1958) . Available Cd and P in soil were extracted by DTPA (Soltanpour and Schawb, 1977) and $NaHCO_3$ (Watanabe and Olsen, 1965), respectively. Cd was measured by Atomic Absorption Spectrophotometry (A.A.S) and P was determined by the method described by Murphy and Riley (1962) , Measurements of total soluble salts and total carbonate wee carried out as outlined by Black *et al.* (1965).

RESULTS AND DISCUSSION

Growth parameter

Data of dry matter yield of leaves, stems, roots and whole plant and leaf area (35 days of age) in relation to cadmium and phosphorus treatments are given in Table 1. In general the dry matter yields , roots and whole plant were significantly reduced by cadmium application while that of stems and leaf area were not affected. On the other hand, phosphorus application showed no significant effect on the studied growth parameters. With an exception of the dry matter of leaves, there existed significant response due to interaction of P x Cd in the growth medium.

Yield and yield component

Data in Table 1 show that increasing Cd application up to 20mg/L significantly

reduced the weight of seeds/plant. However positive response to Cd addition at lower Cd levels was observed . There is no significant effect of Cd on plant height. Phosphorus application showed the same trend with regard to seeds/plant, oil percentage and plant height. In general , from the data presented in Table 1 it seems that Cd had reduced the growth and yield of sunflower plants which has been found by many workers using different plant species (Mahler *et al.*, 1982, Khan and Frankland, 1983).

Soil extractable Cd and P

Data reported in Table2 show that increasing cadmium application to the soil led to an increase of the DTPA-extractable Cd. Means of the extractable Cd in the untreated soil varied between 0.08 and 0.13 mg Cd/ kg soil. In soils treated with 5,10 and 20mg Cd/L, the DTPA - extractable Cd increased to 0.26, 0.48 and 0.74 mg Cd/kg soil, respectively. On the other hand, at 6,12, and 24 mg P/kg soil , the extractable Cd increased to 0.32, 0.47 and 0.40mg Cd/kg soil, respectively. These increases for extractable Cd due to superphosphate addition is due to Cd impurities in superphosphate fertilizer (Williams and David, 1977).

The amounts of NaHCO3-extractable P (Table 1) significantly increased by increasing amounts of P application. This effect was clear at 24 mg P/kg soil.

Cadmium and phosphorus content in plant

Data in Table 2 show clearly that increasing Cd application markedly increased the Cd content in sunflower leaves. The percent Cd increased relative to the content was 35.6, 43.2 and 70.8% at 5,10 and 20mg Cd/L, respectively. The Cd content of sunflower leaves was not consistent due to P application. Moreover, the Cd content of sunflower seeds was not affected by cadmium or phosphorus application.

Conclusion

Application of $CdCl_2$ and /or superphosphate to the soil increased the level of DTPA - extractable Cd from soil. Cadmium reached the soil from $CdCl_2$ solution was relatively high and brought about substantial increases in Cd uptake by sunflower leaves, whereas cadmium reached from superphosphate fertilizer was relatively low and not effective to induce excessive Cd accumulation and poor plant performance. When cadmium contents of leaves and seeds were compared as a function of DTPA extractable Cd (Fig.1) the Cd content in leaves of sunflower increased progressively while Cd content of seeds was not affected as DTPA extractable CD in-

Table 1. Yield and yield components of sunflower plants after 35 days and at harvest as influenced by Cd and P treatments.

Treatments		Leaf area	Leaves	Stems	Roots	Whole plant	Plant height	Weight of seed	Oil
Cd	P	<-----35 days age------->					<-----At harvest--->		
mg/L	mg/kg Soil	cm2	dry matter, g/plant				cm	g/plant	%
0.00	6.00	134.13	21.37	4.63	1.87	27.86	142.67	14.89	27.72
	12.00	126.77	22.67	6.03	1.90	30.60	160.67	19.87	23.39
	24.00	132.34	21.50	4.77	1.90	28.16	164.67	16.66	22.16
Mean		131.08	21.85	5.14	1.89	28.87	155.78	17.14	24.42
5.00	6.00	100.03	19.97	4.63	1.60	26.20	149.33	16.52	35.16
	12.00	98.49	21.10	4.87	1.70	27.66	177.67	19.12	26.74
	24.00	120.91	20.07	5.33	1.83	27.23	160.00	20.03	23.83
Mean		106.48	20.38	4.94	1.71	27.03	162.33	18.56	28.58
10.00	6.00	102.37	18.30	3.37	1.47	23.13	167.67	19.98	27.89
	12.00	115.75	19.43	4.60	1.43	25.16	171.00	18.42	33.88
	24.00	115.07	21.57	4.73	1.40	27.70	167.33	21.58	19.63
Mean		111.06	19.77	4.23	1.43	25.33	168.67	20.00	27.13
20.00	6.00	110.99	20.63	4.93	1.67	27.23	172.67	18.28	27.33
	12.00	103.64	19.47	4.63	1.50	26.30	163.00	13.25	26.62
	24.00	113.86	20.30	5.33	1.73	27.36	176.33	13.02	32.74
Mean		109.50	20.13	4.97	1.63	26.36	170.67	14.85	28.86
Mean of all	6.00	111.88	20.07	4.39	1.65	26.11	158.09	17.42	29.50
	12.00	111.16	20.67	5.03	1.63	27.43	168.09	17.67	27.66
	24.00	120.55	20.86	5.04	1.72	27.61	164.83	17.82	24.59
LSD (0.05)									
For Cd	--	--	1.06	--	0.31	1.80	--	3.11	--
For P	--	--	--	--	--	--	--	--	--
For Cd*P	--	--	1.84	--	--	--	--	--	--

Table 2. Effect of added Cd and P on their extractable amounts from soil and their content in leaves and seeds of sunflower.

Treatment Cd	Treatment P	Soil Cd	Soil P	Cadmium in Leaves	Cadmium in Seeds	Phosphorus in Leves	Phosphorus in Seeds
mg/L	mg/kg soil	mg/kg soil	mg/kg soil	<---ppm--->		<----%---->	
0.00	6.00	0.08	3.13	3.00	1.00	1.75	4.58
	12.00	0.13	3.43	2.00	1.00	1.13	3.99
	24.00	0.13	3.53	2.50	1.42	3.25	3.75
Mean		0.11	3.36	2.50	1.14	2.04	4.11
5.00	6.00	0.29	3.27	3.25	0.83	1.58	2.12
	12.00	0.25	2.80	3.50	1.00	1.13	2.99
	24.00	0.23	4.07	3.41	1.33	1.63	2.87
Mean		0.26	3.38	3.39	1.05	1.45	2.66
10.00	6.00	0.45	2.97	3.75	1.67	1.95	5.00
	12.00	0.45	0.40	3.50	1.08	1.04	2.41
	24.00	0.53	3.40	3.50	1.58	1.72	3.29
Mean		0.48	3.26	3.58	1.44	1.57	3.57
20.00	6.00	0.47	3.10	3.83	1.33	1.33	4.29
	12.00	1.04	3.20	4.33	1.00	1.25	2.50
	24.00	0.70	4.53	4.66	1.08	1.08	3.87
Mean		0.74	3.61	4.27	1.14	1.22	3.55
Mean of all	6.00	0.32	3.12	3.46	1.21	1.65	4.00
	12.00	0.47	3.21	3.33	1.02	1.14	2.97
	24.00	0.40	3.88	3.52	1.35	1.92	3.45
LSD (0.05)							
	For Cd	0.13	--	0.75	--	--	--
	For P	0.08	0.58	--	--	1.02	--
	For Cd*P	0.20	--	--	--	--	--

crease. Previous studies related to Cd-uptake indicated that most of Cd taken up by plants was retained in roots rather than shoots (Jarvis *et al.*, 1976, Cataldo *et al.*, 1981, and Cabrera *et al.*, 1988). The study of Williams and David (1973) indicated that grains had a lower cadmium content than any other part of the plant. These and the present findings presented are of particular importance to oil crops such as sunflower.

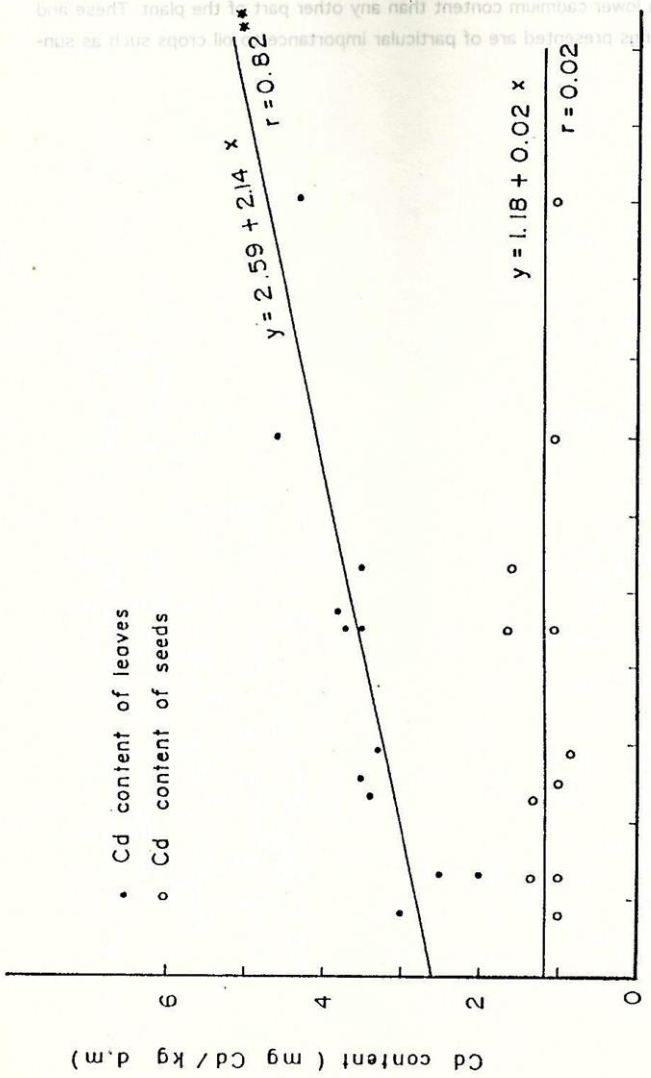

Fig. 1 : Relationship between DTPA-extractable Cd and Cd content of leaves and seeds of sunflower plants.

RFERENCES

1 . Black, C.A. (Ed.). 1965. Methods of Soil Analysis. Parts 1 and 2 The Series of Agronomy, Amer. Soc. Agron., Inc. pub. Madison, Wisconsin, USA.

2 . Cabrera, D., S.D. Young and D.L. Rowell . 1988. The toxicity of Cadmium to barley plants as affected by complex formation with humic acid. Plant and Soil. 105 : 195 - 204.

3 . Cataldo, D.A., T.R. Garland and R.E. Wildung 1981. Cadmium distribution and chemical fate in soybean plants. Plant Physiol. 68:835-839.

4 . Comstock, V.E. and J.O. Culbortson, 1985. A rapid method of determining the oil content and iodine values. Agron. J. 50 (1) :113-114.

5 . Iwai, I., T. Hera and J. Sonada. 1975. Factors affecting Cadmium uptake by corn plant. Soil Sci. Plant Nut. (Tokyo), 21 ; 37-46.

6 . Jarvis, S.C., L.H.P. Jones and M.J. Hooper. 1976. Cadmium uptake from solution by plants and its transport from roots to shoots. Plant and Soil 44:179-191.

7 . Khan, D.H. and B. Frankland. 1983. Effect of Cadmium and Lead on radish plants with particular reference to movement of metals through soil profile and plant. Plant and soil 70:335-345.

8 . Mahler, R.J., F.T. Bingham, A.L. Page and J.A. Rayan. 1982. Cadmium enriched sewage sludge application to acid and calcareous soils : Effect on soil and nutrition of lettuce, corn, and swiss chard. J. Environ. Qual. 11: 674-700.

9 . Murphy, J. and J.P. Riley. 1962. A modified single solution fot the determination of phosphate in natural waters Anal. Chem. Acta. 27: 31-36.

10 . Oien, A. and K. Jjerdingen. 1977. Determination of Cd and Pb in soils by means of solvent extraction and atomic absorption. Acta . Agric. Scand. 27: 67-70.

11 . Schroeder, H.A., A.P. Nason, I.H. Typton and J.J. Balassa. 1967. Essential trace metals in man : Zinc relations to environmental Cadmium. J. Chron. Dis. 20 : 179-210

12 . Soltanpour, P.N. and A.P. Schwab. 1977. A new soil test for simultaneous extraction of macro and mirco-nutrients in alkaline soils. Comm. Soil Sci. Plant Anal. 8(3) : 195-207.

13 . Watanabe, F.S. and S.R. Olsen. 1965. A colorimetric determination of phosphorus in water extracts of soil . Soil Sci. 93, 183.

14 . Williams, C.H., and D.J. David. 1973. The effect of superphosphate on the cadmium content of soils and plants. Aust. J. Soil Res. 11 : 43-56.

15 . Williams , C.H. and D.J. David. 1977. Some effects of the distribution of Cadmium and phosphate in the root zone on the Cadmium content of plants . Aust. J. Soil Res. 15: 59-68.

تأثير الكادميوم علي نمو عباد الشمس النامي في أرض جيرية

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أجريت تجربة قصاري لدراسة تأثير مستويات من الكادميوم علي نبات عباد الشمس وقد نقص الوزن الجاف للاوراق والسيقان والجذور للنبات عند عمر ٣٥ يوم وأيضا وزن محصول البذرة نتيجة لاضافة الكادميوم بينما لم يتأثر الوزن الجاف للسيقان والنسبة المئوية للزيت وطول النبات ومساحة سطح الورقة.

كما لا يوجد تأثير للفوسفورفي صورة سوبر فوسفات علي أجزاء النبات بينما زاد محتوي الكادميوم فى الأوراق بزيادة الكادميوم ولم يتأثر محتوي البذور من الكادميوم.

كما وجد أن أضافة الكادميوم الى الأرض أدت الي زيادة الكادميوم المستخلص ومن محتوي الاوراق من الكاديموم أكثر من الشوائب الموجودة في سماد السوبر فوسفات.