J. Agric. Sci. Mansoura Univ., 33 (9): 6473 - 6497, 2008

EFFECT OF SOIL POLLUTION BY Cd AND Zn ON CARROT (*Daucus carrota,* L.) PLANTS IN GAZA STRIP – PALESTINE

Hanafy Ahmed, A. H.; J. A. Wady and E. D. El Shakh Ali
Plant Physiology Section, Agric. Botany Dept., Fac. Of Agric.,Cairo Univ., Egypt

ABSTRACT

Survey experiment was carried out in northern area of Gaza strip–Palestine to evaluate the heavy metals accumulation in the soils and edible parts of (spinach, wheat, strawberry, carrot, onion, squash, cabbage, potato, faba bean and cucumber) which were grown in three sites of this area. The concentration of these heavy metals (Cd, Zn, Pb and Fe) in the soils and plants were lower and within the normal range, except concentration of Pb which was higher and above the normal range by the soils and plants on site B (Monttar and Gaza City Center).

Pot experiments were carried out in the two successive seasons, 2006 and 2007 on carrot *Daucus carrot* L. var. Nantesa superior on Ministry of Local Government (Al Zahra Municipality), Gaza strip-Palestine, to study the effect of heavy metals (Cd and Zn) soil addition at different rates (10, 20 and 40 ppm Cd) and (75, 150 and 225 ppm Zn) on plant. All the studied growth characters (root length, shoot height, fresh and dry weights of shoot and root) were decreases with increasing Cd soil addition either alone or combined with Zn soil addition at all levels, while, plant pigments (chlorophyll a, chlorophyll b and total carotenoids) were non significantly effected, except chlorophyll a which was decreased with increasing Cd soil addition, but increased when increasing Zn at all levels. Also, the effect of Cd and Zn either alone or there combination on minerals (Cd, Zn and Fe) were studied. Adding Zn alone was non significantly affected on growth characters, while if combined with Cd in different levels may be overcome to some extent the toxicity of Cd on growth characters as well as minerals and chlorophyll a concentration.

Keywords: Cadmium, Zinc, Carrot Plant, Pollution, Soil, Gaza Strip- Palestine.

INTRODUCTION

Gaza strip as one of the most densely populated areas in the world with limited and deteriorated resources has already started to suffer the outcomes of environment quality deterioration. The situation in Gaza strip below the desired standard which is attributed to the absence of environmental legislation and the public awareness. The engine to motor vehicles is the most important resources of air pollutant near the city center (Sawidis *et al.*, 1994) this fact for the city to Gaza, where thousands of motor vehicles. Trace metals released in the environment may be a hazard to natural biological system and human heath, plant and soil surface are the major sink for airborne metal. Moreover, plants form the basis of food chains by which bio-toxic trace metals are transmitted to man (Alfani *et al.*, 1996). Cd is classified as probable human carcinogen (Group B1) by inhalation; however, only limited data are available to determine if it causes cancer in humans. Cd is also known to cause damage to the kidney, liver and nervous system (ATSDR, 1997a and b).The total zinc content in adult human tissue is 2 – 4 g. The daily requirement of 6 – 22 mg is provided by a normal diet. Zinc deficiencies in animals cause serious disorders, while high zinc intake by humans is toxic (Belitz and Grosch, 1999). Salim *et al.* (1992) treated the carrot plants by Cd and Pb foliar or root application of 0, 10 and 90 ppm Cd and 0, 18 and 80 Pb. They found that Cd toxicity was more obvious than Pb toxicity and these symptoms were more sever in foliar treated than in root–treated plants, Cd application decreased Dw of whole plants, shoots and roots, when compared with control-untreated plants. Baccio *et al.* (2005) reported that transition metals such as zinc are essential micronutrients for many physiological processes, but they become toxic at elevated levels, zinc is one of the most abundant trace heavy metals present in agro-ecosystems. Madhoolika and Rajesh (2006) treated carrot plant with two Cd concentration (10 and 100 µg M) and two Zn concentrations (100 and 300 µg M) and their combination. The author pointed that bioaccumulation of Cd in root and leaf was greater at the low metal–application rates of Cd and Zn in combination than the higher rates. Zn was found in some cases to depress Cd uptake, indicating some kind of interaction between these metals. (Cakmak *et al.*, 2000 and Oliver *et al.*,1997). The aims of the present study was to investigate the effect of different levels of Zn soil addition to reduce the physiological impact caused by Cd soil addition and their effects on growth, yield and chemical composition of carrot plants. As well as to estimate the bioaccumulation of metals such as (Pb, Cd, Zn and Fe) in plant species and soils of Gaza strip- Palestine.

MATERIALS AND METHODS

Field survey and pot experiments were carried out to evaluate the nutritional status of certain crops growing under different levels of heavy metals soil pollutants and to overcome to some extent the hazard effects induce by Cd on carrot plant by using Zn soil addition.

2-1-Field survey experiment:

Gaza strip–Palestine area is bout 360 Km^2. The area under field survey experiment is about 120 Km^2, The area of survey has several anthropogenic influence and we can divided it into three different sites, (Industrial, urban and rural site), as all sites under study were lies between Israel Gump and bordered and Mediterranean sea. A field survey experiment was carried out in the north area of Gaza strip to asses the level of certain heavy metal in soils and some growing plants at three different locations. Four samples of plants and four samples of soils were taken at January 2006. These samples were collected from each three sites, (site A, B and C) as illustrated in table **(1)** and fig. **(1)**. Thus, the survey experiment included 12 samples from all sites. Also, soil samples were taken from the same position of plants sample location, also included 12 samples on all sites. Samples of spinach, wheat, strawberry and carrot were collected from site **(A)** onion, squash, spinach and cabbage from site **(B)** and potato, carrot, faba bean and cucumber from site **(C)**. All plants samples were taken at flowering stage and washed in water and dipped in distilled water and divided into its parts, then oven dried at 70 ^{o}C for 2 days, as well as soils samples were oven dried at 40 ^{o}C for 2 days and they were then shipped to Egypt in plastic bags. Available Fe, Pb, Zn and Cd were extracted by DTPA according to Lindsay and Norvell (1978) and estimated by Atomic Absorption Spectrophotometer GBC 939 and determined on the Ministry of Agriculture–Agriculture Research Center–Soils, Water and Environment Res. Institute, Soils, Water and Environment Unit–Egypt.

Table 1. and Fig 1. Anthropogenic influence of Site on northern area of Gaza strip-Palestine location from which samples were taken.

Location	Site	Anthropogenic influence
Northern area of Gaza Strip	Beit Hanon and Beit Lahya site (A) Al Monttar and Gaza City Center site(B) AlZytoon and Shakh Ejleen site (C)	Industrial and rural site Industrial and urban site Rural and urban site

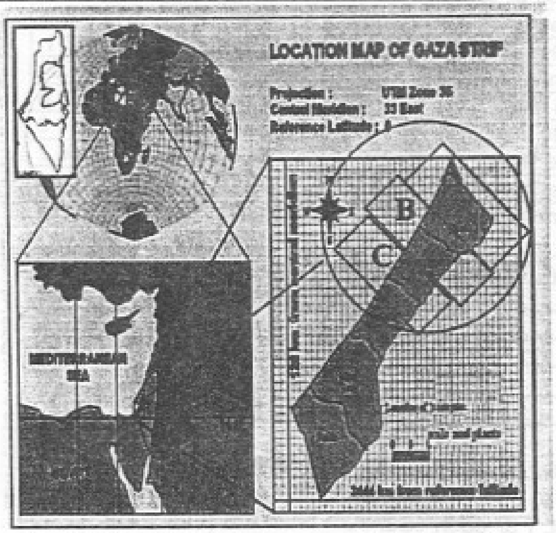

Fig . (1): Gaza strip Palestine region and site of samples.

2-2-Pot experiment:

Pot experiment was carried out in the open field of the Ministry of Local Government (Al Zahra Municipality) Gaza Strip-Palestine in the two successive seasons, 2006 and 2007. The aim of this experiment was to evaluate the effect of some heavy metal (Cd and Zn) and their interaction on the growth and chemical composition of carrot plants. Moreover, attempts were carried out to reduce the toxic effect of Cd in plant by using different rates of Zn. Plastic pot of 80 cm length, 20 cm width and 25 cm depth were used in this experiment. Each pot was filled with 25 kg soil obtained from Ministry of Local Government (Al Zahra Municipality)-Gaza Strip-Palestine. Seeds of carrot *(Daucus carrota* L.*)* var. Nantesa superior were sown on 11th October 2006 in the first season and on 15th January 2007 in the second season. 15 seeds of carrot were placed in each plastic pot. Fertilization was carried out according to recommendation of the Ministry of Agriculture–Egypt.

Each pot was received 18 gram ammonium sulfate (20.5% N), 9 gram of potassium sulfate (48%K_2O) and 21.5 gram of calcium superphosphate (15.5 %P_2O_5). The fertilizers were applied to the plants as soil dressing at three doses / season, the first dose after seeding from 21 days and the second dose after the first dose from 21 days and the third dose after the second dose from 21 days. The mechanical, chemical analysis of the soil and water irrigation of plants under investigation were analyses in the Library of Ministry of Agriculture-Palestine, and in the Ministry of Agriculture–Agriculture Research Center–Soils, Water and Environment Res-institute- Soil, Water and Environment Unit–Egypt. The results of analyses were presented in table (2).

Table 2.Chemical properties of water irrigation and mechanical, chemical properties of soil under study.

	Property		Value	Property		Value
Water irrigation	pH		7.9	Magnesium mg/l		48.1
	EC m mho /cm		2.1	Potassium mg/l		3.0
	T.D.S mg/l		1413.0	Sodium mg/l		273.6
	Chloride mg/l		462.6	Total alkalinity mg/l		210.0
	Sulfate mg/l		142.4	HCO_3 mg/l		256.2
	Nitrate mg/l		50.0	CO_3 mg/l		0.0
	Calcium mg/l		106.7	Hardness mg/l as $CaCO_3$		465.2
Soil	**Property**	**Value**	**Property**	**Value**	**Property**	**Value**
	Sand %	82.0	E.C mmho/c	0.579	K (meq / l)	6.50
	Clay %	11.0	NO_3 mg /l	106.1	Fe ppm	80.90
	Silt %	7.0	CO_3 meq /l	0.0	Zn ppm	52.40
	S.P %	19.3	HCO_3 meq/ l	3.0	Pb ppm	22.00
	pH	7.8	Ca+Mgmeq/l	10.4	Cd ppm	0.02

In the two successive seasons, before planting, four levels of cadmium (0, 10, 20 and 40 ppm) were added to soil, which were obtained by adding cadmium sulphate ($CdSO_4 . 5H_2O$) salt. For each cadmium level the pots were divided into 4 groups, the first group received the normal level of fertilizers as mentioned before, but without any other soil additions. The second, third and fourth groups were similar to the first group but the pots received zinc as the soil addition before planting in the farm of zinc oxide (ZnO) at the rates (0, 75, 150 and 225ppm). Thus, the experiment included four levels of cadmium soil addition represented the main treatments while zinc soil addition served as sub-treatment, this given 16 treatments. In the experiment, each treatment included 45 plants / 3 pots arranged randomized in three replicates. Two samples were taken from each treatment after 70 and 140 days from sowing and the plant was divided into roots and leaves, the following measurements were recorded: root length (cm), shoot height (cm), fresh and dry weights of the shoot and root (g). Growth analyses were also calculated. Leaf weight ratio **(LWR)** and relative growth rate **(RGR** mg $g^{-1}d^{-1}$) were estimated between the two successive samples on the average of two seasons. Also, rate of production of one sub-cellular component per unit of Cd and Zn (mg/g

Cd or Zn per day) and Specific utilization rate(**SUR** mg dw. mg Cd^{-1} or Zn^{-1} d^{-1}) were estimated between the two successive samples on the second season according to the methods described by Hunt (1978).using the following equations:

$(\mathbf{LWR}) = \{(Lw_1 \div W) + (Lw_2 \div W)\} \div 2$

$(\mathbf{RGR}\ mg\ g^{-1}\ d^{-1}) = {}^{ln}W_2 - {}^{ln}W_1 \div T_2 - T_1$

$(\mathbf{SUR}\ mg\ mg^{-1} d^{-1}) = ({}^{W}{}_2 - {}^{W}{}_1 \div {}^{T}{}_2 - {}^{T}{}_1) \times ({}^{ln}M_2 - {}^{ln}M_1 \div M_2 - M_1)$

Rate of production eg. of mg (**A**) g^{-1}(**B**) $d^{-1} = ({}^{A}{}_2 - {}^{A}{}_1 \div {}^{T}{}_2 - {}^{T}{}_1) \times ({}^{ln}B_2 - {}^{ln}B_1 \div B_2 - B_1)$

B = Cd or Zn content, A = elements contents, T = Time samples W = dry weight, M = Cd, Zn and Fe accumulations, 1 = first sample, 2 = second sample. Lw = leaves dry weight.

Also, Heavy metals Fe, Zn, and Cd were determined in the two samples (70 and 140 days after sowing) for root and shoot in the 2nd season. For the determination using the atomic absorption Spectro-photometer (Pu 9100*) in the Ministry of Agriculture – Agriculture Research Center–Soils, Water and Environment Res. Institute. Soils, Water and Environment Unit–Egypt. As well as, Chlorophyll & total carotenoids (mg/g FW) were extracted by acetone 80% and calorimetrically determined according to the method described by Hoyden (1965) in the fresh leaves of plants. In the pot experiment statistical analysis data were statistically analyzed by using factorial experiments and the means of different treatments were compared using the least significant different test (L.S.D) at 0.05 level of probability in the two samples as average of two successive seasons (Snedecor & Cochran, 1980).

RESULTS AND DISCUSSION

1- Field survey experiment.

Soil samples were collected from three selected sites of northern area of Gaza strip-Palestine, (site A, B and C). Data in table (**3**) revealed that the extractable heavy metals Pb, Zn, Cd and Fe were 9.9, 41.2, 0.0075 and 333.6 ppm, respectively in site **A** (Beit Hanen and Beit Lahya site) and were 20.9, 42.9, 0.0075 and 18.2 ppm, respectively in site **B** (Monttar and Gaza City Center site) and were 16.3, 53.9, 0.00 and 248.9 ppm in site **C** (Al Zytone and Shakh Ejleen site). Similar results were obtained under Palestine condition by Shomar (2006) for all metals except, Fe. The author mentioned that the total Pb, Zn, Cd and Fe were 32, 50, 0.0052 ppm and 2.2% respectively, in the open farm soils of Gaza strip and were 61, 60, 0.0067 ppm and 1% for iron respectively, in the strawberry farm soils in Gaza strip.

Concerning the heavy metals concentration in the plants growing in the area under study, data in table (**3**) indicated that lead concentration in plants is affected by plant organs. The highest concentration of Pb in site **(A)** was (22.1 ppm) which was recorded in the root of carrot but the lowest concentration (12.1 ppm) was recorded by strawberry (fruit).Lead concentration in the edible parts of the plants under studied can be arranged in the following order: carrot (root) > spinach (leaves) > wheat (shoot) > strawberry (fruit). Moreover, the highest concentration of Pb in site (B) was (95.0 ppm) which was recorded by the bulb of onion while the lowest concentration (0.11 ppm) was recorded by spinach (leaves), the values can be arranged in the following order according to Pb concentration in site (B): onion (bulb) > cabbage (leaves) > squash (fruit) > spinach (leaves). As well as in the site **(C)** the highest concentration of Pb (12.5 ppm) was recorded in tuber of potato, but the lowest concentration (10.1ppm) was detected by cucumber (fruit). The values of Pb concentration in site **(C)** can be arranged in the following order: potato (tuber) > faba bean (seeds) > carrot(root) > cucumber (fruit). In this respect, it can be suggested that the highest concentration of Pb was recorded by root, bulb and tuber when compared with another parts of plants (leaves, fruit and seeds). Moreover, it is important here to mention that, the increase on Pb concentration in the different organs of plants among different three sites can be arranged in the following order: onion bulb (95.0 ppm) > carrot roots (16.6 ppm) > wheat shoots (13.15 ppm) > potato tuber (12.5 ppm) > strawberry fruit (12.1 ppm) > faba bean seeds (11.25 ppm) > cucumber fruit. (10.1 ppm) > spinach leaves (7.8 ppm) > cabbage leaves (1.21 ppm) > squash fruit (1.12 ppm). In this respect, Bowen (1997) reported that the normal range of Pb in edible vegetables range between 0.20 - 20 ppm Thus, from these data, it can be suggested that Pb concentration in all plants grown under study area were within the normal range except for onion and carrot which were contained Pb up the normal concentration range.

Table 3. Heavy metals concentration (ppm) in the soil and plants growing in the area under study.

Sites name	Sites	Name and organs of plant	Metals concentration (ppm)							
			Soils				Plants (dry matter)			
			Pb	Zn	Cd	Fe	Pb	Zn	Cd	Fe
Beit Hanon and Beit Lahya	A1	Spinach (leaves)	18.1	46.8	0.0200	711.0	15.5	32.0	0.0000	19.4
	A2	Wheat (shoot)	6.5	38.7	0.0000	412.0	13.1	90.3	0.0200	13.5
	A3	Strawberry (fruit)	8.9	34.7	0.0000	112.0	12.1	33.2	0.0000	78.3
	A4	Carrot (root)	6.0	44.7	0.0100	99.4	22.1	25.6	0.0100	114.0
Mean A			9.8	41.2	0.0075	333.6	15.7	45.2	0.0075	56.3
Monttar and Gaza City Center	B1	Onion (bulb)	5.8	54.6	0.0300	447.2	95.0	33.2	0.0200	55.3
	B2	Squash (fruit)	20.1	51.2	0.0000	111.2	1.12	54.2	0.0300	66.0
	B3	Spinach (leaves)	24.5	5.80	0.0000	71.0	0.11	25.4	0.0000	65.2
	B4	Cabbage (leave)	33.2	60.1	0.0000	115.5	1.21	33.2	0.0100	114.0
Mean B			20.9	42.9	0.0075	186.0	24.3	36.5	0.0150	75.1
Al Zytoon and Shakh Ejleen	C1	Potato (tuber)	12.2	41.2	0.0000	211.0	12.5	41.5	0.0400	54.0
	C2	Carrot (root)	14.2	55.5	0.0000	324.2	11.1	42.0	0.0000	88.0
	C3	Faba bean (seed)	22.5	65.2	0.0000	211.5	11.2	32.7	0.0000	22.4
	C4	Cucumber (fruit)	----	----	-------	----	10.1	30.1	0.0100	41.0
Mean C			16.4	53.9	0.0000	248.9	11.1	36.7	0.0120	51.3

Moreover, it's clear from the results in table **(3)** that, the levels of zinc concentration in the studied plants grown in site **(A)** could be arranged in the following order according to their zinc concentration: wheat shoot (95.3 ppm) > strawberry fruit (33.2 ppm) > spinach leaves (32ppm) >carrot root (25.6ppm), but in the site **(B)** it can be arranged in the following order; squash fruit (54.2 ppm) > onion bulb = cabbage leaves (32ppm) > spinach leaves > (25.4ppm), while in the site **(C)** it can be arranged in the following: carrot root (42 ppm) > potato tuber (41.5ppm)> faba bean seed (32.7ppm)>cucumber fruit (30.1 ppm). However, it's important here to mention that the uptake of zinc depends on plant species and their plant parts. Moreover, the data revealed, that leaves of some plant and root of another plant contained the highest values of Zn compared with other plants parts. Regarding the normal zinc level in plant its reported to be within 8–400 ppm, while the toxic level is>400 ppm (Kabata-Pendias & Pendias, 1984). Therefore, it can be suggested that zinc concentration in all plants grown under the studied area were within the normal range.

Moreover, it's clear from the results in table (3), that the levels of iron concentration in the different parts of plants grown in site (A) can be arranged in the following order according to their iron concentration which were: carrot root (114.0 ppm) > strawberry fruit (78.3 ppm) > spinach leaves (19.4 ppm) > wheat shoot (13.5 ppm), but in the site (B) it can be arranged in the following order which were, cabbage leaves (114.0 ppm) > squash fruit (66.0 ppm) > spinach leaves > (65.2 ppm) > onion bulb (55.3 ppm), while in the site (C) it can be arranged in the following order which were: carrot root (88.0 ppm) > potato tuber (54.0 ppm) > cucumber fruit (41.0 ppm) > faba bean seed (22.4 ppm). In this respect, Das (2000) reported that, the normal iron level in plant was between 50 – 250 ppm. Therefore, it can be suggested that the iron concentration in all plants grown in the studied sites was within the normal range.

Concerning the concentration of cadmium in plants the results in table (3) revealed that, the plants grown in site (A) cadmium concentration in wheat shoot and carrot root were 0.02 and 0.01 ppm in respectively, but in site (B) Cd concentration were 0.02, 0.03 and 0.012 ppm in onion bulb, squash fruit and cabbage leaves respectively, while cadmium concentration in site (C) were 0.04 and 0.01 ppm for potato tuber and cucumber fruit. However, in the other plants Cd can not be detected. In this respect, Kabata Pendias & Pendias (1984) reported that the cadmium concentration in contaminated plants ranges between 5 - 30 ppm, therefore, Cd concentration in all plants grown in the three different studied sites was within the normal range.

2-Pot experiment:

The aim of this experiment was to evaluate the effect of heavy metal (Cd and Zn) on growth, yield and chemical composition of carrot plants as well as to study the interaction between Cd and Zn in plants. Moreover, attempts were carried out to reduce the toxicity effect of Cd in plants by using different rates of Zn.

1- Growth and yield Parameters:

Growth of carrot at the two different ages (70 & 140 days after sowing) was measured by recording (height of shoot, root length, as well as fresh and dry weights of shoots and roots).Moreover, at harvesting (140 from sowing) yield and yield components of carrot was recorded. It's worthy to mention that in the two successive seasons showed similar re sponse to Cd and Zn soil addition either alone or in combination.

A- Effect of cadmium:

It's clear from the results in table (4) that, the cadmium soil addition either alone or combined with zinc soil addition gradually and significantly decreased all of the studied growth characters (shoot height, root length, as well as fresh and dry weights of shoots and roots). In generally, the decreases due to cadmium soil addition were more sever toxic in some growth parameters when cadmium used alone. Similar results were obtained by Salim *et al.*(1992) and Lata & Johri (1999) on carrot plants, Bai Song *et al.* (2003) on rice plants. Bayctailu and Ozden (2004) on common oak and Azevedo *et al.* (2005) on sunflower plant cv. (*Helianthus annuusl*). In this respect, Smilde *et al.* (1982) & Bayctailu and Ozden (2004) they mentioned that toxic effects of Cd accumulation on *Quercus robur* su sp, *Robur* (Common Oak) and *Acre negundo (Box Elder)* were due to decreases in chlorophyll content and fluctuations in peroxides activity.

Generally, it's important here to mention that, in carrot plants, the decreases in shoot and root dry and fresh weights as a result of cadmium soil addition were associated with pronounced decreases in shoot height and root length. This might be attributed to its effects on cell division and/or cell expansion, might be through its effect on DNA and RNA synthesis. These results were agree with those reported by Barcelo *et al.* (1988) & Cakmak, *et al.* (2000) they pointed out that the content of nitrogen, amino acids, DNA and RNA were decreased with increasing Cd application. Moreover, Shah & Dubey (1995) working on rice reported that Cd application caused a concomitant inhibition of enzyme RNAase activity; results suggest possible suppression of RNA hydrolysis in rice plants under Cd toxicity. It's therefore, possible that the effect of Cd on plant height and root length observed here may have been induced as a result of inhibition of cell elongation and or cell division through its effect on genetic components (DNA and RNA formation).Furthermore, it is important here to mention that, Cd as a metal constitute a trace amount of the dry weight of plants. Hence, cadmium cannot in itself, cause any large change in growth in terms of rate of increase in dry weight. Any change in the growth rate which results from increasing Cd supply must be dependent on change in the rate of net photosynthesis, these reduces the supply of carbohydrates or proteins and consequently decrease the growth of the plant. In this respect, Abo Kassem *et al.* (1997) working on wheat, Skorzynska and Baszynski (1995) working on bean plant, they pointed out that; the application of Cd resulted in reduction of photosynthesis efficiency and transpiration. In this connection, Kater *et al.* (1991) working on faba bean reported that chlorophyll content decreased with increasing Cd rate. Tukendorf & Baszynski (1991) and Geiken *et al.* (1998) working on pea and faba bean plants found that both photosystem I (PSI) and photosystem II (PSII) were decreased with increasing Cd addition.

B- Effect of Zinc:

Data in table (4) revealed that, the effect of three different levels of zinc (75, 150 and 225 ppm) soil addition on the growth characters (fresh and dry weights of root and shoot, root length and shoot height) tended to record non-significantly affected, except fresh and dry weights of shoot in the second sample and shoots height in the first sample which were significantly, increased as compared with control–zinc untreated plants. Similar results were reported by Salam (1998), Hegazy (2001) on faba bean plants. In this respect, Zn is an essential component of over 300 enzymes, (Fox & Guerimot, 1998).

Table 4. Root length, shoot height (cm), fresh & dry weight (g) of carrot root & shoot as the average of the two seasons in the two samples (70 & 140 days after sowing) as affected by different levels of Cd and Zn soil addition.

Growth character		Root length (cm)					Shoot height (cm)				
plant age(days)	Treatment	Control	Zn1	Zn2	Zn3	Mean Cd	Control	Zn1	Zn2	Zn3	Mean Cd
70	Control	15.2	14.5	13.9	12.5	14.0	15.8	15.8	16.2	15.3	15.8
	Cd1	12.1	13.0	13.1	12.7	12.7	12.9	14.0	14.5	12.9	13.6
	Cd2	10.8	12.4	12.7	13.0	12.2	12.4	13.8	14.3	12.9	13.3
	Cd3	9.2	10.9	11.4	11.8	10.8	10.1	11.9	13.0	11.9	11.7
	Mean Zn	11.9	12.7	12.8	12.5		12.8	13.8	14.5	13.2	
	L.S.D 0.05	Cd =1.51 Zn = NS Cd*Zn = 2.26					Cd =1.02 Zn = 1.02 Cd*Zn = 1.53				
140	Control	21.2	21.6	21.3	17.6	20.4	23.6	25.4	24.8	21.9	23.9
	Cd1	17.1	18.3	18.6	16.9	17.7	20.9	22.4	23.6	23.3	22.5
	Cd2	14.8	16.4	16.0	16.4	15.9	18.5	21.9	21.7	20.6	20.6
	Cd3	13.6	16.2	14.4	15.3	14.9	16.9	19.8	20.2	21.4	19.6
	Mean Zn	16.7	18.1	17.5	16.5		19.9	22.4	22.6	21.8	
	L.S.D 0.05	Cd = 2.11 Zn = NS Cd*Zn = 3.16					Cd = 3.77 Zn = NS Cd*Zn = 5.56				
		Root					Shoot				
		Fresh weight (g)									
70	Control	3.73	3.99	3.25	2.90	3.46	4.75	4.34	4.95	4.05	4.52
	Cd1	2.35	2.74	2.72	2.36	2.54	3.15	3.65	3.89	3.34	3.50
	Cd2	2.46	2.76	2.70	2.74	2.67	3.21	3.65	3.41	2.59	3.21
	Cd3	1.78	1.62	1.76	2.04	1.80	2.50	2.53	2.92	3.13	2.77
	Mean Zn	2.58	2.75	2.61	2.51		3.40	3.54	3.79	3.28	
	L.S.D 0.05	Cd = 1.24 Zn = NS Cd*Zn =1.86					Cd = 1.47 Zn = NS Cd*Zn = 2.20				
140	Control	44.18	43.18	38.27	32.25	39.47	12.24	9.50	11.80	9.60	10.80
	Cd1	28.45	34.72	35.80	30.12	32.27	7.50	8.70	11.40	11.60	9.80
	Cd2	26.43	37.00	36.47	37.90	34.45	5.89	10.00	8.70	9.00	8.40
	Cd3	19.89	29.65	29.50	29.65	27.17	7.98	8.80	9.00	9.50	8.80
	Mean Zn	29.70	36.10	35.00	32.50		8.40	9.30	10.30	10.00	
	L.S.D 0.05	Cd = 6.50 Zn = NS Cd*Zn = 9.75					Cd = 1.76 Zn = 1.88 Cd*Zn = 2.82				
		Dry weight (g)									
70	Control	0.475	0.438	0.376	0.366	0.414	0.526	0.500	0.466	0.480	0.493
	Cd1	0.267	0.337	0.354	0.278	0.309	0.364	0.408	0.455	0.404	0.408
	Cd2	0.235	0.258	0.274	0.288	0.264	0.350	0.423	0.406	0.327	0.376
	Cd3	0.212	0.213	0.204	0.240	0.217	0.292	0.311	0.358	0.352	0.328
	Mean Zn	0.297	0.311	0.302	0.293		0.383	0.410	0.421	0.390	
	L.S.D 0.05	Cd = 0.122 Zn = NS Cd*Zn= 0.183					Cd = 0.099 Zn = NS Cd*Zn = 0.148				
140	Control	4.58	4.31	4.27	3.38	4.44	1.41	1.36	1.34	1.12	1.31
	Cd1	2.75	3.58	3.49	3.15	3.24	0.90	1.21	1.16	1.17	1.11
	Cd2	2.47	3.29	3.39	3.43	3.14	0.80	1.36	1.04	1.21	1.10
	Cd3	2.00	2.98	3.00	3.09	2.77	0.85	1.02	1.12	1.01	1.00
	Mean Zn	2.95	3.54	3.53	3.26		0.99	1.24	1.17	1.13	
	L.S.D 0.05	Cd = 0.950 Zn = NS Cd*Zn =1.42					Cd = 0.21 Zn = 0.21 Cd*Zn = 0.31				

Zn1 = 75 ppm, Zn2= 150 ppm, Zn3= 225 ppm. Cd1 = 10 ppm , Cd2 = 20 ppm Cd3 = 40 ppm

In most of these enzymes, Zn makes up an integral of the enzyme structure. Moreover, Dickinson *et al.* (2003) reported that the role of Zn in DNA and RNA metabolism, in cell division, and protein synthesis has been documented for many years. Zn is very closely involved in the nitrogen metabolism of plants. In plants with Zn deficiencies protein synthesis and protein levels are drastically reduced whereas amino acids accumulate. On the other hand, it is important here to mention that, in the first sample, high values of root fresh, dry weights and length of root, as well as shoots dry weight were obtained by the plants treated with the lowest rate of Zn alone when compared with the plant treated by the highest rate of Zn alone. In this respect, Rashad and Hanafy Ahmed (1997) working on faba bean plants mentioned that Zn (50 ppm) foliar applications significantly increase most of the study growth characters (plant height and number of leaves per plant) while the highest rate of Zn (75 ppm) had adverse affect on most of studies growth and yield parameters. In this respect, Smiled *et al.*(1982) reported that Zn soil addition of 2000 mg/kg substrate proved toxic for lettuce and spinach, whereas 3000 mg Zn was toxic for grass and french beans. Moreover, Van *et al.* (1987) found that toxic doses of Zn inhibit shoot growth but increase the capacity of several leaf enzymes in dwarf bean. In this connection, it can be suggested that, the reduction in carrot plant growth as affected by high Zn treatments may be induce due to its inhibitor effects on enzyme system responsible for growth process.

2- Plant pigments:

Data in table (5) revealed that, the concentration of the all plant pigments (chlorophyll a, chlorophyll b and total carotenoids) were non significantly affected in the two samples, except chlorophyll a which was significantly decreased with increasing cadmium soil addition either alone or in combined with zinc at all levels as compared with control untreated cadmium plant. In this connection, Bazzaz and Govindjee (1974) reported that Cd adversely affects the emerge producing mechanisms of chloroplasts and mitochondria. Chloroplasts isolated from corn leaves and treated with 0.005mM Cd $(NO_3)_2$ exhibited inhibitions of photosystem II activities at the water oxidation level. In addition, exposure to Cd resulted in the total amount of chlorophylls, a decrease in the ratio of chlorophyll a to chlorophyll b and the decrease in the ratio of shoot to long wave length forms of chlorophyll a. This might be due to the role played by Cd in photosynthesis, PSII activity, enzymes activity and accumulations of organic matter in plants exposed with cadmium. In this respect, Bai Song *et al.* (2003) pointed out that Cd application at the rates of 0, 1, 5, 30 and 100 mg /l nutrient solutions reducing the chlorophyll on rice seedlings. Also, Bayctailu and Ozden (2004).mentioned that toxic effects of Cd accumulation on *Quercus robur* su sp, *Robur* (Common Oak) and *Acre negundo* (Box Elder) was due to decreases in chlorophyll content and fluctuations in peroxides activity. Rai *et al.*(2003) working on *Potamogenton pectinatus,* L. cultured in Hogland solution containing 0, 5, 5, 25, 50, 100 and 200 µM cadmium. They found that Cd significantly reduced photosynthesis pigments (chlorophyll a, b and the total chlorophyll) and the highest reduction in carotenoids content was observed when plant treated with 200 µM, protein and cystiene content decreased in plants exposed to 100 µM of cadmium. Moreover, Nagoor &Vyas (1997) reported that carbohydrate metabolism, including alpha amylase, beta amylase, invertase activities as well as reducing and non reducing sugar contents, were reduced by 20, 150, 200, 250 and 300mg $CdCl_2$ /Ml on wheat cv. Soualika.

Moreover, all plant pigments (chlorophyll a, b and carotenoids) in the two samples were non significantly affected with increasing zinc soil addition, except chlorophyll a in the first sample which was increased when compared with control zinc untreated plant. In this respect, Garg *et al.* (1986) reported that the application of zinc increased chlorophyll a and b concentration. In addition, Zn plays a key role in photosynthesis, affecting the activity of enzymes such as carbonic anhydrase (Rengel, 1995), as well as affecting chlorophyll concentration and stomatal conductance (Hu & Sparks, 1991) Also, Rashad & Hanafy Ahmed (1997) working on faba bean plant, mentioned that in the first sample (55 days) there were increases on total chlorophyll and carotenoids concentration in response to zinc foliar application (50 ppm) if compared with the control – untreated plants.

Table 5. Chlorophyll a & b as well as carotenoids concentration (mg/g fresh weight) in the leaves of carrot plant in the two samples (70 and140 days after sowing)as affected by different levels of Cd and Zn soil addition, as the average of two seasons.

Plant age (days)		70					140				
Plant Pigment	Treatment	Control	Zn1	Zn2	Zn3	Mean Cd	Control	Zn1	Zn2	Zn3	Mean Cd
Chlorophyll a	Control	4.41	4.79	4.88	5.32	4.85	4.94	5.63	5.68	5.49	5.43
	Cd1	3.83	4.13	4.93	4.84	4.43	4.20	4.58	4.61	4.8	4.55
	Cd2	3.51	4.04	4.41	4.36	4.08	4.57	5.10	5.14	5.15	4.99
	Cd3	3.33	4.45	4.52	4.82	4.28	3.68	3.92	4.18	4.39	4.04
	Mean Zn	3.77	4.35	4.69	4.84		4.35	4.80	4.90	4.96	
	L.S.D	Cd = 0.70 Zn = 0.70 Cd*Zn = 0.99					Cd = 0.83 Zn = NS Cd*Zn=1.17				
Chlorophyll b	Control	1.43	1.34	1.20	1.24	1.30	1.81	1.60	1.69	1.82	1.73
	Cd1	1.14	1.08	1.26	1.34	1.21	1.72	1.78	1.85	1.66	1.75
	Cd2	1.20	1.15	1.09	1.35	1.20	1.35	1.63	1.80	1.56	1.59
	Cd3	1.46	1.38	1.42	1.33	1.40	1.73	1.75	1.75	1.72	1.74
	Mean Zn	1.31	1.24	1.24	1.321		1.65	1.69	1.77	1.69	
	L.S.D 0.05	Cd = NS Zn = NS Cd*Zn = NS					Cd = NS Zn = NS Cd*Zn =0.46				
Carotenoids	Control	1.70	1.81	1.76	1.73	1.75	2.38	2.31	2.35	2.20	2.31
	Cd1	1.49	1.53	1.56	1.59	1.54	2.03	2.12	2.18	2.23	2.14
	Cd2	1.48	1.42	1.48	1.42	1.45	1.82	1.92	1.95	1.86	1.89
	Cd3	1.27	1.42	1.47	1.37	1.38	1.68	1.88	2.00	1.90	1.87
	Mean Zn	1.49	1.55	1.57	1.53		1.98	2.06	2.12	2.05	
	L.S.D 0.05	Cd = NS Zn = NS Cd*Zn=NS					Cd = NS Zn = NS Cd*Zn=NS				

Zn1 =75 ppm, Zn2=150 ppm, Zn3 = 225 ppm. Cd1 = 10 ppm , Cd2 = 20 ppm Cd3 = 40 ppm

3- Mineral composition:

1- Cadmium.

Concerning the effect of cadmium soil addition on Cd concentration in carrot plants, its clear from the results in table (6) that, in the two successive samples in the second season, significant and gradually increases in cadmium concentrations were recorded by the roots and shoot in carrot plant supplied with the three different rates of cadmium soil addition either alone or combined with zinc when compared with control–untreated plant or control cadmium untreated plants. Similar results were reported by Hegazy (2001) on radish and faba bean, Lagriffoul *et al.* (1998) on maize plant, Chaoui *et al* (1997) on bean plant. Moreover, the results revealed, that cadmium concentration in the different parts of carrot plant was mostly related to it's concentration in soil. In this respect, many workers pointed out that the amount of cadmium absorbed by plant was a function of cadmium concentration in the soil. Cutler & Rains (1974) working on barley found three passive mechanisms for cadmium uptake: exchange absorption, irreversible binding and diffusion.

Concerning the cadmium concentration in the different parts of carrot plants, the results showed that, the root of carrot plants always contained the higher values of Cd than shoot. In this connection, Pettersson *et al.* (1976) working on rape, cucumber, wheat, oats and tomato mentioned that cadmium is probably mainly absorbed on the root surface and not available for translocation. It was found that the roots had a several times higher level of cadmium than the shoots, but only in the root parts which were directly exposed to the contaminated soil. Moreover, Ouariti *et al.* (1997) working on bean reported that Cd accumulated at higher levels in roots than in shoots, indicating that roots acted as a carrier restricting Cd transport. Also, Leita *et al.* (1996) working on bush bean mentioned that most of the Cd was bound at the cell wall. All forms of Cd were in higher concentrations in roots than in leaves. Bipasha *et al.* (1997) working on linseed noted that, estimation of metal uptake inside the cell demonstrated the accumulation of Cd in the cytoplasm in the regenerated roots. In this respect, the percentage increase of cadmium concentration in the root due to increasing cadmium soil addition (10, 20 and 40 ppm) either alone were 230.4, 230.4 and 247.8 % in the 1st sample and were 390.6, 441.3 and 444.6 % in the 2nd one, and the increases in the shoot were 207.2, 373.8 and 496.3 % in the 1st sample and were 481.9, 509.8 and 567.2% in the 2nd sample, respectively. In this respect, Mengel and Kirkby (1987) reported that the normal levels of cadmium in different plants species ranged between (0.10 to 1.00 ppm). Also, Kabata Pendias & Pendias (1984) reported that the cadmium concentration in contaminated plants ranges between 5 - 30 ppm. The results in table **(6)** revealed that, the range of Cd concentration in the roots of carrot plants treated with the three different rates of cadmium alone (10, 20 and 40 ppm) was between 5.33 –5.6 ppm in the first sample and between 7.36 – 8.1 ppm in the second sample of root, while in the shoots of carrot plants was between 3.41 – 6.62 ppm in the first sample and 7.1- 8.14 ppm in the second samples. Thus, it can be concluded that cadmium concentration in the shoot and root of carrot cadmium treated plant were within the normal range and not in toxic level. However, as the recommendation of the National Research Council of the United States (1980) the cadmium content of forage crop should not be more than o.5 µg g^{-1} in order to limit the concentration of cadmium in the liver and kidney of animals feeding on these crops to protect humans against cadmium toxicity. Moreover, the data indicated that, in the second sample, the root and shoot always contained the highest values of cadmium when compared with the values in the first sample. Thus, it can be suggested that the time of explosion is factor very important for cadmium uptake and accumulation in plants. Similar results were obtained by Rauser (1986) on tomato, Dang *et al.* (1990) on onion, Khan & Frankland (1983) on radish, Obata & Umebayashi (1997) on maize, cucumber and pumpkin plants

Table 6. Dry weight (g) and Cd, Zn and Fe concentration (ppm) of carrot root & shoot in the two samples (70 &140 days after sowing) as affected by different levels of Cd and Zn soil addition, in the second season.

plants organs		Root					Shoot				
Plant age (days)	Treatment	Control	Zn1	Zn2	Zn3	Mean Cd	Control	Zn1	Zn2	Zn3	Mean Cd
Dry weight (g)											
70	Control	0.475	0.455	0.393	0.366	0.422	0.594	0.567	0.517	0.548	0.557
	Cd1	0.253	0.337	0.342	0.269	0.300	0.420	0.530	0.537	0.431	0.480
	Cd2	0.222	0.228	0.253	0.275	0.245	0.442	0.462	0.476	0.353	0.433
	Cd3	0.210	0.228	0.191	0.228	0.214	0.374	0.360	0.436	0.415	0.396
	Mean Zn	0.290	0.312	0.295	0.285		0.458	0.480	0.491	0.437	
L.S.D0.05		Cd = 0.123 Zn = NS Cd* Zn = 0.175					Cd = 0.142 Zn = NS Cd*Zn = 0.202				
140	Control	4.10	3.88	3.70	2.87	3.64	1.80	1.81	1.70	1.40	1.68
	Cd1	2.67	3.13	3.07	2.67	2.89	1.02	1.63	1.50	1.37	1.38
	Cd2	2.30	2.67	2.87	2.83	2.67	0.87	1.85	1.27	1.53	1.38
	Cd3	1.73	2.53	2.33	2.67	2.32	1.13	1.27	1.43	1.27	1.28
	Mean Zn	2.70	3.05	2.99	2.76		1.20	1.64	1.48	1.39	
L.S.D 0.05		Cd = 0.882 Zn = NS Cd*Zn= 1.254					Cd= 0.266 Zn= 0.266 Cd*Zn = 0.378				
Cadmium (ppm)											
70	Control	1.62	1.38	1.32	1.56	1.47	1.12	3.31	1.37	1.37	1.79
	Cd1	5.32	5.14	4.53	5.12	5.03	3.41	4.32	4.33	3.83	3.97
	Cd2	5.32	5.51	5.25	5.96	5.51	5.27	5.45	4.44	5.09	5.06
	Cd3	5.60	6.55	6.65	5.84	6.16	6.63	5.45	5.87	5.35	5.82
	Mean Zn	4.46	4.65	4.44	4.62		4.10	4.63	4.00	3.91	
L.S.D0.05		Cd =0 .29 Zn = NS Cd*Zn =0.41					Cd = 0.64 Zn =0.64 Cd*Zn =0.92				
140	Control	1.50	1.84	2.00	2.02	1.84	0.61	2.20	1.27	1.59	1.42
	Cd1	7.36	7.48	7.57	7.48	7.47	7.11	7.18	7.23	7.08	7.15
	Cd2	8.12	8.22	8.29	7.47	8.02	7.44	7.94	7.58	7.76	7.68
	Cd3	8.17	8.52	8.27	8.57	8.38	8.14	8.56	7.47	8.47	8.16
	Mean Zn	6.29	6.51	6.53	6.38		5.82	6.47	5.89	6.22	
L.S.D0.05		Cd = 0.39 Zn = NS Cd*Zn = 0.56					Cd = 0.51 Zn = 0.51 Cd*Zn = 0.73				
Zinc (ppm)											
70	Control	46.5	73.5	86.5	97.0	75.9	32.5	41.5	59.0	85.0	54.5
	Cd1	33.5	86.0	82.0	93.5	73.8	32.0	52.0	73.0	77.0	58.5
	Cd2	29.5	62.5	69.0	92.5	63.4	27.0	43.5	64.5	82.0	54.3
	Cd3	27.0	70.0	64.5	84.5	61.5	23.5	47.0	73.0	75.0	54.6
	Mean Zn	34.1	73.0	75.5	91.9		28.8	46.0	67.4	79.8	
L.S.D 0.05		Cd = 6.8 Zn = 6.8 Cd*Zn = 9.7					Cd = Ns Zn = 6.2 Cd*Zn = 8.8				
140	Control	81.0	145.5	156.0	153.0	133.9	81.5	93.5	132.0	141.0	112.0
	Cd1	71.0	139.5	147.0	148.0	126.4	75.5	119.5	124.0	133.0	113.0
	Cd2	68.5	148.0	149.0	144.5	127.5	65.5	127.0	131.0	135.0	114.6
	Cd3	59.5	135.0	136 5	140.0	117.8	60.0	117.0	124.0	124.5	106.4
	Mean Zn	70.0	142.0	147.1	146.4		70.6	114.3	127.8	133.4	
L.S.D 0.05		Cd = 6.3 Zn = 6.3 Cd*Zn = 9.0					Cd =8.4 Zn = 8.4 Cd*Zn = 11.9				
Iron (ppm)											
70	Control	54.5	63.0	93.5	108.0	79.8	44.0	52.0	72.0	105.0	68.3
	Cd1	62.5	97.0	74.0	94.5	82.0	35.5	66.5	90.5	94.5	71.8
	Cd2	84.5	71.0	95.5	110.5	90.4	35.5	56.5	76.5	85.0	63.4
	Cd3	85.0	84.0	108.0	92.5	92.4	28.5	61.0	82.5	76.0	62.0
	Mean Zn	71.6	78.8	92.8	101.4		35.9	59.0	80.4	90.1	
L.S.D 0.05		Cd = 4.6 Zn = 4.6 Cd*Zn = 6.5					Cd = 7.6 Zn = 7.6 Cd*Zn = 10.9				
140	Control	159.0	172.0	162.0	171.5	166.1	70.5	44.5	45.5	53.0	53.4
	Cd1	123.5	153.0	162.0	177.0	153.9	49.5	85.0	88.0	88.5	77.8
	Cd2	109.5	153.0	128.0	165.5	139.0	42.0	83.5	79.0	87.0	72.9
	Cd3	146.5	153.5	163.0	163.5	156.6	42.0	81.0	92.0	84.0	74.8
	Mean Zn	134.6	157.9	153.8	169.4		51.0	73.5	76.1	78.1	
L.S.D0.05		Cd = 7.5 Zn = 7.5 Cd*Zn = 10.7					Cd = 6.0 Zn = 6.0 Cd*Zn = 8.6				

Zn1 = 75 ppm, Zn2 = 150 ppm, Zn3=225 ppm, Cd1=10 ppm, Cd2 =20 ppm Cd3 = 40 ppm

From the previous results, it can be suggested that several detrimental effects attributed to cadmium soil addition on all of the studied growth characters of carrot plants might be partially due to increases in cadmium concentration and consequently its negative effects on net photosynthesis, transpiration, chlorophyll a as well as nutrients contents. Chen *et al.* (1996) concluded that when soil Cd was > 22.3 mg / kg the yield, nutrient content as well as physiological and biochemical properties of mulberry leaves showed distinct change, and the damage become greater as cadmium concentration increased.

As regards the effect of zinc soil addition on cadmium concentration in carrot plants, it is clear from the results that, in the 1st sample the lowest value of cadmium concentration was obtained by the root and shoot of the plant supplied with the middle rate of zinc when compared with control plants untreated Zn. In this respect, it can be suggested that, zinc soil addition may be overcome, to some extent, the inhibition effects of cadmium on absorption, accumulation and translocation of cadmium within carrot plant. Similar results were reported by Choudhary *et al.* (1994) on wheat plant and Hegazy (2001) on radish plant. In this respect, Das (2000) reported that the application of Zn in soils decreased the concentration of Cd in soils and subsequently decreased the content and uptake of Cd by the plants which also suggest antagonistic relationship between them. However, Dabin *et al.* (1978) concluded that zinc and cadmium are bound to different legends in rice roots. Also, Zn was found in some cases to depress Cd uptake, indicating some kind of interaction between these two metals. There are several factors affecting the uptake and accumulation of Cd in plants. Among these factors, soil salinity and soil zinc (Zn) status play a critical role (Cakmak *et al.*, 2000 & Oliver *et al.*, 1997).On the other hand, its important here to mention that, as reported before high values of cadmium concentration were obtained by the root or shoot of carrot plants, supplied with the three different rates of zinc combined with the three different rates of cadmium when compared with control–untreated plants or plants supplied with the same level of zinc or cadmium soil addition, in this respect, it can be suggested that the effect of Zn soil addition on plant cadmium concentration might depended on the concentration of Cd and Zn in soil. In this connection, Mitchell (1981), mentioned that at low soil cadmium levels (about 0.1 µg/g), increasing levels of soil Zn reduced the concentration of Cd in lettuce leaves, but at higher soil Cd levels (20-80 µg/g), the added Zn either showed no effect or increased leaf Cd concentration. The interaction between soil Zn and Cd, as well as the correlation between leaf Zn and leaf Cd, has not been confirmed at the high soil Cd (10µg /g) and Zn (300-600 µg/g) levels.

2- Zinc.

Concerning the effect of cadmium and zinc soil addition on Zn concentration in carrot plants, the results in table (6) indicated that gradually decreases in zinc concentration were detected by the shoot and roots of carrot plant supplied with the three different rates of cadmium soil addition either alone or combined with zinc, except in the first sample of the shoots which was indicated non significantly effect when compared with control-untreated plant or control – cadmium untreated plant. Moreover, the results revealed that, the range of Zn concentration in the shoots of carrot plants treated with the three different rates of cadmium alone (10, 20 and 40 ppm) was between 27.0 - 33.5 ppm in first sample and between 59.5 – 71.0 ppm in the second sample, while in the roots which was between 23.5 – 32.0 ppm in the first sample and 60.0 - 75.5 ppm in the second sample. Similar results were obtained by Hegazy (2001) working on bean and Abo Hussien and Faiyad (1996) on corn plants.

As regards the effect of zinc soil addition on zinc concentration in carrot plants, the results in table (6) revealed that, significant and gradually increases in zinc concentration were recorded by the root and shoot of carrot plant, supplied with the three different rates of zinc either alone or in combined with cadmium soil addition when compared with control- untreated plants or plant supplied with cadmium soil addition alone. Moreover, it is clear from the results, that zinc concentration in the root and shoot of carrot plant was agreed with its levels in soil. It had been reported by many workers that certain essential heavy metals, such as zinc are taken into plant cells by metabolic mechanisms (Marschner, 1995). The fact that cadmium is a toxic heavy metal and zinc an essential element makes this association interesting as it raises the possibility that the toxic effects of cadmium may be preventable or treatable by zinc. In this respect, Abd el Sabour *et al.* (1988) working on corn and soybean mentioned that Zn application reduced plant Cd concentrations. Moreover, Dominic *et al.* (1983) pointed out that in soybean plant, root absorption and transfer from root to shoot of Cd was inhibited by Zn.

As regards the zinc concentration in the edible parts of carrot plants (shoot and root) the results in table (6) showed that, the range of zinc concentration in the roots of carrot plants treated with the three different rates of zinc alone (75, 150 and 225 ppm) was between 41.5 – 85.0 ppm in the first sample and between 93.5 – 141.0 ppm in the second sample, while in the shoots of carrot plants the range was between 73.5 – 97.0 ppm in the first sample and 145.5 – 153.0 ppm in the second sample. Regarding the normal Zn level in plant dry weight it is reported to be 8 - 400 ppm, while the toxic level is > 400 ppm (Kabata- Pendias & Pendias 1984). Thus, zinc concentration in the edible parts of carrot (shoot and roots) are within the normal rang regardless zinc soil addition levels.

3- Iron.

Data in table (6) indicated that gradually decreases in iron concentration were detected by the shoot and the root of carrot plant supplied with the three different rates of cadmium soil addition either alone or combined with zinc, with some exceptions on the shoot in the 2nd sample, since the higher values were recorded by the shoot of plants supplied with both Cd and Zn in this sample. In this respect, Siedlecka and Krupa (1999) reported that Cd is one of the most dangerous environmental pollutants, interacts with Fe modifying effects of deficient or excessive Fe supply, and the effect of modified Fe and Cd supply on the uptake of both metals. Their distribution, plant growth and photosynthesis are explained. Also, the Fe transporters have been shown to be able to transport several metals including Cd in Arabidopsis (Korshunova *et al.*, 1999 & Thomine *et al.*, 2002). Moreover, Yang *et al.* (1996) reported that influx of Fe decreased with increasing external Cd levels, in maize plant grown with Cd up to 14 µM compared to control. Also, Foroughi *et al.* (1982) mentioned that high Cd concentration in the growing medium suppresses the Fe uptake by the bean plant.

As regard the effect of zinc soil addition on iron concentration in carrot plants, the results in table (6) revealed that, the significant and gradually increases in iron concentration were recorded by the root and shoot of carrot plant, supplied with the three different rates of zinc either alone or in combined with cadmium soil addition when compared with control- untreated plants or plant supplied with cadmium soil addition alone. Similar results were obtained by Hegazy (2001) on faba bean plant and Abd El Rahman (2003) on navel orange leaves. In this respect, Foroughi *et al.* (1982) mentioned that Zn had an antagonistic effect on Fe. Moreover, Lyszcz & Ruszkowska (1992) reported that Zn application smaller increases Fe levels in pea tissue.

4- Growth analysis:

Data in table **(7)** revealed that, gradually increases in the mean values of the leaf weight ratio **LWR** were recorded by the plants treated with the three different doses of cadmium soil addition either alone or when combined with Zn soil addition as the average of the two seasons when compared with control Cd-untreated plant. Thus, in this respect, it can be suggested that, the depressing effect of Cd supplies either alone or combined in Zn was more severe on root growth as compared with its effect on the growth of shoot. Similar results were obtained by Leita *et al.* (1993) on pea plants and Nagoor and Vyas (1997) on wheat. In this connection, El Enany and Abd Alla (1995) mentioned that root of faba bean accumulated Cd at higher levels than shoots, indicating that the roots acted as barrier restricting Cd transport. Moreover, Hegazy (2001) suggested that the reduction in faba bean plant growth as affected by Cd may be inducing as a result of root damage. Moreover, the results in table **(7)** revealed that the zinc soil addition either alone or combined with cadmium tended to increased the leaf weight ratio **LWR** in the all levels except, at the lowest level of Zn alone, and when the highest level of zinc addition combined with the middle and the highest level of cadmium soil addition.

As regards the relative growth rate (**RGR** mg $g^{-1}d^{-1}$) between the two successive samples as the average of the two seasons, it is clear from the results in table **(7)** that, gradually decreases in **RGR** value were recorded with increasing cadmium soil addition alone. However, a reverse tend was detected when cadmium soil addition combined with any of the three different doses of Zn soil addition or the mean values of these treatments. These results supported the assumption that Zn application can be overcome, to some extent, the toxic effect of cadmium in plants. In this respect, Das *et al.* (1997) mentioned that zinc and cadmium have many physical and chemical similarities as they both belong to group II of the periodic table. They are usually found together in the ores and compete with each other for various legends. Moreover, they mentioned that the biochemical mechanisms of Cd-Zn interaction are unknown, but various cellular and sub-cellular processes like the ratio of Cd to Zn in tissues, induction of synthesis of different types of metallothionein, binding characteristics of metallothionein, alteration of absorption and tissue distribution of one metal by another, and competition at the level of zinc containing metalloenzymes are known to be involved in the interactions.

Data in table **(7)** revealed that, the relative growth rate (**RGR** mg $g^{-1}d^{-1}$) were increased with increasing zinc soil addition either alone or combined with any of the three different levels of cadmium except, the plants treated with the highest level of zinc soil addition alone which recorded the lowest value. This might be attributed to a high metabolic activity of the plant by zinc due to increase photosynthesis and / or decrease in respiration rate thus increased rate of dry matter production in the two parts of plant. In this respect, Wilkinson (1994) suggested that, the basic Zn functions in plants are related to metabolism of carbohydrates, proteins, and phosphate and also to auxins, RNA and ribosome formations. On the other hand, the highest value of (RGR mg $g^{-1}d^{-1}$) was recorded by the plants treated with the lowest level of zinc combined with the highest rate of cadmium when compared with the plants non supplied with either zinc or cadmium soil addition (untreated control plants).In this respect, it may be suggested that the inhibiting effects of the high levels of zinc soil addition or all levels of cadmium soil addition alone on plant growth and dry matter accumulation can be overcome to some extent by adding these two metals to plants. In this connection, it may be concluded that the effect of these two ions in combination was different when cadmium concentration in soil 40 ppm and zinc 75 ppm from the individual effects of metal alone. In this respect, Smilde *et al.* (1982) mentioned that the threshold dose of toxic metals (Cd and Zn) applied in combination was generally lower than that of metals given singly.

Generally it is important here to mention that in carrot plant the decreases in shoot or root dry and fresh weights as a result of cadmium soil addition were associated with pronounced decreases in shoot height and root length. This might be attributed to its effects on cell division and / or cell expansion might be through its effect on DNA and RNA synthesis. Also, Abo Kassem *et al.* (1997) suggested that, the root and shoot dry weight, relative growth rate **RGR** on wheat were significantly reduced by 5 and 10 mM Cd and the application of Cd resulted in reduction of photosynthesis and transpiration. Moreover, Bayctailu and Ozden, (2004).mentioned that toxic effects of Cd accumulation on *Quercus robur* su sp, Robur (Common Oak) and Acre Negundo (Box Elder) was due to decreased in chlorophyll content and fluctuations in peroxidase activity. In this respect, Wagner (1993) suggested that the occurrence of significant accumulation of phytochelatins (PCs) in crops exposed to low Cd concentration and suggested another two mechanisms for detoxification of Cd, (i) phytochelatins (PCs) produced in response to high Cd challenge appear to sequester accumulated Cd, mainly in the vacuole , and (ii) Binding of metals in the cell walls , chelation in the cytosol, cytosolic chelation and subsequent transfer to the vacuole, and transport of free metal ions into the followed by sequestration with organic acids and other legends.

Data in table (7) revealed that, the gradually decreases in the **SUR** specific utilization rate (mg mg $Cd^{-1}d^{-1}$) were recorded by the plants treated with the three different doses of cadmium soil addition either alone or combined with any of the three different dose of zinc soil addition when compared with control– cadmium untreated plants. In this respect, it can be assumed that cadmium supply might affect photosynthetic activity or respiration rate or both leading to the decrease in dry matter production per unit cadmium concentration in plant. In this respect, El Nabarawy (2002) pointed out that the uptake and physiological effects of cadmium (Cd) on spinach was related to mineral accumulation, artificially contaminated with Cd levels (11.24, 56.21, 112.41 mg Cd/kg soil), that Cd uptake in different plant organs was parallel with Cd increments in root soil medium, and that associated with continuous reduction of spinach organ growth, in terms of leaf number, whole plant leaf area, and fresh and dry weights of roots and shoots.

Table 7. Leaf weight ratio (LWR) & relative growth rate (RGR mg $g^{-1}d^{-1}$) as the average of two successive seasons and specific utilization rate (SUR mg mg Cd^{-1} d^{-1}or mg mg Zn^{-1} d^{1}) and rate of production (mg Zn or Fe g Cd^{-1} d^{-1} & mg Cd or Fe g $Zn^{-1}d^{-1}$) in the second season of carrot plant as affected by different levels of Cd and Zn soil addition.

	Cadmium affect					Zinc affect				
Treatment	Control	Zn1	Zn2	Zn3	Mean Cd	Control	Zn1	Zn2	Zn3	Mean Cd
	LWR					RGR mg $g^{-1}d^{-1}$				
Control	0.394	0.388	0.395	0.411	0.397	25.6	26..0	27.1	23.9	25.7
Cd1	0.412	0.400	0.406	0.431	0.412	25.1	27.0	25.0	26.3	25.8
Cd2	0.422	0.457	0.416	0.396	0.423	24.7	27.0	26.7	28.8	26.9
Cd3	0.439	0.424	0.455	0.421	0.435	24.9	29.0	28.5	27.6	27.5
Mean Zn	0.417	0.420	0.418	0.415		25.1	27.0	26.8	26.7	
	(SUR) mg mg^{-1} $Cd^{-1}d^{-1}$					(SUR) mg m g^{-1} Zn^{-1} d^{-1}				
Control	19.24	11.53	15.78	13.25	14.95	0.385	0.251	0.219	0.178	0.258
Cd1	4.06	3.88	3.79	4.13	3.96	0.439	0.233	0.207	0.215	0.273
Cd2	3.25	3.78	3.69	3.95	3.67	0.447	0.266	0.224	0.236	0.293
Cd3	3.06	3.55	3.51	3.51	3.41	0.514	0.271	0.239	0.240	0.316
Mean Zn	7.41	5.68	6.69	6.21		0.446	0.255	0.222	0.217	
	mg Zn g^{-1} Cd d^{-1}					mg Cd g^{-1} Zn d^{-1}				
Control	1742.4	1671.4	2590.8	2237.5	2060.5	0.463	0.464	0.407	0.356	0.423
Cd1	329.2	572.3	584.9	642.1	532.1	3.508	1.862	1.696	1.740	2.202
Cd2	254.6	588.0	590.5	614.8	512.0	3.863	2.285	1.969	2.031	2.537
Cd3	210.3	505.1	505.9	507.8	432.3	4.443	2.444	1.993	2.119	2.750
Mean Zn	634.1	834.2	1068.0	1000.6		3.069	1.764	1.516	1.562	
	mg Fe g^{-1} Cd d^{-1}					mg Fe g^{-1} Zn d^{-1}				
Control	2895.1	1703.8	2118.7	1765.8	2120.8	57.92	37.13	29.44	23.68	37.04
Cd1	470.4	547.0	570.0	609.8	549.3	50.83	32.90	31.18	31.74	36.66
Cd2	330.1	513.9	440.5	465.1	437.4	45.37	36.21	26.75	27.78	34.03
Cd3	366.4	497.3	509.7	517.4	472.7	61.46	37.98	34.69	35.37	42.37
Mean Zn	1015.5	815.5	909.7	839.5		53.90	36.06	30.51	29.64	

Zn1 = 75 ppm, Zn2=150 ppm, Zn3 = 225 ppm, Cd1 = 10 ppm, Cd2 = 20 ppm Cd3 = 40 ppm

As regards the rate of production of mg (Zn & Fe) g $Cd^{-1}d^{-1}$ the data indicated that the plants treated with the three different rate of cadmium alone or combined with zinc soil addition were gradually, and pronounced decreased when compared with control- Cd untreated plant. In this respect, it can be assumed that, the increasing of cadmium supply might affect on absorption and translocation of elements on plant. In this respect, Sarkunan *et al.* (1996) reported that plant growth decreased progressively with increasing levels of Cd at all rate of Zn. Cd toxicity symptoms, however, appeared at 100 mg /kg Cd in soil. The affected plants gave a rosette appearance. In this respect, Das (2000) suggested that cadmium and zinc are chemically very similar. Cd is thus able to mirric the behavior of the essential element Zn in its uptake, translocation and other metabolic functions. The presence of Cd disturbs enzyme activity, in plants excess may also disturb Fe metabolism and cause chlorosis. Also, Alcantara *et al.*(1994) reported that heavy metals are known to induce Fe chlorosis in different plant species. This chlorsis is generally correlated with low plant Fe contents. Under Fe–deficient condition, dicotyledonous plants enhance root Fe (III) reductase (Ferroxidase) activity, thus increasing the capacity reduce Fe (III) to Fe(II), the form in which roots absorb Fe . Cd (5mμ) severally inhibited the induction of root Fe (III) reductase.

Data in table (7) revealed that, gradually decreases in the **SUR** specific utilization rate (mg mg $Zn^{-1}d^{1}$) were recorded by the plants treated with the three different doses of zinc soil addition either alone or combined with any of the three different doses of cadmium soil addition, when compared with control-untreated plant. In this respect, it might be suggested that the favorable effect of Zn soil application either alone or combined with Cd soil addition on plant growth as well as the detrimental effect of high Zn soil addition might be attributed to its effect on enzymatic systems responsible for the biosynthesis of amino acid, protein, chlorophyll and photosynthesis. In this connection, many workers mentioned that zinc is an essential component of number of enzymes as dehydrogenases, proteinases, phosphohydrolases and peptidases (Singh, 1981; Wilkinson, 1994 and Marschner, 1995). Moreover, Abd el Reheem *et al.* (1992) working on faba bean mentioned that the absence of zinc from the nutrient medium reduced catalase and carbonic anhydrase activities. On the other hand, in the mean values, high value of **SUR** (mg mg $Zn^{-1}d^{1}$) were recorded by the plants treated with any of the three different levels of cadmium alone. Moreover, low values of **SUR** (mg mg $Zn^{-1}d^{1}$) were recorded by the plants treated with any of the three different levels of cadmium combined with the highest level of zinc (225 ppm Zn).Such decreases might be attributed to the inhibiting effect of high dose of both these two elements on metabolic activity of the growth.

The results in table (7) revealed that rate of production. (mg Cd & Fe) g Zn^{-1} d^{1} were decreased by the plants treated with the any of the three different rate of zinc either alone or combined with Cd soil addition when compared with control- Cd untreated plant. In this respect, it can be assumed that increasing zinc supply might affect on decreasing elements accumulations on plants thought the compotation between zinc and elements uptake or translocation on plant. In this respect Dominic *et al.* (1983) pointed that in soybean plant, root absorption and transfer from root to shoot of Cd was inhibited by Cu, Fe, Mn and Zn. Das (2000) reported that the availability of Cd as mentioned earlier has been found to be affected by the presence of other cations and anions in soils particularly Zn and Cu which decreased the availability of Cd in soils. Also, suggested that, the application of Zn in soils decreased the concentration of Cd in soils and subsequently decreased the content and uptake of Cd by the plants which also suggest antagonistic relationship between them. Moreover, Ruana *et al.* (1987) on bean plant showed that significant positive relations with the Zn concentration supplied were found for Fe content in roots. The ratios of the mineral content organs suggested inhibition of translocation of Fe.

REFERENCES

Abd El Rahman, A.M. (2003).Effect of some nutrients and growth substance application on fruiting, yield and fruit quality of navel orange trees. Bull. Fac. Agric., Cairo Univ., 54 (2): 175-188.

Abd El Reheem, A.M.;Gendy, E.N. and El-Awady, R.M. (1992). Response of broad bean plants grown in alluvial soils to potassium and zinc application. Egypt. J. of Soil Sci., 32:4, 537-545.

Abd El Sabour, M.; Mortvedt, J. and Kelose, J.(1988).Cd-Zn interaction in plant and extractable Cd and Zn fractions in soil. Soil Sci, 145: 424-431.

Abo Hussien, E. and Faiyad, M.(1996).The combined effect of Zn and cobalt on corn growth and nutrients uptake in alluvial soils. Egypt.J. Soil Sci., 36(1): 47-58.

Abo Kassem, E.;Sharaf El Din, A.; Mohamed, A. and Foda, E.(1997).Effect of different cadmium concentration on growth photosynthesis and ion relation of wheat. Egypt. J. Physiol. Sci., 21(1):41-51.

Alcantara, E.;Romera, E.;Canete, M. and Guardia, M.(1994). Effect of heavy metals on both induction and function of root Fe(III) reductase in Fe-deficient cucumber. Plants J.of Exp.Bot., 45(281):1893-1898.

Alfani, A.; Baldantoni, D.;Moisto, G.;Bartoli, G. and Santo, A. (1996).Temporal and sapatial variation in C, N, S and trace element contents in the leaves of *Quereusilex* within the urban area of Nables. Italy J.of Plant Nutrition, 17(3): 557-573.

ATSDR (1997a).Draft Toxicological Profile for Lead Us Department of Health and Human Service Agency for Toxic Substances Disease Registry, (August 1997).

ATSDR (1997b).Draft Toxicological Profile for Cadmium Us Department of Health and Human Service Agency for Toxic Substances, Disease Registry, (September 1997).

Azevedo, U.; Moral, R.; Gilkes, R. and Moreno, J.(2005). Comparisons of extractants for heavy metals in contaminated soils from sunflower plant. J. of Plant and Soil,11(2):1165-1172.

Baccio, D.;Kopriva, S.;Sebastiani, L. and Rennenberg, H.(2005).Does glutathione metabolism have a role in the defence of poplar against zinc excess. New Phytologist, 167(1): 73-80.

Bai Song, L.; Zhi, B.; BaiYan, B. and BaiBao, Z. (2003). Effect of water cadmium pollution on primary growth of rice seedlings. Journal of Jilin Agricultural University, 25(2): 128-130.

Baiqing, T.; Tang, M. and Qin, P.(2005). Effects of different modifiers on growth and chlorophyll content of *Eulaliopsis binata* growing on soil polluted by Pb / Zn. Gangue.Rural Envi., 21(4):54-57.

Barcelo, J.;Vasquex,M. and Poschenrieder,C. (1988). Structural and ultra structural disorders in Cd treated bean plants. New Phytol., 1 (8):37-39.

Bayctailu, G. and Ozden, H.(2004).Cadmium exposure and changes in some physiological parameters of *Quercus robur ssp robur* L. (Common oak) and *Acer negundo* L.(box elder) seedlings. Fresenius Envi., Bulletin, 413(3):268 273.

Bazzaz, F.A. and Govindjee, R.W. (1974).The effect of heavy metals on plants part 1 inhibitions of gas exchange in sunflower by Pb, Cd, Ni and Ti. Beijing, China. China Environmental Science, Environ.Pollute.,5(7):241–246

Belitz, D.H. and Grosch, W. (1999).Food Chemistry Translation from German. Edition by M.M Burghagen, D. Hadziyev, P.hessèl, S. Jordan and C. Sprinz .Second Edition.

Bipasha, N.; Ozan, L.; Gkova, M. and Raisto, U. (1997).Distribution of Cd, Pb and Zn in plants grown on heavily polluted soils .Czech University of Agriculture, Czech Republic, Rostlinna Vyroba, 43(6): 249-256.

Bowen, H.J.M. (1997).Environmetal Chemistry of the Elements .Academic press, New York, P : 333.

Cakmak, I.;Welch, R.;Erenoglu, B.;Romheld, V.;Norvell, W.and Kochian, L. (2000). Influence of varied zinc supply on retranslocation of cadmium (Cd^{109})and rubidium (Rb^{86}) applied on mature leaf of durum wheat seedlings. Journal of Plant Nutrition, 2 (9): 99-103.

Chaoui, A.;Ghorbal, N. and El Ferjani, E.(1997). Effects of Cd-Zn interaction on hydroponically growth bean *(Phaseolus vulgaris* L.*)*. Plant Sci., 126 (1): 21-28.

Chen, C.; Gong, H.; Wang, K. and Chen, C. (1996).Effect of Cd on quality physiological and biochemical characteristics of mulberry leaves and it mechanism. Chinese Journal of Applied Ecology Bibliographic Citation, 9(80) 595-602.

Choudhary, M.; Bailey, L.D. and Grant,C.A. (1994). Effect of Zn on Cd concentration in the tissue of durum wheat. Can.J.Plant Sci., 6(74):549-552.

Cutler,J.M. and Rains, D.W.(1974). Characterization of Cd uptakeby plant tissue. Plant Physiol., 54(1):67-71.

Dabin, P.;Marafante, E.;Mousny, T. and Myttenaerco, C. (1978).Absorption and binding of Cd and Zn in irrigated rice plants. Plant and Soil, 50(4):32-39.

Dang, Y.P.; Chhabra, R. and Verma, K. (1990).Effect of Cd, Ni, Pb and Zn on growth and chemical composition of onion and fenugreek common. In Soil Sci. Plant Anal., 21 (9 – 10): 717 – 735.

Das, D. K. (2000).Micronutrients: Their Behaviour in Soils and Plants.First edition, Administrative Office, New Delhi, India.

Das, P.; Samantaray,S. and Rout,G.(1997).Studies on cadmium toxicity in plants: a review. Environmental Pollution, 98 (1): 29-36.

Dickinson, K.; Obrin, J.; Voet,L and Edwards, T.(2003).Metalisate zinc in plant nutrition. ALBION, June, 4 (2):1-4.

Dominic, A.; Thomas, R. and Raymond, E.(1983). Cd uptake kinetics in intact soybean plants. Plant Physiol.,73:844-848.

El Baz, E. (2003).Effect of foliar sprays of Zn and B on leaf mineral composition, yield and fruit storability of balady mandarin trees. J. Agri. Sci., Mansoura Univ., 28(9): 6911-6926.

El Enany, A. and Abd Alla, M.(1995).Cd resistance in rhizobium- faba symbiosis. Synthesis of cadmium-binding proteins.Photon-Horn.,35(1):45-53.

El Nabarawy, K.A. (2002). Effect of cadmium (Cd) accumulation on spinach plant. Journal of Plant Physiology, 17(1): 21-34

Foroughi, M.; Venter, F. and Techer, K.(1982). Experimental determination of heavy metals accumulation and distribution in bush bean. Landwirtscha Aftliche Forschung, 38: 239-248.

Fox, T.L. and Guerimot, M.L.(1998). Molecular biology of cation transport in plants . Ann. Rev.Plant Physiol.Plant Mol.Biol., 49: 669-696.

Garg, O.; Hemantaran, J. and Ramesh, C.(1986).Effect of iron and zinc fertilization on senescence in frech bean (*Phaseolus vulgaris*). J of Plant Nutrit., 9 (37):257-266.

Geiken, B.; Masojidek, J.; Rizzuto, M.; Pompili, M. and Giardi, M. (1998). Incorporation of (35s) melethionine in higher plants reveals that stimulation of the D1 reaction centre II protein turnover accompanies tolerance to heavy metal stress.Plant Cell and Environ., 21(12):1265-1273.

Hegazy, M.H. (2001).Some physiological studied on the effects of Cd, Zn and Ni on faba bean and radish plants. Ph.D. Thesis, Plant Physiology .Section, Agr. Bot, Dep., Fac. Agri., Gairo Univ., Egypt.

Hoyden, M.G. (1965). Plants Phosioligical Inorganic Mater Analysis.2th.Edn., Caalifornia.

Hu, H. and Sparks, D. (1991). Zn deficiency inhibits chlorophyll synthesis and gas exchange in Stuart Pecan. Hort.Sci., 26:267-268.

Hunt, R. (1978).Plant growth analysis. The institute of biology's studies in biology no. 96 Edward Arnold. The Camelot Press Ltd, Southampton, Great Britain.

Kabata Pendias, A. and Pendias, H. (1984).Trace elements in soils and plants 2nd Ed. Lewis Publ. Inc, Bocd Florida.

Kater,N.; Garland, T.R. and Wildung, R.E. (1991). Cadmium uptake and affects in intact faba bean plants. J. of Plant and Soil,7(6):11-20.

Khan, D.H. and Frankland, B. (1983).Effects of cadmium and lead on radish plants with particular reference to movement of metal through soil profile and plant Plant and Soil, 70(3).335-345.

Korshunova, Y.; Eide, D.; Clark, W.; Guerinot, M.and Pakrasi, H. (1999) .The IRT1 protein from *Arabidopsis thaliana* is a metal transporter with a broad substrate range. J.of Plant and Soil., 1(3)88-98.

Kucharski, J. (1994).Effect of Zinc on the activity of *Rhizobium leguminosaram* (*biovar. Viciae*) and other groups of soil microorganisms. Acta. Academiae – Agriculturae – ac – Technicae Olstenesis – Agricultura, 58: 69-76.

Lagriffoul, A.;Mocquot B.;MEnch, M. and Vangronsveld, J. (1998). Cadmium toxicity effects on growth and chlorophyll contents and activities of stress related enzymes in young maize plants (*Zea maze* L.).Plant and Soil, 200(2).241-250

Lata,S.A. and Johri, E.N. (1999).Effects of Cadmium on the growth and some physiological components of carrot plant. Assiut University Egypt. Botany Department, J. of Science, 7(9) 67-72.

Leita, L.;De Nobili, M.; Mondini,C. and Baca Garica, M.(1993). Response of Leguminosae to Cd exposure.J. of Plant Nutri., 16(10) :2001 -2012.

Leita, L.;De Nobili, M.;Cesco, S.;Mondini,C. and Nobili,M.(1996). Analysis of intercellular Cd forms in roots and leaves of bush bean. J. of Plant. Nutri., 19(3-4)527-533.

Lindsay, W.L. and Norvell, W.A. (1978).Development of DTPA soil test for zinc,Fe, Mn and Cu. Soil Soc. Am.J., 42:421-428.

Liuszuz, Y. and Rusczkowska, Y.S. (1992).Effects of Cd and Fe and their complex pollution on some physiological indicators in tobacco leaves. Acta Ecologica Sinic., 12(2):147-154.

Madhoolika,A. and Rajesh, K. S. (2006).Single and combined effects of Cd and Zn on carrots:Uptake and Bioaccumulation. Plant Nutri., 29 (10):1791-1804.

Marschner,H.(1995).Mineral Nutrition of Higher Plants .2nd Ed. Academic press Harcourt Brace and Company, publishers London, San Diego, New york.

MEnA. (2002). Gaza Coastal and Marine Environmental Action Plan, LIFE–Project 2002, Ministry of Environmental Affairs, Gaza, Palestine, pp 42-51.

Mengel, K. and Kirkby, E.A. (1987). Principles of Plant Nutrition. 4th ed. Int. Potash Inst., Bern, Switzerland.

Mengel, K. and Kirkiby, E.A. (1978). Principles of Plant Nutrition. International Potash Institute, Berlin, Germany.

Mitchell, G.A.(1981).Interactive effect of Cd, Cu, Ni and Zn on phytotoxicity and metal uptake by lettuce. Ph.D. Dissertation Univ.,of Caalifornia, Riverside CA.

Nagoor,S. and Vyas, V.(1997). Heavy metal induced changes in growth and carbohydrate metabolism in wheat seedlings. Indian J. of Environ. And Toxico., 7(2):98-103.

National Research Council of the United States (1980). Mineral tolerance of domestic animals, pp, 577. Nati. Acad. Sciences, Washington, DC.

Obata, H. and Umebayashi, M. (1997). Effect of Cd on mineral nutrient concentration in plants differing in tolerance for Cd. J. of Plant Nutri., 20 (1):97-105.

Oliver, D.;Wilhelm, N.;McFarlane, J.;Tiller, K. and Cozens, G. (1997). Effect of soil and foliar applications of Zn on Cd concentration in wheat grain. Aust. J. Exp Agric., 3(7):677-681.

Ouariti, O.; Gouia, H. and Ghorbal, M. (1997). Responses of bean and tomato plants to Cd growth, mineral nutrition and nitrate reduction. Plant Physiol. and Bioche. Paris., 35 (5): 347-354.

Pettersson, O.(1976).Heavy metal ion uptake by plants from nutrient solution with metal ion, plant species and growth period variations. Plant and Soil,45: 445-459.

Rai, U.;Tripathi, R.;Vajpayee, P.;Pandey, N.; Ali, M. and Gupta,D. (2003). Cd accumulation and its phytotoxicity in (*Potamogeton pectinatus*, L.) Bulletin of Environmental Contamination and Toxicology, 70(3):566-575.

Rashad, M.H. and Hanafy Ahmed, A.H. (1997).Physiological studies on the effect of iron and zinc supplied on bean plant. J. Agric. Sci., Mansoura Univ., 22(3):729-743.

Rauser, W.E. (1986). Effects of excess cobalt, nickel and zinc on the water relation of *Phaseolus vulgaris*. Environmental and Experimental Botany, 21 (21): 249-255.

Rengel, Z.(1995).Carbonic anhydrase activity in leaves of wheat genotypes differing in Zn efficiency. J. Plant Physiol., 147:251-256.

Ruana, A.;Barcelo,J. and Poschenrieder, C. (1987). Zn toxicity induced variation of elements composition in hydroponically grown bush bean plants. J.of Plant Nutrit.,10 (4):373-384.

Salam, A.S.(1998). Effect of soil and foliar application of nitrogen in combination with Zn on the biomass yield and grain quality of faba bean grown on Lacustrine soil. Alexandria J. of Agricultural Research, 34(1): 129-139.

Salim, R.;Al Subu, M.;Douleh, A.;Chenavier, L. and Hagemeyer, J. (1992). Effects of root and foliar treatments of carrot plants with lead and cadmium on the growth, uptake and the distribution of uptake of metals in treated plants.Journal of Environmental Science and Health Part A. and Engineering, 27 (7): 1619 – 1642.

Sarkunan,V.; Misra,K. and Mohapatra, R. (1996). Effect of some heavy metals on root growth of germinating seeds of (*Vicia faba*, L.). Environmental J. Indian Soc. Soil Sci., 44. 346-348.

Sawidis, T.; Mamasidis,T.; Zachariadsand,G. and Strats, J. (1994).A study of air with heavy metals in thessaloniki city (Greece) using trees as biological indicators. Journal of Environmental, 185 (4): 113 – 122.

Shah, K. and Dubey,R. (1995).Effect of Cd on RNA level as well as activity and molecular forms of ribonuclease in growing rice seedlings. Plant Physiol. And Biochemistry, Paris,33(5):577-584.

Shomar, B. (2006).Inorganic and Organic Environmental Geochemical Issues of the Gaza Strip-Palestine.Ph.D. Enviro Geochemistry., University of Heidelberg, Germany.

Siedlecka, A. and Krupa, Z.(1999).Cd/Fe interaction in higher plants its consequences for the photosynthetic apparatus. Photosynthetica, 36(3):321-33.

Singh, M. (1981). Effect of Zn, P and N on tryptophan concentration in rice grains grown on limed and unlimed soil. Plant and Soil, 62: 305-308.

Skorzynska,E and Baszynski, T. (1995).Some aspects of rummer bean plant response to cadmium at different stages of the primary leaf growth. Acta Societies Botanicorm Poloniae, 64 (2): 165-170.

Smilde, J.;Driel, W. and Luit, B.(1982). Concentration in cropping heavy metal contaminated fluvial sediments .Sci. of the Totall Enviro., 2(5): 215-224.

Snedecor, G.W. and Cochran, W.G.(1980).Statistical methods.Oxford and J.B.H. Publishing com: 7 th edition.

Thomine, S.; Wang, R.; Ward, J. and Crawford, N.(2002).Cadmium and iron transport by members of a plant metal transporter family in *Arabidopsis* with homology to Nramp genes. J. of Plant Physiol., 9(1):33-39.

Tukendorf, A. and Baszynski, T.(1991).The *in vivo* effect of Cd on photochemical activities in chloroplasts of bean plants. Acta-Physiologiae- Plantarum, 13 (1): 51-57.

Van, D.;Smild, K. and Van, L.(1987). Comparisons of heavy metal uptake of *Cyperus esulentus* .and of agronomic plants grown on contaminated Dutch sediments. Misscellaneous paper D-83-1, Institute for Soil Fertility for the US Army Engineer Water Ways Experiment Station, Vicksburg and M.S.

Wagner, G.J. (1993). Accumulation of cadmium in crop plants and its consequences to human health. Journal of Health Sciences,5(1) 444 – 449.

Wilkinson, R.E.(1994).Plant–Environment Interactions Marcel Dekker Inc., New York, Basal, Hong Kong.

Yang, X.;Baligar, V.V.;Martens, D.C. and Clark, R.B. (1996).Plant tolerance to nickel toxicity. II. Nickel effects on influx and transport of mineral nutrients in four plant species. J. Plant Nutr., 1(9): 265 – 279.

تأثير تلوث التربة بالكادميوم والزنك علي نبات الجزر في قطاع غزة – فلسطين

احمد حسين حنفي احمد، جواد عاشور وادي وعماد عيسي الشيخ علي
فرع فسيولوجيا النبات- قسم النبات الزراعي- كلية الزراعة – جامعة القاهرة – مصر

أجريت تجربة مسح حقلي في مناطق شمال قطاع غزة – فلسطين لتقييم محتوي التربة من بعض العناصر الثقيلة وكذلك تقييم محتوي هذه العناصر في بعض النباتات (بطاطس ،قمح ،فراوله ،فول ،بصل ،سبانخ ،جزر،خيار وكوسا) والمزروعة عشوائيا في تلك المناطق . وقد أوضحت الدراسة أن تركيز العناصر محل الدراسة (كادميوم ،رصاص ,زنك وحديد) في التربة والنباتات في الحدود المسموح بها عالميا باستثناء عنصر الرصاص, كان مرتفعاً. وسجلت أعلي تركيزات لهذا العنصر في منطقة المنطار ووسط مدينة غزة, حيث فاق الحدود المسموح به عالمياً.

كذلك أجريت تجربة أصص في موسمين متتاليين 2006 و 2007 لدراسة تأثير تلوث التربة بالكادميوم بأربع تركيزات (0, 10, 20, 40 جزء في المليون) والزنك باربع تركيزات (0, 75, 150, 225 جزء في المليون) علي صفات النمو المختلفة لمحصول الجزر *Daucus carrota*, L. من نوع Nantesa superior ومكوناته (طول الجذر, طول الأوراق, وكذلك الوزن الجاف والرطب للأوراق والجذر) والصبغات النباتية (كلوروفيل أ, ب والكاروتنويدات) وعناصر (الكادميوم ,الزنك والحديد) وكذلك لدراسة تقليل الإضرار الناتجة عن الكادميوم عن طريق إضافة الزنك بمستوياته المختلفة. أدت إضافة الكادميوم في مستوياته الثلاث إلي تقليل معظم صفات النمو المدروسة وكذلك تقليل تركيز كلوروفيل أ و العناصر وكذلك أدت إضافة الزنك مع الكادميوم إلي تقليل سمية الكادميوم لمعظم صفات النمو المدروسة ولم يكن للزنك تأثير عند استخدامه منفرداً علي معظم صفات النمو والصبغات النباتية باستثناء كلوروفيل أ وتركيز النبات من العناصر حيث ارتفع تركيزها بأستثناء إنخفاض تراكم عنصر الكادميوم مع بعض الاستثناءات وكذلك كانت هناك بعض التأثيرات الإيجابية والتغيرات لتركيز النبات من الصبغات النباتية و العناصر.