J. Agric. Sci. Mansoura Univ., 28(5): 3571 - 3602, 2003

CONTROL THE PHYSIOLOGICAL STRESS RESULTED FROM Cd AND Pb FOLIAGE APPLICATION ON SUGAR BEET PLANT BY USING FOLIAR SPRAY WITH CERTAIN GROWTH REGULATORS.

Abd El-Hamid, M.F.*; Amera A.A. El Nabarawy*; A. A. Gaber and Amal M. Kamil****

* Fac. of Agric., Moshtohor, Zagazig Univ., Agric. Botanty Dept., Qalubeia, Egypt.

** Agric. Res. Cen., Sugar Crops Inst., Giza, Egypt.

ABSTRACT

Cd and Pb are an air serious wide global pollution problem, leading to great losses in agricultural yield and hazardous man's health through the contaminated food. Their foliage absorption and direct shoot uptake represent potential mode of entry to plant tissues, beside their entry through roots. However, very little is known about their toxicity uptake by leaves, comparing to those known by roots. Accordingly, this study is dealing with their probable toxicity under foliage uptake in relation to foliar spray with certain varieties of growth regulators (GA_3, NAA or B_9), using sugar beet plant grown under field conditions during successive seasons extended from 1999 to 2001. The interaction treatments of Cd or Pb (HM) × growth regulators (GR) during the first season trail were 20 or 50 mg/l from each beside control × 50 mg/l from everyone of GA_3, NAA and B_9 beside control. While during the second season trial the levels used of Cd or Pb were 50 or 100 mg/l from everyone × 50 or 100 mg/l from each of GA_3 or B_9 only, beside control of HM or GR. Every factor, HM or GR, treatments were applied as foliar spray to sugar beet leaves separately with 24 h interval using GR treatments at first, followed by HM treatments. The treated plants received the above mentioned rates from each factor twice with the same serial successive application of GR at first followed by HM treatments. The first application ones were after 69-70 days after sowing, followed by the second one after 21 days. The following results may be summarized as follows: (1) Both Cd or Pb could be absorbed through leaf surfaces of sugar beet plant with variable degree according to the used concentration and the used metal species and seemed to be translocated into roots. (2) Both used species of HM, exerted their obvious toxicity in sugar beet plant in the form of retardation effects on most plant growth parameters, with more pronounced decline in whole plant leaf area, with the association of decrements in the concentrations of photosynthetic pigments, sharp decline in SLA and troublness in leaf water balance, beside their minimizing actions in the concentrations of sugars fractions in root and the total uptake of N, P, K and Na. These findings lead to suggest that, the main sited of phytotoxification action of Cd or Pb seemed to be on leaf organ properties and its physiological functional processes, and it is the most sensitive organ in sugar beet plant to the adverse effects of Cd and Pb. These adverse effects on leaf must be reflected their actions on the other parameters. These adverse effects were mostly increased with increasing the dose of the used HM and the concentration of them in plant tissue organ. It was found that Cd seemed to have mostly more toxification actions on sugar beet plant than Pb. (3) It was found that GR especially GA_3 and some time B_9 could be used with some extend to regulate the desfunctional effects of Cd or Pb in sugar beet plants, and that seemed to be through their detoxification actions on most properties of the functional sensitive organ (leaves), and also to their minimizing effects on the accumulation of Cd or Pb in different plant tissues. (4) The interaction effects of Cd or Pb in relations to GA_3 or B_9 treatments, seemed to be connected with the rate of both tested factors which judged by many factors, such as the used HM species, the tested variety of G.R, the used rates of both factors, the proportion degree of their uptake and translocation within plant organs, the sensitivity degree of the tested process, the plant age and the prevailing environmental conditions during both experimental trails. (5) It may be concluded that, it is difficult to determine the primary toxic and antitoxic actions of GR× HM, as many series of progressive subsidiary reactions may be interfere through most studies characters. Thus, it is difficult to distinguish between the primary and the subsidiary action. (6) It may be recommended to use GA_3 at the rate of 100 mg/l to alleviate the toxic effects and may be the foliar uptake of either Cd or Pb by sugar beet plant. In addition, the factor(s) affecting the uptake of Cd or Pb by leaves of sugar beet plant are still unclear, and additional work must be carried out if the question is to be fully answered.

INTRODUCTION

Environmental agro-eco-system contamination with non-essential-soft-heavy metals, such as cadmium (Cd) and lead (Pb), has become a worldwide problem, leading to great losses in agricultural yield and hazardous man's health, as they enter human food chain (Nellessen and Fletcher, 1993; Guo *et al.*, 1995; Salt *et al.*, 1995; Schickler and Caspi, 1999; Lindim *et al.*, 2001and Michalska and Asp, 2001). The serious global Cd and Pb pollution trends will continue to increase under agro-eco-system as long as both heavy metals release to environments (air, water, soil and all of biota), as most of anthropogenic activities increments involve in this pollution problem (Wong *et al.*, 2000 and Prochnow *et al.*, 2001). Cd and Pb are air pollutants, which are the source of about 29% of yearly addition of everyone of them to plantations, waters and soils (Greger *et al.*, 1993). They are effectively absorbed by plants through their root and leaf tissues (Schickler and Caspi, 1999), as foliar absorption and direct stem uptake also represent potential modes of entry (Greger *et al.*, 1993). Under some conditions plant shoot seem to be good absorbers of Cd and Pb than root (Erjala and Ervio, 1994), as many internal and/or external factors involve in this process (Greger *et al.*, 1993). Compared to knowledge of heavy metals uptake by roots, very little is known about Cd or Pb uptake by leaves.

There are complete agreements between most of workers that Cd and Pb, induce great variations of adverse physiological effects when taken up by plants, leading to check up plant growth and the loss of economical yield are finally obtained (Salim *et al.*, 1993 and 1995; Erjala and Ervio, 1994; Singh *et al.*, 1994; Kupper *et al.*, 1998 and Sorial and Abd El-Fattah, 2001). On the other hand, it has been long established between most of workers that different families of growth regulators at certain rates bring vast varieties of physiological useful modifications of exposed plants. Accordingly, the possible uses of certain variety of growth regulators could be used to control the adverse effect of specific stress conditions (Abd El-Hamid *et al.*, 1992 a and b), like phytotoxification of heavy metals (Fouda and Arafa, 2002). However, very little is known about the use of growth regulators as a phyto-detoxification agent to control the stress effects of Cd and Pb.

Most of the previous studies on the response of different plant species to Cd and Pb were carried out under hydroponic culture control conditions and very rare information in this respect were available under natural field conditions. This study is a trail to control the phytotoxification effects of Cd and Pb foliage uptake by using certain varieties of growth regulators, i.e. GA_3, NAA and B_9 in sugar beet plant grown under field conditions.

MATERIALS AND METHODS

Two field trails were carried out on sugar beet plant at Sakha Agricultural Research Station, Kafer El-Sheikh governorate during the successive seasons, 1999-2000 and 2000-2001, with trying to control phytotoxification of Cd or Pb foliage uptake using some growth regulators. Before sowing and during the two trails, samples from the top-soil-surfaces (> 0-30 cm), and the used irrigation water were collected for analysis according to the standard procedure of Soil and Water Research Institute, A.R.C., Egypt, as follows:

The soil mechanical analysis was determined after Jackson (1973). In soil and water samples, pH values, E.C., carbonate, bicarbonate, sulphate, chloride and available N, were determined after Jackson (1973) methods. Available K and P were estimated using the methods of Black (1965) and Olsen *et al.* (1954), respectively. Available Ca, Mg, Na, Fe, Cu, Zn, Mn, Cd and Pb were determined using Atomic-Absorption Spectrophotometer as described by Lindsay and Norvell (1978).

It was found very limiting variation between the analytical properties of either soil or irrigation water samples during the two cultivation seasonal trails, hence, the mean values of such properties were as follows:

1- Soil properties: soil texture was clay loam, containing 39.1, 21.7 and 39.2 percentages of sand, silt and clay, respectively. The pH value (2.5:1), E.C. (mmhos/cm), T.S.S. (ppm) and $CaCO_3$ were 8, 0.4, 252.8 and 4.1, respectively. Anions (meq/l) such as HCO_3^-, Cl^-, SO_4^{2-} were 0.8, 1.0 and 2.8, respectively. Cations (meq/l) as: Ca^{2+}, Mg^{2+}, Na^+ and K^+ were 1.4, 0.7, 2.4 and 0.3, respectively. Available elements (ppm) of N, P, K, Fe, Cu, Zn, Mn and Pb were 10.0, 7.3, 298, 10.0, 3.9, 0.28, 3.6 and 2.8, respectively, while available Cd was not detected in the outer 30 cm of top soil surfaces.
2- Irrigation water analyses were as follows, as the mean values of both seasonal trials: pH, 7.8; E.C. (mmhos/cm), 0.38; T.S.S. (ppm), 243.2. The anions and cations (meq/l) were as follows: HCO_3^-, 1.6; Cl^-, 1.3; SO_4^{2-}, 3.1; Ca^{2+}, 0.23; Mg^{2+}, 3.7; Na^+, 1.59; K^+, 0.36; Pb^{2+}, 1.0 and Cd was not detected.

Methods of planting seeds:

The experimental plot contained 6 ridges, 50 cm apart and 5 m length, with an area of 15 m^2 (1/280 feddan). Sugar beet seeds, "Negma" variety (multigerm) were sown on one side of the ridge, with 20 cm apart between the hills, at 27th and 30th of October (1999-2000) of the first and second experimental trails, respectively. Thinning was carried out four weeks after sowing leaving one seedling in every hill. Different fertilizers of N, P and K were applied as soil dressing at the recommended rates per feddan as follows: (1) 15.5 kg P_2O_5 (as uperphosphate, applied before seed sowing), (2) 24 kg K_2O as potassium sulphate applied after seedling thinning and (3) 70 kg N as urea divided into two equal doses, the first dose applied after seedling thinning followed by the second one after three weeks.

Other agricultural practices were followed in the normal ways as recommended methods prevailing in the regions.

Harvesting took place at May 25th and 28th of the first and second experimental trials, respectively (210 days after sowing).

Experimental trails planning:

During the course of this study two combined factors were tested, i.e. heavy metals (HM) rates, Cd and Pb × growth regulators (GR) treatments, GA_3, B_9 or NAA. Cadmium used form was $CdCl_2.H_2O$, while lead salt was $Pb(NO_3)_2$. The tested growth regulators were: Gibberellic acid (GA_3), N-dimethyl amino succenamic acid (B_9) and Naphthalene acetic acid (NAA). The treatments of every tested factors (HM and GR) were applied to the foliage of sugar beet plants separately, as will be described latter. It is worthy to mention that, either HM levels or GR rates were used as mg/l. The treatments of the experimental trails were as follows:

1. The first season experiment trials (1999-2000) comprised 20 combined treatments (5 HM treatments x 4 GR treatments, i.e. 20 or 50 (mg/l) Pb, beside control (0.0) x 50 mg/l from either GA_3, NAA or B_9 in addition to control (0.0).
2. The second season experimental trials (2000-2001) comprised 25 combined treatments, i.e the rates of HM were 50 and 100 mg/l from each of either Cd or Pb, beside control (0.0) x GA_3 or B_9 every one applied at the rates of 50 or 100 mg/l, in addition to control (0.0), with NAA exclusion.

During the two experimental trials, every treatments was applied twice to the foliage of sugar beet plant with 21 days interval, and each of the chosen GR factor treatment was applied firstly, followed by HM treatment with 24 h interval. The first application was carried out after 69 and 70 days from sowing for GR and HM treatments respectively, while the second application was 90 and 91 days after sowing for GR and HM treatments respectively. Aqueous solution containing 0.1 % "Egiral" as wetting agent was used for every treatment. The control plants without any treatment and those received one factor treatment, sprayed with water containing 0.1 % wetting agent. During the two successive seasonal trials, a randomized complete block design with four replicates was used.

Sampling procedure

During both of the seasonal experimental trials, two samples were collected from each replicate (3 plants), after 120 and 210 days from sowing date respectively. The sampling plants were quickly washed under current tap water, followed by washing successively three times in distilled water, then translocated immediately into laboratory after covering with moisted cheese cloth to avoid any moisture losses from plant tissues. Plant sample was separately into root and shoot systems (leaves), fresh and dry weights were determined.

Growth criteria (per plant)

Root length (cm), root diameter (cm), root and shoot fresh and dry weight (g), and whole plant leaf area (cm^2) were recorded. Data were subjected to analysis of variance as described by Snedecor and Cochran (1980). Growth analyses were calculated using the formula of Causton and Venus (1981) as follows:

- Leaf area ratio (LAR) = LA/PDW (L_A/W).
- Leaf weight ratio (LWR) = LDW/PDW (L_W/W).
- Specific leaf area (SLA) = LA/LDW. (L_A/L_W).

The succulence index in root tissues was estimated after Greger *et al.* (1991) working on sugar beet plant as follows: R.DW./R.F.W. x 100, while the succulence grade in leaves was measured after Abd El-Hamid *et al.* (1992a & b) as mg water/cm^2 of leaf tissues.

Chemical analysis

Photosynthetic pigments were determined in leaves fresh samples using Wattestein (1957) method. Sugars fractions were determined in roots after A.O.A.C. (1985). Nitrogen was estimated using micro-Kjeldahl method (A.O.A.C., 1985). Colormterical method was used after Chapman and Pratt (1961) for P determination. K and Na were estimated by using flame photometer after Brown and Lilliand (1964). Cd and Pb were determined using inductively coupled plasma emission spectrometer (Perken Elmer,400), according to Allen *et al.* (1997) method.

RESULTS AND DISCUSSION

It was thought advisable to discuss the obtained data of both experimental trials of the first and second seasons as one unit, as the second trial treatments may be considered as an extension of the first one, with some analogous treatments.

Growth criteria *(per plant organ)*

Growth criteria in terms of root length, its diameter (cm); whole plant leaf area (cm^2); root and leaf (shoot) fresh and dry weights (g) are tabulated in Tables from 1 to 4.

On statistical analysis basis the following conclusions may be obtained:

1- Both tested factors, HM and GR, were ever affected significantly plant growth criteria under the conditions of both experimental trials, during different periods of growth, as well as most of their interactions get the same significancy.

2- Treatments with HM factor, irrespective to GR ones retard most plant growth criteria and the *vice versa* was obtained under treatments with GR factor irrespective to HM one, which mostly exhibited stimulatory effects in this respect.

This conclusion seemed to be more obvious when sugar beet leaves received only one factor treatments and in the absence of the other one. Accordingly, it was found that GR treatments alleviated, with variable degrees, the harmful effects of HM treatments on plant growth measurements of different criteria, during different periods of growth, under the conditions of both seasonally trials.

Table (1): Changes in root length (cm) and root diameter (cm) of sugar beet plant during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season	1999-2000											
Growth character	Root length						Root diameter					
Heavy metal HM	Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
(mg/l)	0	20	50	20	50		0	20	50	20	50	
Growth regulator (G.R) (mg/l)	120 days after sowing						120 days after sowing					
Control	32 5	31 8	30 5	31 1	30 0	**31.2**	15 5	15 1	14 1	14 6	14.0	**14.7**
GA$_3$ 50	32 7	34 0	30.8	31 8	31 2	**32.1**	16 0	15.0	14 1	16 0	15 3	**15.3**
NAA 50	32 7	32 2	31 3	31 6	30 0	**31.6**	16.0	15 3	14.1	14 0	13 8	**14.6**
B$_9$ 50	32 5	33.3	33.0	31 5	30 0	**32.1**	16.8	16.8	15 9	15.0	14 6	**15.8**
Mean (HM)	**32.6**	**32.8**	**31.2**	**31.5**	**30.3**	**31.7**	**16.1**	**15.6**	**14.6**	**14.9**	**14.4**	**15.1**
L.S.D. at 5%	HM = 0 7	G R = 0 6		HM × G R = N.S.			HM = 0 4	G R = 0 4		HM × G R = 0 9		
	210 days after sowing						210 days after sowing					
Control	36.0	34.8	32 6	36.1	34 0	**34.7**	20 5	19 6	18.7	19 6	18 9	**19.5**
GA$_3$ 50	39 6	39 9	38 7	37 5	36.3	**38.4**	21 4	21 9	20 8	21 0	20 7	**21.2**
NAA 50	35 5	32 8	31 5	36 7	36 0	**34.5**	20.3	19.3	18 9	19 0	18 7	**19.2**
B$_9$ 50	35.5	36 3	32.4	32 8	31 7	**33.5**	21 0	20 2	19 9	20 1	20 0	**20.2**
Mean (HM)	**36.7**	**36.0**	**33.8**	**35.8**	**34.5**	**35.3**	**20.8**	**20.3**	**19.8**	**19.9**	**19.6**	**20.0**
L.S.D. at 5%	HM = 0 8	G.R = 0 7		HM × G.R = 1.7			HM = 0 4	G R = 0 3		HM × G R = N S		
	2000-2001											
	0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
	120 days after sowing						120 days after sowing					
Control	28.8	22 5	20.5	22 6	20 1	**22.9**	14 6	14.0	12 9	13 9	13 6	**13.8**
GA$_3$ 50	30.0	27 0	25 0	24 6	22 0	**25.7**	15.2	14 1	13 7	15 0	13 9	**14.4**
100	33 0	29 0	27 0	28.0	22 0	**27.8**	17 1	15.2	15 0	15.5	14 1	**15.4**
B$_9$ 50	29 1	23.0	21 0	22 0	23.0	**23.6**	15 4	13 9	14 1	15 3	15 0	**14.7**
100	28 1	25 0	23.0	27 0	25 0	**25.6**	16.1	15.8	15 5	16 1	15.8	**15.9**
Mean (HM)	**29.8**	**25.3**	**23.3**	**24.8**	**22.4**	**25.1**	**15.7**	**14.6**	**14.2**	**15.2**	**14.5**	**14.8**
L.S.D. at 5%	HM = 0.9	G.R = 0 9		HM × G R = 2 0			HM = 0 3	G.R = 0 3		HM × G R = 0 8		
	210 days after sowing						210 days after sowing					
Control	34 4	32 3	29.5	31 0	26.3	**30.7**	20 3	18 8	18.0	19 7	18.6	**19.1**
GA$_3$ 50	35.2	33.3	32 0	32 3	25 3	**31.6**	21 3	20 6	20 3	19 3	21 3	**20.6**
100	38.0	35 0	33.6	34.0	28.0	**33.7**	22 6	22 0	20 3	21 6	23 3	**22.0**
B$_9$ 50	34 0	35.3	30 3	31.0	31 0	**32.3**	22 3	20.2	20 6	21 3	20 0	**20.9**
100	37 6	37 0	32 0	33.3	33.3	**34.6**	23 5	22 0	22.6	23.0	21 4	**22.5**
Mean (HM)	**35.8**	**34.6**	**31.5**	**32.3**	**28.8**	**32.6**	**22.0**	**20.7**	**20.4**	**20.9**	**20.9**	**21.0**
L.S.D. at 5%	HM = 1 4	G R = 1 4		HM × G.R = 3.3			HM = 0.4	G R = 0.4		HM × G R = 0 8		

Table (2): Changes in whole plant leaf area (cm^2) of sugar beet plant, during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G R levels.

Season	1999-2000											
Heavy metal	Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
(HM) (mg/l)	0	20	50	20	50		0	20	50	20	50	
Growth regulator (G.R) (mg/l)	120 days after sowing						210 days after sowing					
Control	7205 0	6246 0	5096 0	7214 0	6514.0	**6455.0**	9230 0	8596 0	7542 0	9837 0	9157 0	**8872.4**
GA$_3$ 50	9423 0	8436 0	7776.0	9320 0	8702 0	**8731.4**	11661.0	10458.0	10532 0	11295.0	10956 0	**10981.0**
NAA 50	6957 0	6336.0	5430 0	6630 0	6351 0	**6340.8**	10683 0	9072.0	8480 0	11250 0	10542 0	**10005.4**
B$_9$ 50	8433 0	6798 0	6138.0	8853 0	8550 0	**7754.4**	10938 0	10320 0	9828 0	10332 0	10000 0	**10283.0**
Mean (HM)	**8004.5**	**6954.0**	**6110.0**	**6754.3**	**7529.3**	**7320.4**	**10128.0**	**9611.5**	**9696.3**	**10678.5**	**10163.8**	**10035.5**
L.S.D. at 5%	HM= 13 6	G R = 12 2		HM × G R = 27 3			HM= 10 5	G R = 9 4		HM × G R = 21 1		
	2000-2001											
	0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
Control	7394	5546	5054	6385	5451	**6006.0**	9543	8706	7335	9861	8611	**8811.2**
GA$_3$ 50	9173	6000	5713	7425	5713	**6804.8**	10475	9320	8208	9600	9870	**9494.6**
100	9966	6784	5970	8676	5940	**7467.2**	10960	10290	8778	11000	10164	**10238.4**
B$_9$ 50	8623	6567	6150	8160	6633	**7226.6**	10869	9890	7980	9080	9061	**9376.0**
100	9322	7260	6752	8480	7585	**7879.8**	11908	10848	8284	10626	9600	**10253.6**
Mean (HM)	**8935.6**	**6431 4**	**5927.8**	**7825.2**	**6264.4**	**7076.9**	**10751.0**	**9810.8**	**8117.0**	**10033.4**	**9461.2**	**9634.7**
L.S.D. at 5%	HM= 83 6	G R = 83.6		HM × G R = 186 9			HM= 19 4	G R = 19 4		HM × G R = 43 3		

Table (3): Changes in leaves and roots fresh weights (g/plant) of sugar beet plant during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season		1999-2000											
Growth character		Leaves fresh weight/plant						Root fresh weight/plant					
Heavy metal (HM) (mg/l)		Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
		0	20	50	20	50		0	20	50	20	50	
Growth regulator (G.R) (mg/l)		120 days after sowing						120 days after sowing					
Control		597.0	591.0	568 0	594 0	580.0	**586.0**	756 2	744.0	731.1	736.4	728.8	**739.3**
GA_3 50		616.0	600 0	585 0	618.0	608.0	**605.4**	791.3	798.8	784.6	772.1	765.5	**782.5**
NAA 50		608.0	590.0	578 0	603.0	595.0	**594.8**	751.7	743.9	719.0	738.2	730.0	**736.6**
B_9 50		618.0	618.0	597.0	619.0	603.0	**611.0**	744.0	774.6	762.3	754.1	745.0	**756.0**
Mean (HM)		**609.8**	**599.8**	**582.0**	**608.5**	**596.5**	**599.3**	**760.8**	**765.3**	**749.3**	**750.2**	**742.3**	**753.6**
L.S.D. at 5%		HM = 6.3 G.R = 5.7 HM × G.R = N.S.						HM = 2.5 G.R = 2.2 HM × G.R = 5 0					
		210 days after sowing						**210 days after sowing**					
Control		*999 0*	*995 0*	*960.0*	*998.0*	*977.0*	**985.8**	*1092.1*	*1077.1*	1054.5	1080 1	1065 9	**1073.9**
GA_3 50		1083.0	1053.0	1038.0	1075.0	1071.0	**1064.0**	1184.2	1160 0	1149.9	1182.5	1178.9	**1171.1**
NAA 50		1048.0	1011.0	985.0	1035.0	1030.0	**1021.8**	1102.2	1100.3	1094.1	1067.8	1056 2	**1084.1**
B_9 50		1083.0	1079 0	1055 0	1063.0	1058.0	**1067.6**	1125 1	1133.3	1126.7	1084.0	1071.8	**1108.2**
Mean (HM)		**1053.2**	**1034.5**	**1009.5**	**1042.7**	**1034.0**	**1034.8**	**1125.9**	**1117.7**	**1106.3**	**1103.6**	**1093.2**	**1109.3**
L.S.D. at 5%		HM = 6 4 G.R = 5 8 HM × G.R = 12.9						HM =5 2 G R = 4.7 HM × G.R = 10 5					
		2000-2001											
		0	**50**	**100**	**50**	**100**	**Mean (G.R)**	**0**	**50**	**100**	**50**	**100**	**Mean (G.R)**
		120 days after sowing						**120 days after sowing**					
Control		620	571	525	620	624	**592**	780.3	756.9	684.4	763.1	727.6	**742.5**
GA_3	50	644	591	551	631	618	**607**	828.1	785.5	710.3	808.0	772.0	**780.6**
	100	656	602	568	641	640	**621**	844.7	798.3	724.0	834 0	813.0	**802.8**
B_9	50	635	579	535	650	668	**613**	790 0	745.0	708.0	766.1	745.0	**750.8**
	100	641	590	557	667	670	**625**	806.0	759.0	715.0	781.3	756.0	**763.5**
Mean (HM)		**640**	**587**	**547**	**642**	**644**	**612**	**809.8**	**768.9**	**708.3**	**790.5**	**762.7**	**768.1**
L.S.D. at 5%		HM = 6.5 G.R = 6.5 HM × G.R = 14.6						HM =6.6 G.R = 6.6 HM × G.R = 14 8					
		210 days after sowing						**210 days after sowing**					
Control		1024	967	879	1006	989	**973**	*1183.7*	*1146.5*	*1114.5*	*1166.0*	*1138.5*	**1149.8**
GA_3	50	1048	972	887	1031	1029	**993**	1213.8	1185.0	1154.0	1198.0	1180.0	**1186.2**
	100	1086	986	881	1062	1043	**1011**	1260.3	1230.0	1202.0	1231 0	1195 0	**1223.7**
B_9	50	1041	990	963	1020	1001	**1003**	1195.1	1145.0	1127.0	1188.0	1163.2	**1163.7**
	100	1064	1027	977	1045	1033	**1029**	1213.1	1181.0	1139.0	1266.0	1180 0	**1195.8**
Mean (HM)		**1053**	**989**	**917**	**1033**	**1019**	**1002**	**1213.2**	**1177.5**	**1147.3**	**1209.8**	**1171.3**	**1183.8**
L.S.D. at 5%		HM = 17.7 G.R = 17.7 HM × G.R = 39.7						HM = 10.0 G.R = 10 0 HM × G.R =22.5					

3- The retardation effects of HM on plant growth, increased mostly with increasing their rate of foliar application. In this respect, it was worthy to mention here that, Lanaras *et al.* (1993), concluded that Cd or Pb are strongly phytotoxic. Pollution by these metals causes growth inhibition, they become extremely toxic to cells and can ultimately cause the death of plants (Steffens, 1990 and Verkleij and Schat, 1990). The term "toxic concentration" is used in the literature for a heavy metal concentration that significantly inhibits metabolic activity and retard partially plant growth without inducing plant death (Lanaras *et al.*, 1993). Intact plants which are exposed to this concentration stay alive, but with, decrease growth and slower development (Clijsters and Van Assche, 1985).

Table (4): Changes in leaves and root dry weights (g/plant) of sugar beet plant during different periods of growth, as affected by combined f oliar s prays o f different HM rates with variable GR levels.

Season	1999-2000											
Growth character	Leaves dry weight/plant						Root dry weight/plant					
Heavy metal (HM) (mg/l) / Growth regulator (G.R) (mg/l)	Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
	0	20	50	20	50		0	20	50	20	50	
	120 days after sowing						120 days after sowing					
Control	83.7	78.3	74.3	79.8	75.1	78.2	145.2	140.1	137.4	137.9	131.9	138.5
GA_3 50	91.8	83.9	82.4	86.5	77.3	84.4	161.1	160.5	155.9	151.0	149.9	155.1
NAA 50	83.3	80.2	74.1	80.2	77.3	79.0	146.9	148.7	130.0	129.4	119.8	135.0
B_9 50	90.8	82.8	80.3	85.4	83.0	84.5	157.4	158.3	151.7	145.0	140.1	150.5
Mean (HM)	87.4	81.3	77.7	82.8	78.2	81.5	152.7	151.9	143.8	140.8	134.7	144.8
L.S.D. at 5%	HM = 0.9 GR= 0.8 HM × GR= 1.9						HM = 0.5 GR= 0.4 HM × GR= 1.0					
	210 days after sowing						210 days after sowing					
Control	193.9	175.4	165.6	185.6	170.9	178.3	236.3	230.2	218.6	227.3	227.7	228.0
GA_3 50	226.7	203.9	171.4	207.4	201.5	202.2	278.9	246.8	239.5	264.5	253.5	256.6
NAA 50	209.6	185.0	172.3	198.7	187.6	190.6	245.1	231.7	208.8	245.2	230.0	232.2
B_9 50	219.5	207.4	195.3	210.4	209.4	208.4	260.7	242.6	236.3	250.5	244.9	247.0
Mean (HM)	212.4	192.9	176.2	200.5	192.4	194.9	255.3	237.8	225.8	246.9	239.0	240.9
L.S.D. at 5%	HM = 2.0 GR= 1.8 HM × GR= 4.0						HM = 1.4 GR= 1.2 HM × GR= 2.8					
	2000-2001											
	0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
	120 days after sowing						120 days after sowing					
Control	87.8	74.5	65.7	83.0	79.9	78.2	155.4	151.1	134.9	142.0	134.0	143.5
GA_3 50	94.4	81.6	70.5	88.3	81.6	83.3	169.6	157.1	143.5	155.1	146.7	154.4
GA_3 100	101.0	85.5	77.2	89.7	88.3	88.4	180.1	170.0	152.0	171.8	162.6	167.3
B_9 50	90.8	77.0	69.6	89.7	90.8	83.6	161.6	155.7	140.2	151.7	149.0	151.6
B_9 100	93.9	82.0	72.4	100.1	97.1	89.1	175.1	160.9	150.2	157.8	152.0	159.2
Mean (HM)	93.6	80.1	71.9	90.2	87.5	84.5	168.4	159.0	144.2	155.7	148.9	155.2
L.S.D. at 5%	HM = 1.7 GR=1.7 HM × GR= 4.0						HM = 1.6 GR= 1.6 HM × GR= 3.6					
	210 days after sowing						210 days after sowing					
Control	200.5	177.1	161.1	188.6	179.4	181.3	266.0	248.2	228.0	251.8	228.0	244.4
GA_3 50	216.4	183.7	157.8	198.9	182.9	187.9	283.1	269.0	253.9	281.5	254.9	268.5
GA_3 100	240.7	189.3	172.6	213.4	188.5	200.9	304.8	295.2	264.4	295.4	276.0	287.1
B_9 50	216.0	196.0	182.9	201.9	198.1	199.0	280.7	258.8	251.3	272.1	240.5	260.6
B_9 100	237.3	208.4	188.5	210.0	216.9	212.2	298.9	271.6	256.3	302.6	269.0	279.7
Mean (HM)	222.2	190.9	172.6	202.6	193.2	196.3	288.7	268.6	250.8	280.7	253.7	268.1
L.S.D. at 5%	HM = 3.6 GR= 3.6 HM × GR= 8.1						HM = 2.4 GR= 2.4 HM × GR= 5.3					

The most obvious effects of both tested contrary factors, HM and GR, on sugar beet plant growth habit seemed to be on photosynthetic organ. whole plant leaf area, and this reflected its effects on dry matter accumulation in different plant organs during various periods of growth under the variable conditions of the two seasons trials. The harmful effects of Cd or Pb on most different growth criteria increased with increasing their rates.

As a general, and irrespective to GR treatments Cd seemed to have mostly more retarding effects on leaf parameters, whole plant leaf area, its fresh and dry weights, comparing to those resulted from corresponding ones of Pb treatments during different periods of growth and under the conditions of the two seasons trials, either each applied as lone or with most different GR treatments combinations. This may be indicated that leaves of sugar beet plants seemed to be more sensitive to Cd foliar application than relatively Pb ones in this respect.

There are complete agreement between most workers that Cd retard plant growth criteria among them Popovic *et al.* (1996), Obata and Umebayashi (1997), Tlustos *et al.*(1998), Schiekler and Caspi (1999), Ghayad (2001), Hegazy (2001), Michalska and Asp (2001), El Nabarawy (2002) and Fouda and Arafa (2002), working on many plant species including sugar beet plant. The same retarding effect on plant growth was also reported on Pb by most workers, among them, Erjala and Ervio (1994), Moftah *et al.* (1992) and Sorial and AbdEl-Fattah (2001).

The growth retardation effects of Cd may be related to its toxification resulted from great varieties of its injurious effects on many various plant processes which include, photosynthesis process retardation (Krupa *et al.*, 1993), cell division and cell enlargement depression (Greger *et al.*, 1991), troublness in plant water relations (Greger and Johansson, 1992), inhibition of chlorophyll synthesis (Greger and Ogren, 1991). El-Nabarawy (2002) came to the same conclusions on spinach plant, as she also concluded that the final physiological phytotoxicity expressions of Cd were exhibited on the growth retardation after many internal control processes including the uptake, translocation, accumulation, distribution in plant tissue organs and assimilation of many essential nutrient elements.

The same conclusions were also gained by Sorial and Abd El-Fattah (2001) using Cd and Pb on pea plant, as they added also that Cd and Pb affected negatively meristematic activity and consequently, retardation of vertical expansion and longitudinal growth and may be cell damage was occurred.

It is well established and known, from a long time, that many varieties of growth regulators bring vast varieties of possible physiological modifications of exposed plants leading to enable plants to tolerate the stress conditions (Abd El-Hamid *et al.*, 1992 a and b). Hence, it could be found under the conditions of this study that the tested growth regulators seemed to have partial detoxification action of Cd or Pb on different plant growth criteria. The most pronounced detoxification actions of GR were gained sometime by foliar applications of GA_3 and/or sometimes by B_9. Sometime GA_3 was more conspicuous in some parameters, while B_9 was more effective than GA_3 in the other ones. These variable detoxification action degree seemed to be alteration according to many factors, which may be included: plant organs, the used rates of GR and HM, the tested growth characters, sampling date, the prevailing environmental conditions (both season trails), the variable toxification action of the tested HM. These variable degrees of toxification actions of HM and the control by GR seemed to be related to the variable mechanism of action with both HM tested elements or between the two varieties of GR. NAA seemed to have mostly the least effect, in this respect.

Growth analysis

Growth analysis in terms of LAR, LWR and SLA are tabulated in Table (5). Before discussing these data, it must be mentioned the following facts:
(1) LWR is considered as leaf dry matter distribution within plant organs, as it is the ratio of LDW/PDW, and it is must be less than one, as leaf weight is a part of whole plant D.W. (2) Specific leaf area (SLA) may be considered as leaf density or leaf expansion index or ratio, as used by Greger *et al.* (1993). (3) There are complete correlation between the different three proportional

ratios, as LAR = LWR × SLA. From these three dimensional proportional ratios it may be detected the following conclusions:

1- Both tested factors, HM and GR regulate the three proportional ratios. In the other words, HM toxification actions, may be extended to include LAR, LWR and SLA. Also, the use of GR as antitoxification agencies, may be extended to include the regulatory effects on the three proportional ratios. These regulatory effects of both tested factors must be judged by plant age and the prevailing environmental conditions. These conclusions based on the complete changes in these ratios during either sampling dates or during the tested seasons trails. As a general, LAR decreased sharply at harvesting stage (210 days after sowing), as related to the first sampling date (120 days). This finding was true during the two trials seasons. The decrement in LAR at 210 days was associated with slight increasing in the proportion of LWR and a sharp decrement in SLA during both seasons.

2-As a general, Cd treatments reduce for some extent LAR comparing with control treated plants during the first sampling dates, but such reduction in LAR seemed to be more or less mostly was very limited during the last sample at harvesting stage. On the other hand, Pb treatments seemed to be have very limiting effects on LAR.

3-As mentioned before, any changes in LAR must be associated with the change in the one or the other two ratios, LWR and SLA. GA_3 increased LAR and SLA over the control one especially at 120 days after sowing, and that may be connected with its action as antitoxification agent for Cd. Its effect was extended to include the toxification action of Pb. B_9 treatments seemed to be with less effect, in this respect, at the first sampling date under the treatments with Cd, but its action increased sharply under Pb treatments (LAR and SLA). This action of B_9 in the presence of Pb on LAR was true during both trials of the first and second periods.

4-Finally, it may be concluded that SLA may be play the main role for determining LAR, either under the treatments with HM or GR detoxification actions, more than LWR during different periods of sugar beet plant growth, as the more obvious changes were pronounced with SLA, i.e. the leaf density or leaf expansion index and that reflected its effects on LAR with relations to phytotoxification of Cd or Pb in the presence of antitoxification agencies especially GA_3 and some time LWR take a part which connected with plant age.

5-The above mentioned growth analysis may be discussed on the following conclusions.

El-Nabarawy (2002) concluded that Cd seemed to be affected spinach plant growth through its depressive effects on SLA, accordingly the decrease in LAR must be related to the decrease in SLA and not related to LWR. In addition, Sorial and Abd El-Fattah (2001) reported that, the highest values of Pb decreased relatively growth rate (RGR), LAR and NAR comparing with untreated plants.

Greger *et al.* (1991) and Landberg and Greger (1994) proved that, Cd inhibited (RGR) in sugar beet plants. However, Abo-Kassem *et al.* (1995)

reported that, toxic effect of Cd on RGR of wheat plants is due to (NAR) retardation ratio than to LAR inhibition, as the main limiting factor on the plant growth was NAR inhibition due to decrease in photosynthesis as the lower of plastid pigments was resulted associated with acceleration of respiration process.

Table (5): Changes in leaf area ratio (LAR – cm^2/g), leaf weight ratio (LWR) and specific leaf area (SLA – cm^2/g) at 120 and 210 days after sowing as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season		1999-2000											
Period		120 days after sowing						210 days after sowing					
Heavy metal (HM)		Cont.	Cd		Pb		Mean (G R)	Cont.	Cd		Pb		Mean
(mg/l)		0	20	50	20	50		0	20	50	20	50	(G R)
Growth regulator (G R) (mg/l)		LAR (cm^2/g)						LAR (cm^2/g)					
Control		31.48	28.60	24 07	33 14	31.47	**29.75**	21.45	21.19	19.63	23 82	22 97	**21.81**
GA_3 50		37.26	34 52	33 05	39.24	38.81	**36.58**	23.06	23.21	24.45	23.91	24 08	**23.74**
NAA 50		30 22	27.68	26.60	31.63	32.22	**29.67**	23.49	21.77	22.35	25.34	25.24	**23.64**
B_9 50		33.98	28.20	26 46	38 42	38 32	**33.08**	22.78	22 93	22 77	22 42	22.01	**22.58**
Mean (HM)		**33.24**	**29.73**	**27.55**	**35.61**	**35.21**	**32.27**	**22.70**	**22.28**	**22.30**	**23.87**	**23.58**	**22.94**
		LWR						LWR					
Control		0 3657	0.3587	0.3510	0.3665	0 3628	**0.3609**	0 4507	0.4324	0.4310	0.4495	0 4287	**0.4385**
GA_3 50		0 3630	0 3433	0.3485	0.3642	0.3448	**0.3528**	0.4484	0 4526	0.4441	0 4390	0.4428	**0.4454**
NAA 50		0 3619	0.3504	0.3630	0.3826	0.3922	**0.3700**	0.4610	0.4440	0.4521	0.4476	0 4492	**0.4508**
B_9 50		0 3658	0 3434	0 3461	0.3706	0 3720	**0.3596**	0.4571	0.4609	0.4525	0.4565	0 4609	**0.4576**
Mean (HM)		**0.3641**	**0.3490**	**0.3522**	**0.3710**	**0.3680**	**0.3608**	**0.4543**	**0.4475**	**0.4449**	**0.4482**	**0.4454**	**0.4481**
		SLA (cm^2/g)						SLA (cm^2/g)					
Control		86.08	79 77	68 59	90.40	86.38	**82.24**	47.60	49 01	45.54	53.00	53 58	**49.75**
GA_3 50		102 65	100 55	94 83	107 74	112.57	**103.67**	51 44	51 29	55.04	54 45	54 37	**53.32**
NAA 50		83 52	79.00	73.28	82 67	82.16	**80.13**	50.97	49 04	49.22	56.62	56 19	**52.41**
B_9 50		92.87	82 10	76 44	103.66	103.01	**91.62**	49.83	49.76	50.32	49 11	47.75	**49.35**
Mean (HM)		**91.28**	**85.36**	**78.29**	**96.12**	**96.03**	**89.41**	**49.96**	**49.78**	**50.03**	**53.30**	**52.97**	**51.21**
		2000-2001											
		0	**50**	**100**	**50**	**100**	**Mean (G.R)**	**0**	**50**	**100**	**50**	**100**	**Mean (G.R)**
		LAR (cm^2/g)						LAR (cm^2/g)					
Control		31.25	24.58	25.19	28.38	25.48	**26.98**	20 46	20.47	18.82	22 39	21 14	**20.66**
GA_3	50	34.75	25 14	26.70	30 51	25.02	**28.42**	20 46	20.59	19.94	19 98	22.57	**20.81**
	100	35.45	26 55	26.05	33 18	23.67	**28.97**	20 09	21 24	20 09	21 62	21 88	**20.98**
B_9	50	34.22	28.22	29.31	33.80	27 66	**30.64**	21.88	21 75	18 38	19 16	20 66	**20.37**
	100	34.65	29.89	30 33	32 88	30 45	**31.64**	22.21	22 60	18.21	20 73	19.76	**20.70**
Mean (HM)		**34.06**	**26.88**	**27.52**	**31.75**	**26.45**	**29.33**	**21.12**	**21.33**	**19.09**	**20.78**	**21.20**	**20.70**
		LWR						LWR					
Control		0 3613	0 3302	0.3275	0 3689	0 3735	**0.3523**	0.4298	0 4164	0 4140	0 4282	0 4404	**0.4258**
GA_3	50	0 3576	0 3419	0.3294	0.3628	0.3574	**0.3498**	0.4332	0 4058	0 3833	0.4140	0 4182	**0.4109**
	100	0.3593	0 3346	0 3368	0.3430	0 3519	**0.3451**	0 4412	0 3907	0.3950	0 4194	0 4058	**0.4104**
B_9	50	0 3603	0.3309	0.3317	0.3716	0 3786	**0.3546**	0 4349	0.4310	0 4212	0 4259	0 4517	**0.4329**
	100	0 3491	0 3376	0.3252	0.3881	0 3898	**0.3505**	0.4425	0.4342	0.4145	0 4097	0.4464	**0.4200**
Mean (HM)		**0.3575**	**0.3350**	**0.3301**	**0.3669**	**0.3702**	**0.3505**	**0.4363**	**0.4156**	**0.4056**	**0.4194**	**0.4325**	**0.4200**
		SLA (cm^2/g)						SLA (cm^2/g)					
Control		86.49	74 44	76 93	76 93	68.22	**76.60**	47 60	49.16	45 53	52 29	48 00	**48.52**
GA_3	50	97 17	73 53	81 04	84 09	70 01	**81.17**	48 41	50 73	52 02	48 27	53 96	**50.68**
	100	98 67	79.35	77 33	96 72	67 27	**83.87**	45 53	54 36	50 86	51 55	53 96	**51.25**
B_9	50	94 97	85.29	88 36	90 97	73.05	**86.53**	50.32	50 46	43 63	44 97	45 74	**47.02**
	100	99 28	88 54	93 26	84 72	78.12	**88.78**	50.20	52 05	43.95	50 60	44 26	**49.37**
Mean (HM)		**95.32**	**80.23**	**83.38**	**86.69**	**71.33**	**83.39**	**48.41**	**51.35**	**47.20**	**49.54**	**49.18**	**49.37**

Plant organ water relation: (Table 6)

Plant organ water relations were determined in roots in terms of root dry weight/root fresh weight × 100, i.e. as a percentage, but in leaves this water relation was estimated as mg H_2O/cm^2 of leaf. It may be detected the following conclusions from these available data:

1- As a general, mostly very limiting increase in the percentage of root dry weight/its fresh weight during different periods of growth, reaching the maximum at harvesting stage 210 days. This indirectly means that the moisture in roots decreased relatively with plant advancing age.
2- Both heavy metals affected the ratio of RDW/RFW, i.e. affected the ratio of water balance in root system. Roots of Cd or Pb treated plants in the absence of growth regulator treatments seemed to have relatively more succulence degree, as the RDW/RFW decreased as related to the control, during most periods of plant growth.
3- In the absence of heavy metal treatments, growth regulators seemed to have limiting effects on the succulence degree of root tissues. However, GA_3 and B_9 mostly regulate slightly the water balance in roots, as both treated plants with them, showed relatively limiting increase in RDW/RFW %, i.e. decreased slightly the succulence grade of roots.
4- The tested growth regulators effects on root succulence grade were extended to regulate the toxic effects of Cd or Pb on water balance in roots. The most obvious effects in this respect, may be shown under GA_3 or B_9 treated plants.
5- We assumed that the limiting changes in root water balance by Cd or Pb, is a part of both heavy metal phytotoxification actions, which may be partially regulated by using specific growth regulators, i.e. partial detoxification actions.
6- With regard to the direct estimation of leaf succulence degree as mg H_2O/cm^2 of leaf area, it was found the following conclusions:
   Both of Cd or Pb treated leaves contained higher amounts of water than the 0.0 treated leaves, and the used growth regulators seemed to be check this troublness in leaves water troublness balance by the phytotoxification of Cd or Pb.
   a) The higher moisture contents exhibited in Cd or Pb treated leaves may be related to the desfunctional closing and opening mechanism under Cd or Pb stress (Greger and Johansson, 1992). It must be mentioned here that, Cd causes closure of stomata (Bazzaz *et al.*, 1974; Schlegel *et al.*, 1987; Barcelo *et al.*, 1988; Poschenrieder *et al.*, 1989 and Greger and Johansson, 1992), and Pb may be have the same effects.
   b) This adverse effect on water statues in leaves could be checked by the used growth regulators, as the succulence degree in leaves was controlled by the use of specific growth regulator, with mostly pronounced effect by using GA_3. The only loss of water from leaves seemed to be from cuticle and epidermal cell wall/cuticular membrane system, but this system is also controlled by the use of heavy metals as foliar spray (see Greger *et al.*, 1993 in their complete study in this respect, on sugar beet plant).

Table (6): Changes in root dry weight/root fresh weight ratio(%) and leaf succulence grade (index) (mg water/cm^2) of sugar beet plant during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season	1999-2000											
Growth character	Root dry weight/root fresh weight (%)						*Leaf succulence grade (index)*					
Heavy metal (HM) (mg/l)	Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
Growth regulator (G R) (mg/l)	0	20	50	20	50		0	20	50	20	50	
	120 days after sowing						120 days after sowing					
Control	19.2	18.8	18.8	18.9	18.1	**18.8**	71	82	97	71	78	80
GA_3 50	20.0	20.1	19.5	19.6	19.1	**19.7**	56	61	65	57	61	**60**
NAA 50	19.5	20.0	18.1	17.5	17.2	**18.5**	75	80	93	79	82	**82**
B_9 50	20.3	20.4	19.9	19.2	18.8	**19.7**	63	79	84	60	61	**69**
Mean (HM)	**19.7**	**19.8**	**19.1**	**18.8**	**18.3**	**19.2**	**66**	**76**	**85**	**67**	**71**	**73**
	210 days after sowing						210 days after sowing					
Control	21.6	21.[illegible]	20.7	21.0	21.4	**21.2**	87	95	105	83	98	**92**
GA_3 50	23.6	21.3	20.8	22.4	21.5	**21.9**	73	81	80	77	79	**78**
NAA 50	22.2	21.1	19.1	23.0	21.8	**21.4**	78	91	96	74	80	**84**
B_9 50	23.2	21.4	21.0	23.1	22.9	**22.3**	79	94	87	83	85	**86**
Mean (HM)	**22.7**	**21.3**	**20.4**	**22.4**	**21.9**	**21.7**	**79**	**90**	**92**	**79**	**83**	**85**
	2000-2001											
	0	**50**	**100**	**50**	**100**	**Mean (G.R)**	**0**	**50**	**100**	**50**	**100**	**Mean (G.R)**
	120 days after sowing						120 days after sowing					
Control	19.9	20.0	19.7	18.6	18.9	**19.4**	70	90	91	84	100	**87**
GA_3 50	20.5	20.0	20.2	19.2	19.0	**19.8**	60	85	84	73	94	79
GA_3 100	21.3	21.3	21.0	20.6	20.0	**20.8**	56	76	82	64	93	74
B_9 50	20.5	20.9	19.8	19.8	20.0	**20.2**	63	76	76	69	87	74
B_9 100	21.7	21.2	21.0	20.2	20.0	**20.8**	59	70	72	67	68	67
Mean (HM)	**20.8**	**20.7**	**20.3**	**19.7**	**19.6**	**20.2**	**62**	**79**	**81**	**71**	**88**	**76**
	210 days after sowing						210 days after sowing					
Control	22.5	21.6	20.5	21.6	20.0	**21.2**	86	91	98	83	94	**90**
GA_3 50	23.3	22.7	22.0	23.5	21.6	**22.6**	79	85	89	87	86	**85**
GA_3 100	24.2	24.0	22.0	24.0	23.1	**23.5**	77	77	81	77	84	**79**
B_9 50	23.5	22.6	22.3	22.9	20.7	**22.4**	76	80	98	90	89	**87**
B_9 100	24.6	23.0	22.5	23.9	22.9	**23.4**	69	75	95	79	85	**81**
Mean (HM)	**23.6**	**22.8**	**21.9**	**23.2**	**21.7**	**22.6**	**77**	**82**	**92**	**83**	**88**	**84**

7- The different aforementioned results, concerned the water balance in either of roots or leaves of sugar beet plant under the stress of heavy metals foliar spray, may be discussed on the following conclusion:

a) The trouble in sugar beet organs water relations, as related to foliar application of Cd or Pb, may be discussed on the basis that both of heavy metal depressed plant growth especially leaf area and SLA, so that the transpiration epicutical area decrease, with relation to the closed stomata as mentioned before.

b) Greger and Johansson (1992) concluded that, Cd affected the water absorption, water transpiration and water translocation within plant, as Cd has harmful effects on plasma membrane, which affected the permeability of water and solutes. Schickler and Caspi (1999) related the disbalance of water within plant organ tissues to the membrane damage and the metabolism troublness as resulted by Cd or Pb.

c) Sorial and Abd El-Fattah (2001) and Aidid and Okamato (1992) reported that, cell membranes are considered the primary site of heavy metal injury. They added also that these metals induced changes in membrane properties leading to membrane disfunction carriers and ion chainels as well as the permeability of cell membranes to water. Many studies showed that, even low concentration of Pb could cause severe ultrastructural damage by interference with the structural integrity of the organelles such as chloroplasts and mitochondria (Buwalada *et al.*, 1992), in addition to inhibiting metabolic processes by direct production of enzyme activities (Quariti *et al.*, 1997).

d) Growth regulators affected the plant water relations under stress conditions, by their control on water absorption, translocation or transpiration (Abd El-Hamid *et al.*, 1992 a and b).

Concentration of photosynthetic pigments (Table 7)

It may be revealed the following conclusions:

1. 1-As a general, the three components of photosynthetic pigments, Chls. a, b and carotenoids, decreased at harvesting stage in sugar beet leaves, i.e. plant senescence stage.
2. 2-The adverse effects of both tested HM were extended to include the concentration of all chloroplast pigment components in sugar beet leaves, as such concentration decline progressively with increasing the used rates of both Cd or Pb.
3. 3-Cd mostly seemed to have more decline effects on the fractions of photosynthetic pigments than those corresponding ones of Pb during most different periods of growth and under the conditions of both seasons trials with some fluctuations between Cd and Pb under some conditions, as Pb may be exhibited more decline effects, in this respect, than Cd in few cases.
4. GR increased mostly the level of different photosynthetic pigments in leaves; hence declined the adverse effects of HM, in this respect. The most obvious effects, in this respect, gained mostly by using GA_3 during most different periods of growth, and mostly under the conditions of both seasons trials, with some fluctuations under other used GR, in this respect. This may be lead us to suggest that the partial detoxification actions of GR seemed to be partially related to their enhancing effects on photosynthetic pigments, on otherwise decline the adverse effects of HM on such pigments.
5. The decline of photosynthetic pigments by Cd and/or Pb was also reported by many workers working on variable plant species, among them; Tukendorf and Baszynski (1991); Babu and Singh (1992); Greger and Ogren (1991); Keshan and Mukherji (1992); Malik *et al.* (1992a & b); Kalita *et al.* (1993); Mishro *et al.* (1994); Zaman and Zereen (1998) and Sorial and Abd El-Fattah (2001).

Photosynthetic pigments have been shown as one of the main sites of the toxic Cd actions. The reduction in chloroplast pigments in Cd treated plants may be due to its biosynthesis retardation (Sorial and Abd El-Fattah, 2001), and/or activation of its enzymatic degradation (Somashekaraiah *et al.*, 1992). In addition, the reduction in photosynthetic pigment concentrations of Cd and Pb treated plant may be attributed to the substitution of Mg^{++} by Cd^{++} or Pb^{++} causing denaturation in chlorophyll molecule (Kupper *et al.*, 1998), or by its effect on delaying formation of thylakoid membranes and disturbed shape and dilution of the thylakoid membranes (Ouzounidou *et al.*, 1996). Lang *et al.* (1995) related the decrease in chlorophylls content to the iron deficiency under Cd treated plants.

Table (7): Changes in chlorophyll a, b and carotenoids (mg/g F.W.) at 120 and 210 days after sowing as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season		1999-2000											
Period		120 days after sowing						210 days after sowing					
Heavy metal (HM) (mg/l)		Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
		0	20	50	20	50		0	20	50	20	50	
Growth regulator (G.R) (mg/l)		Chlorophyll (a)						Chlorophyll (a)					
Control		1.552	1.501	1.398	1.503	1.393	**1.469**	1.184	1.135	1.014	1.104	1.015	**1.090**
GA_3 50		1.634	1.593	1.601	1.600	1.620	**1.630**	1.231	1.156	1.086	1.159	1.113	**1.149**
NAA 50		1.582	1.542	1.445	1.581	1.400	**1.510**	1.189	1.160	1.044	1.152	1.011	**1.111**
B_9 50		1.520	1.499	1.365	1.500	1.489	**1.475**	1.180	1.171	1.015	1.174	1.010	**1.110**
Mean (HM)		**1.572**	**1.559**	**1.452**	**1.546**	**1.476**	**1.521**	**1.196**	**1.156**	**1.040**	**1.147**	**1.037**	**1.115**
		Chlorophyll (b)						Chlorophyll (b)					
Control		0.661	0.635	0.602	0.646	0.621	**0.633**	0.367	0.358	0.337	0.352	0.338	**0.350**
GA_3 50		0.670	0.654	0.623	0.652	0.620	**0.644**	0.391	0.351	0.344	0.350	0.344	**0.356**
NAA 50		0.662	0.638	0.608	0.631	0.606	**0.629**	0.388	0.341	0.338	0.340	0.329	**0.347**
B_9 50		0.690	0.678	0.638	0.680	0.645	**0.666**	0.400	0.363	0.345	0.400	0.340	**0.370**
Mean (HM)		**0.671**	**0.651**	**0.618**	**0.652**	**0.623**	**0.643**	**0.387**	**0.353**	**0.341**	**0.361**	**0.338**	**0.356**
		Carotenoids						Carotenoids					
Control		0.418	0.393	0.382	0.404	0.385	**0.396**	0.229	0.212	0.196	0.218	0.206	**0.212**
GA_3 50		0.449	0.431	0.401	0.431	0.401	**0.423**	0.387	0.268	0.255	0.260	0.249	**0.284**
NAA 50		0.416	0.388	0.355	0.383	0.367	**0.382**	0.221	0.210	0.186	0.219	0.208	**0.209**
B_9 50		0.440	0.421	0.385	0.420	0.400	**0.413**	0.280	0.268	0.245	0.286	0.241	**0.264**
Mean (HM)		**0.431**	**0.408**	**0.381**	**0.410**	**0.388**	**0.404**	**0.279**	**0.240**	**0.221**	**0.246**	**0.226**	**0.242**
		2000-2001											
		0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
		Chlorophyll (a)						Chlorophyll (a)					
Control		1.493	1.393	1.227	1.399	1.350	**1.372**	0.970	0.825	0.760	0.786	0.621	**0.792**
GA_3	50	1.551	1.409	1.341	1.467	1.253	**1.404**	1.187	0.899	0.699	1.201	1.221	**1.041**
	100	1.648	1.548	1.600	1.689	1.642	**1.625**	1.202	1.178	0.800	1.315	1.310	**1.161**
B_9	50	1.580	1.423	1.331	1.519	1.461	**1.463**	0.984	0.876	0.855	1.213	1.111	**1.008**
	100	1.589	1.451	1.354	1.660	1.465	**1.504**	0.995	0.899	0.790	1.282	1.245	**1.042**
Mean (HM)		**1.572**	**1.445**	**1.371**	**1.547**	**1.434**	**1.474**	**1.068**	**0.935**	**0.781**	**1.159**	**1.102**	**1.009**
		Chlorophyll (b)						Chlorophyll (b)					
Control		0.744	0.686	0.585	0.758	0.767	**0.708**	0.525	0.486	0.460	0.492	0.454	**0.483**
GA_3	50	0.761	0.701	0.687	0.802	0.773	**0.745**	0.545	0.499	0.487	0.521	0.508	**0.512**
	100	0.891	0.796	0.738	0.818	0.780	**0.805**	0.583	0.530	0.509	0.561	0.553	**0.547**
B_9	50	0.774	0.706	0.663	0.764	0.729	**0.727**	0.519	0.500	0.484	0.525	0.510	**0.508**
	100	0.787	0.746	0.688	0.788	0.740	**0.750**	0.530	0.518	0.477	0.538	0.524	**0.517**
Mean (HM)		**0.791**	**0.727**	**0.672**	**0.786**	**0.758**	**0.747**	**0.540**	**0.507**	**0.483**	**0.527**	**0.510**	**0.514**
		Carotenoids						Carotenoids					
Control		0.499	0.476	0.442	0.486	0.479	**0.476**	0.385	0.352	0.330	0.371	0.360	**0.360**
GA_3	50	0.496	0.488	0.451	0.491	0.477	**0.481**	0.400	0.384	0.355	0.398	0.379	**0.383**
	100	0.508	0.502	0.465	0.503	0.496	**0.495**	0.421	0.392	0.372	0.410	0.386	**0.396**
B_9	50	0.497	0.470	0.441	0.500	0.483	**0.478**	0.421	0.398	0.388	0.370	0.361	**0.388**
	100	0.503	0.482	0.472	0.513	0.491	**0.492**	0.433	0.411	0.392	0.384	0.380	**0.400**
Mean (HM)		**0.501**	**0.484**	**0.454**	**0.499**	**0.485**	**0.484**	**0.412**	**0.387**	**0.367**	**0.387**	**0.373**	**0.385**

The harmful effect of Pb on the level of photosynthetic pigments may be attributed to the inhibition of their biosynthesis in treated plants, as it is accumulated in chloroplasts leading to chloroplast disorganization ultrastructure and decreasing the formation of chloroplasts (Lukaszek and Poskuta, 1998 and Zaman and Zereen, 1998).

It was suggested that different used G R under the conditions of this study may have a role to minimize the toxic action of HM throughout one or more of the aforementioned action mechanism of retarding the photosynthetic pigments.

Concentration of sugars fractions in root: (Table 8)

It may be revealed the following conclusions:

The economical yield production in sugar beet is the storage sucrose, the non-reducing fraction, with less economical fraction, the reducing one, as the later one is important for chemical industry. The study of both fractions here may be clarified the effects of the tested two factors indirectly on yield, as the yield per plant is the multiplication of sugars concentration × the dry weight of roots. As mentioned before, both studied factors affected significantly the dry weight of roots, and HM treatments seemed to have deleterious effects which control to some extent by using certain growth regulators especially GA_3 and some time B_9. Also, the various treatments with HM or GR alter the photosynthetic area, SLA and the concentration of chloroplast pigments. Accordingly, the biosynthesis and the flow of photoassimilated products must be affected by the using the varieties of the two tested factors, HM and GR. On such basic knowledge, the accumulation of sugars fractions in root as concentration (mg/g D.W.) seemed to be decreased under the tested heavy metal treatments either as reducing, non-reducing or total sugars in roots. In other words, the reduction effects of HM on plant growth were extended to include the rate of sugars accumulation per unit D.W., and hence the total yielded sugars must be reduced with variable extend according to any factors, HM species, their used concentration, the stage of the plant, the prevailing environmental conditions (between two tested seasonal trials and may other factors). In addition, the regulatory effects of the used GR on the adverse effects of HM were also extended to include the level of sugars fractions in roots.

As a general, both of sugar fractions and total one were less during the first sampling date during the second season trials, than those corresponding one of the first season, but the *vice versa* is true during the second sampling date, as non-reducing fraction and total sugars concentrations were higher at harvesting stage during the second season trials comparing to those corresponding one of the first season, but reducing fraction showed contrary results. In spite of, the presence of some fluctuations between Cd and/or Pb with respect to the degree of their retardant effects on sugar fractions, but it may be concluded that Cd seemed to have mostly more deleterious effects on sugar levels in roots of sugar beet plant than Pb.

The use of GR varieties seemed to have pronounced effect on the level of sugars fractions in roots and could be used for minimizing the harmful effects of Cd or Pb, in this respect, especially GA_3.

All the above mentioned results may be discussed on the following basic knowledge:

a) As mentioned before, both two factors, HM and GR affected the level of photosynthetic pigments and its area and that must be affected the level of sugars in roots, as sugar bioassimilation must be affected, and the level of photosynthetic pigments and leaf expansion degree must be contributed in this process through photoreaction system I (PSI), however, (PSII) is contributed also (Greger and Ogren, 1991; Krupa *et al.* (1992); Krupa and Baszynski (1995); Tukendorf and Baszynski, 1991; Babu and Singh, 1992 and Sorial and Abd-El-Fattah, 2001). In addition, CO_2 assimilation is also affected through enzymatic activity especially Ru,1,5D- carboxilase enzymes (Krupa and Mcniak, 1998).

Table (8): Changes in sugars (mg/g D.W.) of sugar beet plant roots, during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season		1999-2000											
Period		120 days after sowing						210 days after sowing					
Heavy metal (HM) (mg/l)		Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
		0	20	50	20	50		0	20	50	20	50	
Growth regulator (G.R) (mg/l)		Reducing sugars						Reducing sugars					
Control		23.6	24.4	21.8	23.9	21.5	**23.4**	32.9	30.3	27.2	31.0	28.7	**30.0**
GA_3 50		28.5	26.2	25.1	25.8	24.7	**26.1**	36.2	35.1	31.2	35.5	32.9	**34.2**
NAA 50		26.2	25.3	23.6	24.8	22.3	**24.4**	34.7	33.7	29.8	31.4	30.4	**32.0**
B_9 50		27.7	25.9	24.3	24.8	22.2	**25.0**	33.5	31.2	28.0	31.6	29.2	**30.7**
Mean (HM)		**27.0**	**25.5**	**23.7**	**24.8**	**22.7**	**24.7**	**34.3**	**32.6**	**29.1**	**32.4**	**30.3**	**31.7**
		Non-reducing sugars						Non-reducing sugars					
Control		433.8	429.2	420.8	429.5	414.3	**425.5**	656.5	639.8	628.9	642.4	635.5	**640.6**
GA_3 50		456.3	423.6	446.3	439.9	435.4	**440.3**	672.2	644.9	652.0	695.6	683.2	**669.6**
NAA 50		415.4	410.5	402.5	408.3	401.7	**407.7**	660.0	655.3	634.9	652.8	660.4	**652.7**
B_9 50		428.9	419.8	413.8	412.2	413.9	**417.7**	660.0	645.5	635.8	634.1	645.8	**644.2**
Mean (HM)		**433.6**	**420.8**	**420.9**	**422.5**	**416.3**	**422.8**	**662.2**	**646.4**	**637.9**	**656.2**	**656.2**	**651.8**
		Total sugars						Total sugars					
Control		459.4	453.6	442.6	453.4	435.8	**449.0**	689.4	670.1	656.7	673.4	664.2	**670.8**
GA_3 50		484.8	479.8	471.4	465.7	460.1	**472.4**	708.4	680.0	683.2	731.1	716.1	**703.8**
NAA 50		441.6	435.8	426.1	433.1	424.0	**432.1**	694.7	689.0	664.7	684.2	690.8	**684.7**
B_9 50		456.6	445.7	438.1	437.0	436.1	**442.7**	693.5	676.7	663.8	665.7	675.0	**674.9**
Mean (HM)		**460.6**	**453.7**	**444.6**	**447.3**	**439.0**	**449.0**	**696.5**	**679.0**	**667.1**	**688.6**	**686.5**	**683.5**
		2000-2001											
		0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
		Reducing sugars						Reducing sugars					
Control		26.0	23.8	19.6	24.1	19.0	**22.5**	30.1	24.0	21.0	25.0	25.0	**25.0**
GA_3	50	27.1	25.2	19.8	25.8	19.3	**23.4**	32.7	27.3	25.3	27.3	25.9	**27.7**
	100	27.5	27.1	20.2	27.0	20.2	**24.4**	33.9	27.8	26.1	27.0	25.3	**28.0**
B_9	50	26.5	25.1	20.0	25.3	19.8	**23.3**	35.1	28.5	25.3	27.9	26.7	**28.7**
	100	26.8	26.3	20.0	26.9	20.0	**24.0**	36.7	28.0	26.1	28.1	26.9	**29.2**
Mean (HM)		**26.8**	**25.5**	**19.9**	**25.8**	**19.7**	**23.5**	**33.7**	**27.1**	**24.8**	**27.1**	**26.0**	**27.7**
		Non-reducing sugars						Non-reducing sugars					
Control		342.5	339.7	324.8	340.0	327.3	**334.9**	684.9	664.0	647.0	662.7	648.1	**661.3**
GA_3	50	363.8	358.1	351.9	363.7	359.4	**359.4**	706.3	672.7	665.7	682.2	679.1	**681.2**
	100	375.2	364.8	347.0	368.9	349.2	**361.0**	709.1	694.2	690.9	701.9	700.0	**699.2**
B_9	50	359.6	344.8	337.4	352.9	347.1	**348.4**	699.9	671.5	664.7	692.7	694.1	**684.6**
	100	364.9	358.7	340.3	359.1	349.8	**354.6**	705.3	703.0	691.9	701.0	692.2	**698.7**
Mean (HM)		**361.2**	**353.2**	**340.3**	**356.9**	**346.6**	**351.6**	**701.1**	**681.1**	**672.0**	**688.1**	**682.7**	**685.0**
		Total sugars						Total sugars					
Control		368.5	363.5	344.4	364.1	346.3	**357.4**	715.0	788.0	668.0	687.7	673.1	**706.4**
GA_3	50	390.9	383.3	371.7	389.5	378.7	**382.8**	739.0	700.0	591.0	709.5	705.0	**688.9**
	100	402.7	391.9	367.2	395.9	369.4	**385.4**	743.0	722.0	717.0	728.9	725.3	**727.2**
B_9	50	386.1	369.9	357.4	378.2	366.9	**371.7**	735.0	700.0	690.0	720.6	720.8	**713.3**
	100	391.7	385.0	360.3	386.0	369.8	**378.6**	742.0	731.0	718.0	729.1	719.1	**727.9**
Mean (HM)		**388.0**	**378.7**	**360.2**	**382.7**	**366.2**	**375.2**	**734.8**	**728.2**	**676.8**	**715.2**	**708.7**	**712.7**

b) It was found by Salisbury and Ross (1992) that Pb inhibitory effect on photosynthetic enzyme (RuBpC). The regulatory effects of GR detoxification actions in the presence of HM seemed to be one or more of the foregoing factors, in this respect. Again more detail studies must be carried out, in this respect.

N, P, K and Na contents:

It may be noticed from Tables (9-12) the following conclusions:

1- As a general and irrespected to any treatments, sugar beet leaves always possesses less amounts of N, P and K than those found in root during the first sampling date and *vice versa* was obtained at harvesting stage. But the total accumulation of the beneficial element, Na, was always higher in leaves than in root, during different periods of growth and under the variable conditions of both seasons trials.

2- As a general, both used HM declined the accumulatons of N, P, K and Na in different sugar beet tissue organs and whole plant as well, during different periods of growth under the two successive seasons trials, as compared to those of control ones. This decline of nutrients and beneficial elements seemed to be mostly increased with increasing the application dose of HM.

Such decline degree may be changed according to: the used species of HM, their used rates, the variety of the tested nutrient elements, the tested plant organs, the age of the plant, and the variation of environmental conditions prevailing during the seasonal trials, as it was found great fluctuations, in this respect, under the above mentioned factors. Also, fluctuations and irregular trends were observed between the obtained results under the treatments with Cd or Pb, in this respect. The deleterious, troublness and alterations in nutrient elements within plant tissue organs may be extended to include disturbance in the balance in one or more of them in different plant organs and that seemed to take a part in many vital physiological processes, leading to the reduction effects on plant growth. The accumulation declined in different nutrients in sugar beet plant organs and whole plant as well, under the foliar HM applications which increased progressively with increasing HM rates must be related to their negative effects on the uptake, translocation and/or redistribution of nutrients. This negative effects of Pb on N, P and K were also reported by Kahle (1993) and Sorial and Abd El-Fattah (2001). The same conclusion was also concluded by using Cd in different plant species (Symeonidis and Karataglis, 1992; Smolders *et al.*, 1998; Hartley *et al.*, 1999; Sorial and Abd El-Fattah, 2001 and El-Nabarawy, 2002). The later authoress concluded that the toxicity of Cd in plant is often not clearly identifiable entities and it may be the result of complex interaction of the major toxic ions in the question with other essential ions. She also concluded that, the accumulation of different nutrients per plant must be either related to the reduction effect of HM on plant growth or may be due to the capacity of elements uptake and/or the translocation regulation effects of HM within plant organs, also as the root growth was affected by HM the nutrient absorption area must be taken into account.

Table (9): Changes in nitrogen (g/plant) of sugar beet plant, during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season	1999-2000											
Period	120 days after sowing						210 days after sowing					
Heavy metal (HM) (mg/l)	Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
Growth Regulator (G.R) (mg/l)	0	20	50	20	50		0	20	50	20	50	
	Roots						Roots					
Control	2.89	2.43	2.38	2.82	2.41	**2.59**	3.29	2.94	2.39	2.69	1.97	**2.66**
GA$_3$ 50	3.97	3.48	3.19	3.32	2.94	**3.38**	4.23	3.52	3.18	3.82	2.92	**3.53**
NAA 50	3.11	2.83	1.43	2.63	1.86	**2.37**	2.92	2.91	2.07	2.79	1.94	**2.53**
B$_9$ 50	3.51	3.13	2.07	3.16	2.92	**2.96**	3.12	2.32	1.67	3.32	2.52	**2.59**
Mean (HM)	**3.37**	**2.97**	**2.27**	**2.98**	**2.53**	2.82	**3.39**	**2.92**	**2.33**	**3.18**	**2.34**	2.83
	Leaves						Leaves					
Control	2.43	2.19	1.97	2.29	1.98	**2.17**	4.55	3.52	2.83	3.88	3.30	**3.62**
GA$_3$ 50	2.93	2.68	2.47	2.89	2.68	**2.73**	6.24	5.29	4.38	5.18	5.04	**5.23**
NAA 50	2.62	2.51	2.03	2.46	2.15	**2.35**	5.15	4.14	3.93	4.22	3.63	**4.21**
B$_9$ 50	2.79	2.42	2.27	2.58	2.25	**2.46**	5.87	5.14	4.24	5.38	4.73	**5.07**
Mean (HM)	**2.69**	**2.45**	**2.19**	**2.56**	**2.27**	2.43	**5.45**	**4.52**	**3.85**	**4.67**	**4.18**	4.53
	Whole plant						Whole plant					
Control	5.32	4.62	4.35	5.11	4.39	**4.76**	7.84	6.46	5.22	6.57	5.27	6.27
GA$_3$ 50	6.90	6.16	5.66	6.21	5.62	**6.11**	10.47	8.81	7.56	9.00	7.96	**8.76**
NAA 50	5.73	5.34	3.46	5.09	4.01	**4.73**	8.07	7.05	6.00	7.01	5.57	**6.74**
B$_9$ 50	6.30	5.55	4.34	5.74	5.17	**5.42**	8.99	7.46	5.91	8.70	7.25	**7.66**
Mean (HM)	**6.06**	**5.42**	**4.45**	**5.54**	**4.80**	5.25	**8.84**	**7.45**	**6.17**	**7.82**	**6.51**	7.36
	2000-2001											
	0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
	Roots						Roots					
Control	3.28	2.72	2.04	1.68	1.29	**2.20**	3.14	2.46	1.12	1.67	0.96	**1.87**
GA$_3$ 50	4.00	3.14	2.87	2.48	2.35	**2.97**	2.80	2.96	1.78	2.13	1.89	**2.31**
100	4.37	3.57	3.04	2.82	2.65	**3.29**	4.27	3.84	1.85	2.25	2.08	**2.86**
B$_9$ 50	3.78	2.26	1.62	2.88	2.68	**2.64**	2.67	1.90	1.70	2.51	2.25	**2.21**
100	3.98	2.49	1.73	3.16	2.74	**2.82**	2.78	1.93	1.66	3.05	2.48	**2.38**
Mean (HM)	**3.88**	**2.84**	**2.26**	**2.60**	**2.34**	2.78	**3.13**	**2.62**	**1.62**	**2.32**	**1.93**	2.33
	Leaves						Leaves					
Control	2.57	2.15	1.94	2.31	1.89	**2.17**	4.73	2.91	2.46	3.96	3.64	**3.54**
GA$_3$ 50	2.88	2.45	1.90	2.51	2.25	**2.40**	6.05	3.84	2.78	4.61	4.34	**4.32**
100	3.19	2.65	2.24	2.55	2.33	**2.59**	7.18	3.59	3.59	4.90	4.55	**4.76**
B$_9$ 50	2.08	2.25	1.84	1.81	1.75	**1.95**	5.65	4.12	2.56	3.87	3.61	**3.96**
100	2.97	2.38	2.13	2.25	1.88	**2.32**	6.49	4.58	2.83	4.23	4.36	**4.50**
Mean (HM)	**2.74**	**2.38**	**2.01**	**2.29**	**2.02**	2.29	**6.02**	**3.81**	**2.84**	**4.31**	**4.10**	4.22
	Whole plant						Whole plant					
Control	5.85	4.87	3.98	3.99	3.18	**4.37**	7.87	5.37	3.58	5.63	4.60	**5.41**
GA$_3$ 50	6.88	5.59	4.77	4.99	4.60	**5.37**	8.85	6.80	4.56	6.74	6.23	**6.64**
100	7.56	6.22	5.28	5.37	4.98	**5.88**	11.45	7.43	5.44	7.15	6.63	**7.87**
B$_9$ 50	5.86	4.51	3.46	4.69	4.43	**4.59**	8.32	6.02	4.26	6.38	5.86	**6.17**
100	6.95	4.87	3.86	5.41	4.62	**5.14**	9.27	6.51	4.49	7.28	6.84	**6.88**
Mean (HM)	**6.62**	**5.21**	**4.27**	**4.89**	**4.36**	5.07	**9.15**	**6.43**	**4.47**	**6.64**	**5.88**	6.59

The decline effects of HM on nutrients accumulation in different plant organs may be partially ascribed to their indirect factors such as their disturbance effects in water balance within plant organs, especially in leaves as described before, which may lead to control water uptake, translocation and transpiration must be affected the uptake of nutrients through water flow within plant tissues (Sorial and Abd El-Fattah, 2001). However, the complete explanations of Obata and Umebayashi (1997), Larsson *et al.* (1998), Toppi *et al.* (1999) and El-Nabarawy (2002) on the troublness in mineral accumulation and uptake or translocation must be related to the toxic effects of HM on plasma membrane through H^+- ATPase activity which is essential to the proton motive force for the active transport of many solutes Also, they suggested that HM may be reacting with membrane proteins other than ATPase, or may be reacting with phospholipids in the membrane. All or part of these reactions must be contributed to the toxification of HM on nutrients uptake and translocation, hence their accumulation must be under the deleterious effects of HM application.

Table (10): Changes in phosphorus (g/plant) of sugar beet plant, during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season		1999-2000											
Period		120 days after sowing						210 days after sowing					
Heavy metal (HM)		Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
(mg/l)		0	20	50	20	50		0	20	50	20	50	
Growth Regulator (G.R) (mg/l)		Roots						Roots					
Control		0 33	0.27	0.29	0 31	0 29	**0.30**	0.47	0.43	0.41	0 44	0 42	**0.43**
GA_3 50		0.42	0.41	0.37	0.39	0.37	**0.39**	0.58	0.50	0 47	0 52	0.48	**0.51**
NAA 50		0.35	0.34	0.27	0 29	0.27	**0.30**	0.47	0 44	0.37	0.46	0 42	**0.43**
B_9 50		0.41	0.38	0.36	0 35	0.33	**0.37**	0.49	0.44	0.43	0.51	0 49	**0.47**
Mean (HM)		**0.38**	**0.35**	**0.32**	**0.34**	**0.32**	**0.34**	**0.50**	**0.45**	**0.42**	**0.48**	**0.45**	**0.46**
		Leaves						Leaves					
Control		0 24	0.23	0.22	0.24	0.21	**0.23**	0 45	0.39	0 31	0 45	0 40	**0.40**
GA_3 50		0.30	0.27	0.26	0.28	0 26	**0.27**	0 56	0 53	0 46	0.56	0 53	**0.53**
NAA 50		0.25	0 24	0.22	0.24	0 22	**0.23**	0.53	0 46	0 39	0 46	0 48	**0.46**
B_9 50		0 28	0.15	0 14	0 26	0 25	**0.22**	0 60	0 57	0 51	0 55	0 54	**0 55**
Mean (HM)		**0.27**	**0.22**	**0.21**	**0.26**	**0.24**	**0.24**	**0.54**	**0.49**	**0.42**	**0.51**	**0.49**	**0 49**
		Whole plant						Whole plant					
Control		0.57	0 50	0 51	0.55	0 50	**0.53**	0.92	0 82	0 72	0 89	0 82	**0 83**
GA_3 50		0 72	0 68	0 63	0.67	0 63	**0.67**	1.14	1 03	0 93	1 08	1 01	**1 04**
NAA 50		0 60	0.58	0 49	0 53	0 49	**0.54**	1.00	0 90	0 76	0 92	0 90	**0.90**
B_9 50		0 69	0.53	0 50	0.61	0 58	**0.58**	1.09	1 01	0 94	1 06	1 03	**1.03**
Mean (HM)		**0.65**	**0.57**	**0.53**	**0.59**	**0.55**	**0.58**	**1.04**	**0.94**	**0.84**	**0.99**	**0.94**	**0.95**
		2000-2001											
		0	**50**	**100**	**50**	**100**	**Mean (G.R)**	**0**	**50**	**100**	**50**	**100**	**Mean (G.R)**
		Roots						Roots					
Control		0 361	0.319	0 278	0.315	0.309	**0.316**	0.495	0 435	0 374	0 391	0 307	**0.400**
GA_3	50	0.468	0 378	0.321	0.389	0 352	**0.382**	0.532	0.508	0.449	0 440	0 383	**0.462**
	100	0.495	0 430	0.407	0 450	0 411	**0.439**	0.594	0 561	0 505	0 489	0 474	**0.525**
B_9	50	0.390	0.343	0.285	0.377	0.349	**0.349**	0.529	0.457	0 413	0.533	0 464	**0.479**
	100	0.442	0.381	0.342	0.426	0.368	**0.392**	0.551	0.484	0 439	0 602	0 538	**0.523**
Mean (HM)		**0.431**	**0.370**	**0.327**	**0.391**	**0.358**	**0.375**	**0.540**	**0.489**	**0.436**	**0.491**	**0.433**	**0.478**
		Leaves						Leaves					
Control		0 342	0.275	0.221	0.275	0.244	**0.271**	0 585	0 355	0.272	0 448	0 401	**0.412**
GA_3	50	0.361	0.312	0.247	[illegible]	0.275	**0.303**	0.667	0 446	0 314	0.480	0 457	**0.473**
	100	0.394	0 335	0.263	0 337	[illegible]	**0.340**	0.829	0 477	0.368	0.552	0 530	**0.551**
B_9	50	0 352	0.255	0 222	0 303	0.309	**0.288**	0.671	0.475	0.340	0.454	0 426	**0.473**
	100	0 370	0.287	0.238	0.327	0 351	**0.315**	0.763	0 531	0 403	0.483	0 477	**0.531**
Mean (HM)		**0.364**	**0.293**	**0.242**	**0.312**	**0.306**	**0.303**	**0.703**	**0.457**	**0.339**	**0.483**	**0.458**	**0.488**
		Whole plant						Whole plant					
Control		0.703	0 594	0.499	0 590	0 554	**0.588**	1.08	0 79	0.646	0.84	0 708	**0.813**
GA_3	50	0 829	0 690	0 568	0 708	0 627	**0.684**	1 20	0 95	0 763	0.92	0 840	**0.935**
	100	0 889	0 765	0 690	0 787	0 763	**0.779**	1.42	1 04	0 873	1 04	1 00	**1.075**
B_9	50	0 742	0.598	0.507	0.680	0.658	**0.637**	1.20	0 93	0 753	0 99	0 890	**0.953**
	100	0 812	0.668	0 576	0.753	0.719	**0.706**	1 31	1 02	0 842	1 09	1 02	**1.056**
Mean (HM)		**0.795**	**0.663**	**0.568**	**0.704**	**0.664**	**0.679**	**1.242**	**0.946**	**0.775**	**0.976**	**0.892**	**0.966**

Table (11): Changes in potassium (g/plant) of sugar beet plant, during different periods of growth, as affected by combined foliar sprays of different HM rates with variable GR levels.

Season		1999-2000											
Period		120 days after sowing						210 days after sowing					
Heavy metal (HM) (mg/l)		Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
Growth regulator (G.R) (mg/l)		0	20	50	20	50		0	20	50	20	50	
		Roots						Roots					
Control		2.52	2.13	2.04	2.40	2.01	**2.22**	2.78	2.44	1.93	2.65	2.15	**2.39**
GA3 50		3.26	3.05	2.60	2.87	2.50	**2.86**	4.14	3.70	2.87	3.32	3.18	**3.44**
NAA 50		3.05	2.48	1.92	2.35	1.58	**2.28**	3.78	3.44	2.72	2.77	2.13	**2.97**
B9 50		3.24	2.78	2.51	2.59	2.50	**2.72**	3.91	3.42	2.86	2.76	2.67	**3.12**
Mean (HM)		**3.02**	**2.61**	**2.27**	**2.55**	**2.15**	**2.52**	**3.65**	**3.25**	**2.60**	**2.88**	**2.53**	**2.98**
		Leaves						Leaves					
Control		2.60	2.35	2.12	2.42	2.18	**2.33**	3.98	3.43	3.09	3.46	3.07	**3.41**
GA3 50		3.20	2.94	2.72	2.29	3.08	**2.85**	5.05	4.08	3.26	4.54	3.80	**4.15**
NAA 50		2.78	2.75	2.63	2.51	2.26	**2.59**	4.53	3.71	3.14	4.17	3.39	**3.79**
B9 50		3.21	2.83	2.75	3.05	2.80	**2.93**	4.59	4.14	3.30	4.79	4.14	**4.19**
Mean (HM)		**2.95**	**2.72**	**2.56**	**2.57**	**2.58**	**2.67**	**4.54**	**3.84**	**3.20**	**4.24**	**3.60**	**3.88**
		Whole plant						Whole plant					
Control		5.12	4.48	4.16	4.82	4.19	**4.55**	6.76	5.87	5.02	6.11	5.22	**5.80**
GA3 50		6.46	5.99	5.32	5.16	5.58	**5.70**	9.19	7.78	6.13	7.86	6.98	**7.59**
NAA 50		5.83	5.23	4.55	4.86	3.84	**4.86**	8.31	7.15	5.86	6.94	5.52	**6.76**
B9 50		6.45	5.61	5.26	5.64	5.30	**5.65**	8.50	7.56	6.16	7.55	6.81	**7.32**
Mean (HM)		**5.97**	**5.33**	**4.82**	**5.12**	**4.73**	**5.19**	**8.19**	**7.09**	**5.79**	**7.12**	**6.13**	**6.86**
		2000-2001											
		0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
		Roots						Roots					
Control		2.81	2.42	1.76	2.46	2.07	**2.30**	3.40	3.19	2.24	2.69	2.60	**2.82**
GA3	50	3.48	2.98	2.29	2.99	2.25	**2.80**	4.18	4.03	3.30	4.04	3.41	**3.79**
	100	4.00	3.23	2.58	3.64	2.31	**3.15**	5.79	5.61	3.96	5.12	3.68	**4.83**
B9	50	2.97	2.57	2.13	2.61	2.56	**2.57**	4.04	3.43	3.34	3.31	2.46	**3.32**
	100	2.97	2.83	2.31	3.02	2.61	**2.75**	5.08	4.39	3.65	4.29	3.28	**4.14**
Mean (HM)		**3.25**	**2.81**	**2.21**	**2.94**	**2.36**	**2.71**	**4.50**	**4.13**	**3.30**	**3.89**	**3.09**	**3.78**
		Leaves						Leaves					
Control		3.00	2.53	2.07	2.60	2.30	**2.50**	4.50	3.29	2.84	5.36	4.43	**4.08**
GA3	50	3.34	2.77	1.69	3.18	2.61	**2.72**	5.32	4.04	3.79	5.37	4.10	**4.52**
	100	3.68	2.91	2.16	3.32	2.83	**2.98**	7.30	4.16	4.31	5.76	4.75	**5.26**
B9	50	3.10	2.83	1.80	3.10	2.86	**2.74**	5.44	3.87	3.02	4.22	2.93	**3.90**
	100	3.50	3.18	2.01	3.84	3.34	**3.17**	6.09	4.78	3.88	5.06	3.31	**4.62**
Mean (HM)		**3.32**	**2.84**	**1.95**	**3.21**	**2.79**	**2.82**	**5.73**	**4.03**	**3.57**	**5.15**	**3.90**	**4.48**
		Whole plant						Whole plant					
Control		5.81	4.95	3.83	5.06	4.37	**4.80**	7.90	6.48	5.08	8.05	7.03	**6.91**
GA3	50	6.82	5.75	3.98	6.17	4.86	**5.52**	9.50	8.07	7.09	9.41	7.51	**8.32**
	100	7.68	6.23	4.74	6.96	5.14	**6.15**	13.09	9.77	8.27	11.09	8.43	**10.13**
B9	50	6.07	5.40	3.93	5.91	5.42	**5.35**	9.48	7.30	6.36	7.53	5.39	**7.21**
	100	6.47	6.01	4.32	6.86	5.95	**5.92**	11.17	9.17	7.53	9.35	6.59	**8.76**
Mean (HM)		**6.57**	**5.67**	**4.16**	**6.19**	**5.15**	**5.55**	**10.23**	**8.16**	**6.87**	**9.09**	**6.99**	**6.27**

3- With regard to the effects of GR, especially GA_3 and sometimes B_9 or their interaction with HM treatments, it could be concluded that such substances seemed to be regulated positively the harmful effects of HM on the accumulation of the tested nutrients within plant organs and whole plant as well. This regulatory achievement must be related to one or more proposed mechanisms of toxic actions of HM on the uptake, translocation, accumulation and redistribution of nutrients which is discussed before. The most obvious achievement may be mostly obtained by GA_3 which followed by B_9 especially under the use of 100 mg/l applied as foliar spray before foliar additions of HM. However, more additional studies must be carried out in this respect to clarify the interspecific actions of GR and HM, which may be included the water balance in leaves and/or roots and their functionally activity effects on membrane transport system.

Table (12): Changes in sodium (g/plant) of sugar beet plant, during different periods of growth, as affected by combined foliar sprays of different HM rates with variable G.R levels.

Season		1999-2000											
Period		120 days after sowing						210 days after sowing					
Heavy metal (HM)		Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
(mg/l)		0	20	50	20	50		0	20	50	20	50	
Growth Regulator(G.R) (mg/l)		Roots						Roots					
Control		0.28	0.21	0.22	0.26	0.23	**0.24**	0.37	0.33	0.28	0.37	0.34	**0.34**
GA_3 50		0.39	0.39	0.34	0.38	0.34	**0.37**	0.49	0.44	0.34	0.50	0.41	**0.44**
NAA 50		0.32	0.26	0.20	0.28	0.22	**0.26**	0.37	0.31	0.24	0.31	0.22	**0.29**
B_9 50		0.39	0.36	0.28	0.38	0.32	**0.35**	0.46	0.38	0.32	0.48	0.42	**0.41**
Mean (HM)		**0.35**	**0.31**	**0.26**	**0.33**	**0.28**	**0.30**	**0.42**	**0.37**	**0.30**	**0.42**	**0.35**	**0.37**
		Leaves						Leaves					
Control		0.61	0.55	0.51	0.55	0.51	**0.55**	0.62	0.51	0.46	0.55	0.46	**0.52**
GA_3 50		0.73	0.65	0.61	0.69	0.65	**0.67**	0.78	0.65	0.56	0.73	0.60	**0.66**
NAA 50		0.63	0.59	0.55	0.54	0.49	**0.56**	0.64	0.53	0.39	0.59	0.50	**0.53**
B_9 50		0.75	0.66	0.61	0.61	0.56	**0.64**	0.70	0.64	0.57	0.72	0.66	**0.66**
Mean (HM)		**0.68**	**0.61**	**0.57**	**0.60**	**0.55**	**0.60**	**0.69**	**0.58**	**0.50**	**0.65**	**0.56**	**0.59**
		Whole plant						Whole plant					
Control		0.89	0.76	0.73	0.81	0.74	**0.79**	0.99	0.84	0.74	0.92	0.80	**0.86**
GA_3 50		1.12	1.04	0.95	1.07	0.99	**1.03**	1.27	1.09	0.90	1.23	1.01	**1.10**
NAA 50		0.95	0.85	0.75	0.82	0.71	**0.82**	1.01	0.84	0.63	0.90	0.72	**0.82**
B_9 50		1.14	1.02	0.89	0.99	0.88	**0.98**	1.16	1.02	0.89	1.20	1.08	**1.07**
Mean (HM)		**1.03**	**0.92**	**0.83**	**0.92**	**0.83**	**0.91**	**1.11**	**0.95**	**0.79**	**1.06**	**0.90**	**0.96**
		2000-2001											
		0	**50**	**100**	**50**	**100**	**Mean (G.R)**	**0**	**50**	**100**	**50**	**100**	**Mean (G.R)**
		Roots						Roots					
Control		0.37	0.33	0.27	0.31	0.25	**0.31**	0.47	0.34	0.31	0.43	0.32	**0.37**
GA_3	50	0.49	0.37	0.30	0.37	0.31	**0.37**	0.50	0.38	0.36	0.42	0.43	**0.42**
	100	0.56	0.45	0.34	0.48	0.33	**0.43**	0.64	0.56	0.42	0.57	0.51	**0.54**
B_9	50	0.45	0.40	0.31	0.33	0.28	**0.35**	0.52	0.34	0.33	0.51	0.36	**0.41**
	100	0.51	0.42	0.38	0.39	0.35	**0.41**	0.68	0.41	0.33	0.59	0.37	**0.48**
Mean (HM)		**0.48**	**0.39**	**0.32**	**0.38**	**0.30**	**0.37**	**0.56**	**0.41**	**0.35**	**0.50**	**0.40**	**0.44**
		Leaves						Leaves					
Control		0.583	0.460	0.394	0.570	0.460	**0.49**	0.593	0.444	0.358	0.508	0.431	**0.47**
GA_3	50	0.668	0.554	0.465	0.618	0.563	**0.57**	0.732	0.551	0.457	0.470	0.539	**0.55**
	100	0.813	0.795	0.556	0.789	0.618	**0.71**	0.939	0.606	0.500	0.486	0.593	**0.62**
B_9	50	0.646	0.551	0.486	0.595	0.493	**0.55**	0.654	0.463	0.360	0.586	0.435	**0.50**
	100	0.754	0.635	0.520	0.785	0.674	**0.67**	0.783	0.403	0.443	0.661	0.507	**0.56**
Mean (HM)		**0.69**	**0.60**	**0.48**	**0.67**	**0.56**	**0.60**	**0.74**	**0.49**	**0.42**	**0.54**	**0.50**	**0.54**
		Whole plant						Whole plant					
Control		0.953	0.790	1.761	0.880	0.710	**1.019**	1.063	2.173	0.668	0.938	0.751	1.119
GA_3	50	1.158	0.924	0.765	0.988	0.873	**0.942**	1.232	0.931	0.817	0.890	0.969	**0.968**
	100	1.373	1.245	0.896	1.269	0.948	**1.146**	1.579	1.166	0.920	1.056	1.103	**1.165**
B_9	50	1.096	0.951	0.796	0.925	0.773	**0.908**	1.174	0.803	0.690	1.090	0.795	**0.910**
	100	1.264	1.055	0.900	1.175	1.024	**1.084**	1.463	0.813	0.773	1.251	0.877	**1.035**
Mean (HM)		**1.169**	**0.993**	**1.024**	**1.047**	**0.866**	**1.020**	**1.302**	**1.177**	**0.774**	**1.045**	**0.899**	**1.039**

Bioaccumulation of Cd and Pb in plant tissue organs (Tables 13 and 14)

It may be detected the following conclusions:

1- It is worthy to mention that, the upper used soil surfaces of root zone area (0-30 cm) and the used irrigation water seemed to be free from the available Cd, but they can contained relatively some amounts of available Pb. Accordingly, Cd was not detected under Pb treated plants, but *vice versa* was true under Cd treated plants, as sugar beet plant organs accumulated variable levels of Pb which related only to those found in soil root zone and irrigation water. The differences of Pb between those found under control and the foliar application ones must be related to foliage entry of Pb. Also, those amounts of Pb in both soil and irrigation water and the absence of Cd must leading to highly exceeded concentration amounts of Pb, for several times over Cd amounts in different plant organs during different periods of growth, under the variable conditions of both seasons trails. In spite of the highly exceeded accumulation levels of Pb in sugar beet tissue organs for several times over Cd, the relatively trace level accumulation amount of Cd exhibited mostly more retardation effects on plant growth, association with some deterioration effects on some functional processes. The toxic effects of Cd in sugar beet plants mostly exceeded those resulted by Pb. This finding must be supported the idea that, Cd is more toxic than Pb which agreed by most workers (Sorial and Abd El-Fattah, 2001).

2- Leaves always possessed relatively higher levels of Cd or Pb than those corresponding ones in roots. The only exception in this respect, was found in Pb levels during the first sampling date of those plants treated with Pb during only the first season trial, as the roots of Cd and Pb treated plants possessed relatively higher proportion levels with Pb than the leaves. This may be connected with the prevailly variable environmental conditions as it was shown during the first season only and at 120 days after sowing only. As a general the variation in any results either due to the sampling dates or the seasonal alteration was always expected as the complicated environmental factors take a part on the gained results which be varied from year-to-year (Brown *et al.*, 1998; Almas *et al.*, 1999 and El-Nabarawy, 2002) as any plant process is under dynamic changes with the alteration in specific environmental complicated factor(s), which could not be controlled under open field conditions.

3- The levels of Cd or Pb in most plant organs mostly decreased at harvesting stage comparing to those corresponding ones which found at 120 days after sowing. The only exceptions in this respect, the relative increase in Pb levels in leaves treated with Cd or Pb during only the first season trials, but not found under the second ones. The relatively decline in the concentration of Cd or Pb during the later periods of growth seemed to be related to the dilution of the tested HM with progressive increase in plant dry weights which interacted with the relative variable mineral uptake and/or translocation of HM to root during later periods of growth. This dilution may take a part for decline the toxification action of HM, or may be related to partial recovery of the plants.

4- The level of Cd or Pb increased especially in leaves with increasing their foliar application rates either during the first season trials from 20 to 50 mg/l, or during the second ones from 50 to 100 mg/l. however, such levels in roots seemed to show some fluctuation changes in this respect, but mostly sowed higher levels of HM with increasing their application rates. Again this finding gave more support to the idea that the leaves of sugar beet plants seemed to be more or less the most sensitive organ to the foliar application of either Cd or Pb.

Table (13): Changes in cadmium (µg/g D.W.) of sugar beet plant, as affected by combined foliar sprays of different Cd rates with variable GR levels.**

Season		1999-2000							
Period		120 days after sowing			Mean* (G.R)	210 days after sowing			Mean* (G.R)
Element (mg/l) / Growth regulator (G.R) (mg/l)		Cd (mg/l)				Cd (mg/l)			
		0	20	50		0	20	50	
		Roots				Roots			
Control		—	7.5	11	9.3	—	5.5	7.0	6.3
GA_3 50		—	5.0	8.5	6.8	—	4.0	5.5	4.8
NAA 50		—	6.5	10.	8.3	—	5.5	9.0	7.3
B_9 50		—	5.0	8.0	6.5	—	4.0	5.0	4.5
Mean (HM)		—	6.0	9.4	7.7	—	**4.8**	**6.6**	3.7
		Leaves				Leaves			
Control		—	10.0	16.0	13.0	—	10.5	14.0	12.3
GA_3 50		—	8.0	13.5	10.8	—	5.0	5.5	5.3
NAA 50		—	9.5	14.0	11.8	—	9.0	10.0	9.5
B_9 50		—	7.5	11.5	9.5	—	8.0	8.5	8.3
Mean (HM)		—	**8.8**	**13.8**	11.3	—	**8.1**	**9.5**	8.8
		2000-2001							
		0	50	100	Mean (G.R)	0	50	100	Mean (G.R)
		Roots				Roots			
Control		—	7.50	13.00	10.3	—	5.50	9.00	6.8
GA_3	50	—	5.50	10.00	7.8	—	5.00	7.50	6.3
	100	—	4.50	6.50	5.5	—	3.50	4.50	4.0
B_9	50	—	5.50	7.00	6.3	—	4.00	6.50	5.3
	100	—	5.00	6.50	5.8	—	3.00	4.00	3.5
Mean (HM)		—	**5.6**	**8.6**	7.1	—	**4.2**	**6.3**	5.2
		Leaves				Leaves			
Control		—	12.00	20.00	16.0	—	9.00	15.50	12.3
GA_3	50	—	10.00	16.50	13.3	—	6.00	13.50	9.8
	100	—	8.50	15.00	11.8	—	5.00	11.50	8.3
B_9	50	—	10.00	17.00	13.5	—	6.00	12.50	9.3
	100	—	9.00	15.50	12.3	—	5.00	11.00	8.0
Mean (HM)		—	9.9	16.8	13.4	—	6.2	12.8	9.5

* Without Control (0 mg /l)
** Cd was not detected under Pb treatments

5- The foliar applications of GR especially GA_3 and/or some time B_9 decline the proportion accumulation levels of Cd or Pb in most different plant tissue organs, comparing to those untreated corresponding ones. Accordingly, this finding may be lead to the assumption that the role of the tested GR was not only related to their effects as to be antitoxification agence through minimizing HM adverse effects in many processes, but also may be related to their lowering effects on the accumulation levels of Cd or Pb within plant tissues. Also, this finding may indicate that the detoxification action of GR seemed to be mainly through their direct effects on the bioavailability of Cd or Pb.

6- Foliage uptake of Cd or Pb in sugar beet plant could be translocated to roots.

7- The foregain results my be discussed on the following basis:

It is a well known that both essential and non-essential elements may be taken up by leaves, as their aqueous solution prefers enter through leaf cuticle (Marschner, 1986). The cuticular layer functions as weak cation exchanger, due to the negative charges of pectic material and non-esterified cutin polymers (Greger *et al.*, 1993). A distinct gradient from low to high change density occurs from the external surface towards the cell walls, and ion penetration across the cuticle is favoured along this gradient (Yamada *et al.*, 1964).

Table (14): Changes in lead (mg/g D.W.) of sugar beet plant, during different periods of growth, as affected by combined foliar sprays of different HM rates with variable GR levels.

Season		1999-2000											
Period		120 days after sowing						210 days after sowing					
Heavy metal (HM) (mg/l)		Cont.	Cd		Pb		Mean (G.R)	Cont.	Cd		Pb		Mean (G.R)
		0	20	50	20	50		0	20	50	20	50	
Growth regulator (G.R) (mg/l)		Roots						Roots					
Control		0.675	0.580	0.555	1.255	1.410	**0.90**	0.590	0.560	0.545	0.725	0.810	**0.65**
GA_3 50		0.635	0.560	0.500	1.065	1.145	**0.78**	0.555	0.535	0.535	0.655	0.745	**0.61**
NAA 50		0.650	0.640	0.625	1.225	1.365	**0.90**	0.580	0.560	0.540	0.700	0.755	**0.63**
B_9 50		0.625	0.580	0.555	1.185	1.255	**0.84**	0.550	0.535	0.520	0.615	0.730	**0.59**
Mean (HM)		**0.65**	**0.59**	**0.56**	**1.18**	**1.29**	**0.85**	**0.57**	**0.55**	**0.54**	**0.67**	**0.76**	**0.62**
		Leaves						Leaves					
Control		1.455	1.415	1.345	1.555	1.695	**1.49**	0.725	0.665	0.650	0.785	0.845	**0.73**
GA_3 50		1.365	1.315	1.220	1.520	1.595	**1.40**	0.605	0.590	0.590	0.725	0.735	**0.65**
NAA 50		1.425	1.365	1.330	1.610	1.705	**1.49**	0.645	0.630	0.615	0.730	0.740	**0.67**
B_9 50		1.345	1.31	1.270	1.505	1.610	**1.41**	0.665	0.645	0.605	0.725	0.745	**0.68**
Mean (HM)		**1.40**	**1.35**	**1.29**	**1.55**	**1.05**	**1.45**	**0.66**	**0.63**	**0.62**	**0.74**	**0.77**	**0.68**
		2000-2001											
		0	50	100	50	100	Mean (G.R)	0	50	100	50	100	Mean (G.R)
		Roots						Roots					
Control		0.765	0.740	0.725	0.860	0.950	**0.808**	0.485	0.455	0.435	0.525	0.550	**0.490**
GA_3	50	0.740	0.725	0.720	0.845	0.835	**0.773**	0.415	0.400	0.380	0.490	0.515	**0.440**
	100	0.710	0.700	0.685	0.705	0.670	**0.694**	0.400	0.365	0.350	0.480	0.500	**0.419**
B_9	50	0.745	0.715	0.705	0.845	0.890	**0.780**	0.400	0.395	0.375	0.495	0.510	**0.435**
	100	0.735	0.720	0.690	0.830	0.885	**0.772**	0.400	0.385	0.365	0.470	0.500	**0.424**
Mean (HM)		**0.739**	**0.720**	**0.705**	**0.817**	**0.846**	**0.765**	**0.420**	**0.400**	**0.381**	**0.492**	**0.515**	**0.442**
		Leaves						Leaves					
Control		1.425	1.400	1.385	1.690	1.755	**1.531**	0.885	0.815	0.705	1.010	1.045	**0.892**
GA_3	50	1.360	1.255	1.200	1.615	1.655	**1.417**	0.865	0.800	0.650	0.950	0.970	**0.847**
	100	1.305	1.265	1.245	1.540	1.560	**1.383**	0.760	0.710	0.610	0.900	0.910	**0.778**
B_9	50	1.385	1.335	1.275	1.620	1.675	**1.458**	0.845	0.800	0.755	0.945	0.980	**0.865**
	100	1.340	1.280	1.265	1.500	1.575	**1.392**	0.800	0.760	0.720	0.920	0.945	**0.829**
Mean (HM)		**1.363**	**1.307**	**1.274**	**1.593**	**1.644**	**1.436**	**0.831**	**0.777**	**0.688**	**0.945**	**0.970**	**0.842**

This mechanism gives a preferential absorption of cations over anions. The uptake of substance through the cuticle is promoted by high relatively humidity, e.g., by rain, dew and fog, since the cuticle is then in its most open and swollen condition and the passage of water solution substance increased (Martin and Juniper, 1970). Heavy metals are absorbed by the leaves to different degrees, depending upon many internal and/or external environmental factors in addition to the used metal species involved (Hemphill and Rule, 1978). Cd showed a greater leaf penetration than Pb, which is mostly adsorbed to the waxes at the leaf surface (Little and Martin, 1972). Both used HM affected the cell membrane desfunctional and integrity (Sorial and Abd El-Fattah, 2001), and that may play a part for the diffusion of more toxic elements through leaf cells into the inner tissues; and it was proposed that, GA_3 and/or B_9 seemed to have a partial protection action on the integrity of membrane, thus decrements in the absorption of excess Cd or Pb may be gained.

The absence of Cd under control-treated plants or those receiving Pb may be indicated that the air beside irrigation water and soil under over tested area during the course of this study seemed to be free from Cd contamination. In addition, the level of Pb in control plant organs, must be resulted from those amounts found in soil and irrigation water. The differences between the levels of Pb in control plant minus those of Pb foliar application were the net gain of Pb foliar uptake. This amount of Pb foliar uptake was varied according to the used level of Pb application.

REFERENCES

Abd El-Hamid, M.F.; Abd El-Hadi, Nadia I.M.; Ahmed, Rokaia, B. and E.M. Soliman (1992 a). Response of grape (*Vitis vinifera*, L.) seedlings to the interaction effects of soil moisture stress and some growth retardants. Poc., 5th Bot. Conf. Saint Catherine, April 28-30, Sinai, Egypt, 443-457.

Abd El-Hamid, M.F.; Ahmed, Rokaia B.; Abd El-Hady, Nadia I.M. and I.S.Amin (1992 b). Response of pomegranate (*Punica granatum*) seedling to the interaction effects of soil moisture stress and some growth retardants. Pro., 5th Bot.Conf.Saint Catherine, April 28-30, Sinai, Egypt, 459-475.

Abo-Kassem, E.; A. Sharaf El-Din; J. Rozema and E.A. Foda (1995). Synergistic effects of cadmium and NaCl on the growth, photosynthesis and ion content in wheat plants. Biol.Plant.,37:241-249.

Aidid, S.B. and H. Okamato (1992). Effect of lead, cadmium and zinc on the electric membrane potential at the xylem symplast interface and cell elongation of *Impatiens balsamina*. Environ. and Exp. Botany, 32: 439-448.

Allen, L. B.; P. H. Sitonen and H. C. Thomposon (1997). Methods for the determination of arsenic, cadmium, copper, lead and tin in sucrose, corn syrups and high fructose corn syrups by inductively coupled plasma atomic emission spectrometry. J. Agric. Food Chem., 45 (1): 162-165.

Almas, A.; B.R. Sing and B. Salbu (1999). Mobility of cadmium-190 and zinc-65 in soil influenced by equilibration time, temperature, and organic matter. J. Environ. Qual., 28: 1742-1750.

A. O. A. C. (1985). Official Methods of Analysis. Association of Official Agriculture Chemists., 14th Edition, Washington, D,C., U.S.A.

Babu, E. and V.P. Singh (1992). Triadimefon ameliorated cadmium toxicity in wheat seedlings. Indian J. of Plant Physiol., 35 (2): 195-197.

Barcelo, J.; M. D. Vazquez and Ch. Poschenrieder (1988). Cadmium-induced structural and ultrastructural changes in the vascular system of bush bean stems. Bot. Acta, 101: 254-261.

Bazzaz, F.A.; R.W. Carlson and G.L. Rolfe (1974). The effect of heavy metals on plants. I. Inhibition of gas exchange in sunflower by Pb. Cd and Tl. Environ. Pollut., 7: 241-246.

Black, C.A. Ed (1965). Methods of Soil Analysis, Part 2, Amer. Soc. of Agronomy, Madison, Wisconsin, USA.

Brown, S. L.; R. L. Chaney; J. S. Angle and J. A. Ryan (1998). The Phyto-availability of cadmium to lettuce in long-term biosolids-amended soils. J. of Environ. Quality, 27: 1071-1078.

Brown, J. D. and O. Lilliand (1964). Rapid determination of potassium and sodium in plant material and soil extracts by Flamphotometry. Proc. Amer. Soc. Hort. Sci., 48: 341-346.

Buwalada, J.G.; T.G.A. Green and J.P. Curtis (1992). Canopy photosynthesis and respiration of Kiwi fruit (*Aclinidia deliciosa* var. deliciosa) vines growing in the field. Tree Physiol., 10: 327-341.

Causton, D. R. and J.C. Venus (1981). The biometry of plant growth. Edward Arnald Publishers,Ltd, London WCIB, 18-22.

Chapman, H. D. and F. P. Pratt (1961). Methods of analysis for soils, plants and water. Univ. of California, Div. of Agric. Sci.

Clijsters, H. and F. Van Assche (1985). Inhibition of photosynthesis by heavy metals. Photosynth. Res., 7: 31-40.

El-Nabarawy, Amera, A. A. (2002) Uptake and Physiological effects of cadmium in spinach (*Spinacia oleracea*, L) related to mineral provision Annals of Agric. Sci., Moshtohor, 40 (1): 153-180.

Erjala, M. and R. Ervio (1994). Heavy metal concentrations in sugar beet fields and sugar beet in Finland. . (BiBlio graphic Citation). Proceedings of the 1994 Sugar Processing Research Conference Helsinki, Finland, 7-9 August 1994, 151-169.

Fouda, R.A. and A.A. Arafa (2002). Alleviation of cadmium toxicity on soybean, *Glycine max* (L) Merr. by inoculation with Bradyrhizobium and Veicular-Arbuscular mycorrhizae or kinetin. J. Agric. Sci., Mansoura Univ., 27 (11): 7385-7403.

Ghayad Nemat, I. (2001). Contamination of soil with heavy metals and the consequent implications on plant growth. Ph. D. Thesis, Fac. of Agric., Moshtohor, Zagazig Univ. (Banha branch), Egypt.

Greger, M.; E. Brammer; S. Lindberg; G. Larsson and J.I.Almquist (1991). Uptake and physiological effects of cadmium in sugar beet (*Beta vulgaris*) related to mineral provision.J.of Exp.Botany,42(239):729-737

Greger, M. and M. Johansson (1992). Cadmium effects on leaf transpiration of sugar beet (*Beta vulgaris*). Physiol. Planta., 86: 465-473.

Greger, M.; M. Johansson; A. Stihl and K. Hamza (1993). Foliar uptake of Cd by pea (*Pisum sativum*)and sugar beet (*Beta vulgaris*). Physiol. Planta., 88 (4): 563 – 570.

Greger, M. and E. Ogren (1991). Direct and indirect effects of Cd^{2+} on photosynthesis in sugar beet (*Beta vulgaris*). Physiol. Planta., 83 (1):129-135.

Guo, Y.; H. Marschner and Y.T. Gue (1995). Uptake, distribution, and binding of cadmium and nickel in different plant species. J. Plant Nut., 18: 2691-2706.

Hartley, J.; J.W.G. Cairney; P. Freestone; C. Woods and A.A. Meharg (1999). The effects of multiple metal contamination on ectomycorrhizal Scots pine (*Pinus sylvestris*) seedlings. Environ. Poll., 106: 413-424.

Hegazy, Sanaa A. M. (2001). Some physiological studies on the effects of cadmium, nickel and zinc pollutants of faba bean and radish plants. Ph. D. Thesis, Fac. of Agric., Cairo Univ., Egypt.

Hemphill, D.D. and J. Rule (1978). Foliar uptake and translocation of ^{210}Pb and ^{109}Cd. –1nt. Conf. Heavy Metals Environ., Symp. Proc. II (1). Toronto. Ont., 1975. pp. 77-86.

Jackson, M.L. (1973). Soil Chemical Analysis, Pretic-Hall of Indian Private limited, New Delhi.

Kahle, H. (1993). Response of roots of trees to heavy metals. Environ. Exp. Bot., 33: 99-119.

Kalita , M. C.; P. Devi and I. Bhattacharya (1993). Effect of cadmium on seed germination, early seedling growth and chlorophyll content of *Triticum sativum*. Indian J. of Plant Physiol., 36 (3): 189-190.

Keshan, U. and S. Mukherji (1992). Effect of cadmium toxicity on chlorophyll content, Hill activity and chlorophyllase activity in *Vigna radiata* l. leaves. Indian J. of Plant Physiol., 35: 225-230.

Krupa, Z. and T. Baszynski (1995). Some aspects of heavy metals toxicity toward photosynthetic apparatus-direct and indirect effects on light and dark reaction: a review. Acta Physiol. Plant., 17: 177-190

Krupa, Z. and M. Moniak (1998). The stage of leaf maturity implicates the response of the photosynthetic apparatus to cadmium toxicity. Plant Science Limerick, 138 (2): 149-156.

Krupa, Z.; G. Oquist and P. Huner (1992). The influence of cadmium on primary Photosystem II Photochmistry in bean as revealed by chlorophyll a fluorescence-a preliminary study. Acta Physiol. Planta., 14 (2): 71-76.

Krupa, Z.; G. Oquist and P. Huner (1993). The effects of cadmium on photosynthesis of *Phaseolus vulgaris* -(a) fluorescence analysis. Physiol. Plant., 88: 626- 630.

Kupper, H.; F. Kupper and M. Spiller (1998). *In situ* detection of heavy metal substituted chlorophyll's in water plants. Photo. Rese., 58 (2): 123-133.

Lanaras, T.; M.Moustakas; L. Symeonidis; S. Diamantoglou and S. Karataglis (1993). Plant metal content,growth responses and some photosynthetic measurements on field-cultivated wheat growing on ore bodies enriched in Cu. Physiol. Plant., 88: 307-314.

Landberg, T. and M. Greger (1994). Influence of selenium on uptake and toxicity of copper and cadmium in pea *(Pisum sativum)* and wheat (*Triticum sativum*). Physiol. Plant., 90: 637- 644.

Lang, F.; E. Sarvari; Z. Szigeti; F. Fodor and E. Cseh (1995). Effects of heavy metals on the photosynthetic apparatus in cucumber. In: Mathis, P. (ed.), Photosynthesis: from light to biosphere. IV, pp 533-536, Kluwer Academic Publishers, Dordresht-Boston- London.

Larsson, E. H.; J.F. Bornman and H. Asp (1998). Influence of UV-B radiation and Cd on chlorophyll fluorescence, growth and nutrient content in *Brassica napus*. J. Exp. Botany, 49 (323): 1031-1039.

Lindim, C.; A. de Varennes; M.O. Torres and A.M. Mota (2001). Remediation of sandy soil artificially contaminated with cadmium using a polyacrylate polymer. Commun. Soil Sci. Plant Anal., 32 (9&10): 1567-1574.

Lindsay, W.I. and W.A. Norvell (1978). Development of DTPA soil test zinc, iron, manganese and copper. Soil Sci. Amer. J., 42: 421-428.

Little, P. and M.H. Martin (1972). A survey of zinc, lead and cadmium in soil and natural vegetation around a smelting complex. Environ. Pollut., 3:241-254.

Lukaszek, M. and J.W. Poskuta (1998). Development of photosynthetic apparatus and respiration in pea seedlings during greening as influenced by toxic concentration of lead. Acta Physiol. Plant., 20 (1). 35-40.

Malik, D.; I. S. Sheoran and R. Singh (1992 a). Carbon metabolism in leaves of cadmium – treated wheat seedlings. Plant Physiol. Biochem., 30: 223-229.

Malik, D.; I. S. Sheoran; R. Singh ; S. Randir and M. Darshan (1992 b). Lipid composition of thylakoid membranes of cadmium treated wheat seedlings. Indian J. of Biochem. and Biophysics, 29 (4): 350-354.

Marschner, H. (1986).Uptake of mineral elements by leaves and other aerial plant parts. In: Mineral Nutrition in Higher Plants. (H. Marschner, Ed.),pp. 103-114. Acadenic Press, London.

Martin, T.J. and E.B. Juniper (1970). The cuticles of plants. Edward Arnolds Ltd, Edinburgh. ISBN 0-7131-2245-5.

Michalska, M. and H. Asp (2001). Influence of lead and cadmium on growth, heavy metal uptake, and nutrient concentration of three lettuce cultivars grown in hydroponic culture. Commun. Soil Sci. Plant Anal., 32 (3&4): 571-583.

Mishro, S.; S. Bhutani and D.B. Singh (1994). Influence of nitrate supply on cadmium toxicity in *Brassice Juncea* during early seedling growth. Indian J. of Plant Physiol., 37:12-16.

Moftah, A.E.; A.A. Gendy and E.M. Eid (1992). Effect of some sources of pollution on tomato plants. 1. Growth analysis, yield and anatomy. J. Pest Control and Environ. Sci., 4 (2): 1-24.

Nellessen, J.E. and J.S. Fletcher (1993).Assessment of published literature on the uptake, accumulation, and translocation of heavy metals by vascular plants. Chemosphere, 9:1669-1680.

Obata, H. and M. Umebayashi (1997). Effect of cadmium on mineral nutrient concentrations in plant differing in tolerance for cadmium. J. of Plant Nut., 20:97-105.

Olsen, S.R.; C.V. Cole; F.S. Watanabe and L.A. Dean (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dep. Of Agric., Circ., 939.

Ouzounidou, G.; M. Moustakas and E.P. Eleftheriou (1996). Physiological and ultra-structural effects of cadmium on wheat (*Triticum destivum* L.) leaves. Archives of Environ. Contam. And Toxico., 32 (2): 154-159.

Popovic, M.; S. Kevreson; J. Kandrac; J. Nikolic; N. Petrovic and R. Kastori (1996). The role of sulphur in detoxication of cadmium in young sugar beet plants. Biol. Planta., 38(2):281- 287.

Poschenrieder, Ch.; B. Gunse and J. Barcelo (1989). Influence of cadmium on water relation, stomatal resistance, and abscisic acid content in expanding leaves. Plant Physiol., 90: 1365-1371.

Prochnow, L.I; L.P.M. Plese and M.F. Abreu (2001). Bioavailability of cadmium contained in single superphosphates produced from different Brzilian raw materials. Commun. Soil Sci Plant Anal.,32 (1&2):283-294.

Quariti, O.; H. Gouia and M.H. Ghorbal (1997). Responses of bean and tomato plants to cadmium: growth, mineral nutrition and nitrate reduction. Plant Physiol. and Biochem., 35: 347-354.

Salim, R.; M. Al-Suba and A. Atallah (1993). Effect of root and foliar treatments with lead, cadmium and copper on the uptake, distribution and growth of radish plants. Environ. Intern., 19: 393-404.

Salim, R.; M. Isa; M Al-Subu.; S.A. Syrafi and O. Syrafi (1995). Effect of irrigation with lead and cadmium on growth and on the metal uptake of cauliflower, spinach and parsley. Journal. of Enviro. S ci. a nd H ealth. Part A, Environ. Sci. and Engineering, 30: 831-849.

Salisbury, F.B. and C.W. Ross (1992). Plant Biochemistry. In: Plant Physiology. 4^{th} ed . pp. 189-326, Wadsorth Pub. Co.

Salt, D.E.; M. Blaylock; N.P.B.A. Kumar; V. Dusenkov; B.D. Ensley; I. Chet and I. Raskin (1995). Phytoremediation: A novel strategy for the removal of toxic metals from the environment using plants. Bio. Technol., 13:468-474.

Schickler, H. and H. Caspi (1999). Response of antioxidative enzymes to Nickel and Cadmium stress in hyperaccumulator plants of genus *Alyssum*. Physiol. Plant., 105:39-44.

Schlegel, H.; D. L. Godbold and I. Huttermann (1987). Whole plant aspects of heavy metal induced changes in CO_2 uptake and water relations of spruce (*Picea abies*) seedling. Physiol. Plant., 69: 265-270.

Singh, N.; S.N. Singh; M. Yunys and M. Ahmad (1994). Growth response and element accumulation in (*Beta vulgaris* L.) raised in Fly – ash amended soils. Ecotoxicology, 3(4): 287-298.

Smolders, E.; R.M. Lambergts; M.J. McLaughlin and K.G. Tiller (1998). Effect of soil solution chloride on cadmium availability to Swiss chard. J. Environ. Qual., 27: 426-431.

Snedecor, G. W. and W.G. Cochran (1980). Statistical Methods.Seventh ed., Iowa State Univ. Press, Ames, Iowa, USA, pp.255-269.

Somashekaraiah, B. V.; K. Padnaja and A. R. K. Prasad (1992). Phototoxicity of cadmium ions on germination seedling of mung bean, involvement of lipid peroxides in chlorophyll degradation. Physiol. Plant., 85: 85-89.

Sorial, Mervate a nd M . A . A bd E l-Fattah (2001). A lleviation o f t he a dverse effect of lead and cadmium on growth and chemical changes of pea plant by phosphorus and calcium treatments. J. Pest Cont. & Environ. Sci., 9 (4) : 161-194.

Steffens, J.D. (1990). The heavy metal-binding peptides of plants. Annu. Rev. Plant Physiol. Mol. Biol., 41: 533-575.

Symeonidis, L. and S. Karataglis (1992). Interactive effects of cadmium, lead and zinc on root growth of two metal tolerant genotypes of *Holcus lanatus* L. Biometals, 5: 173-178.

Tlustos, P.; D. Pavlikova; J. Balik; J. Szakova; A.Hanc and M. Balikova (1998). The accumulation of arsenic acid and cadmium in plants and their distribution. Rostlinna-Vyroba.(Czech Republic), 44(10): 463-469.

Toppi, S.L.; M. Lambardi; B. Pecchioni; L. Pazzagli; M. Durante and R. Gabbrielli (1999). Effects of cadmium stress on hairy roots of *Daucus carota*. J. Plant Physiol., 154: 385-391.

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

Verkleij, J.A.C. and H. Schat (1990). Mechanisms of metal tolerance in higher plants,-In Heavy Metal Tolerance in Plants: Evolutionary Aspects (A.J. Shaw, Ed) pp 179-193. CRC Press, Boca Raton, FL. ISBN 0-8493-6852-9.

Wattestein, D. (1957). Chlorophyll-lethal und der submikrostopiche formwechel der plastiden. Exp. Cell Res., 12: 427-433.

Wong, C.K.C.; R.Y.H. Cheung and M.H. Wong (2000). Heavy metal concentrations in green-lipped mussels collected from Tolo Harbour and markets in Hong Kong and Shenzhen.Envi. Pollut., 109:165-171.

Yamada, Y.; M.J. Bukovac and S.H. Wittwer (1964). Jonbinding by surfaces of isolated cuticular membrane. Plant Physiol., 39: 978-982.

Zaman, M. S. and F. Zereen (1998). Growth response of radish plants to soil cadmium and lead contamination. Bull. Environ. Conta. and Toxicol., 61 (1): 44-50.

التحكم في الإجهاد الفسيولوجي الناشئ عن الإضافة الورقية للكادميوم و الرصاص علي نبات بنجر السكر باستخدام الرش الورقي ببعض منظمات النمو.

محمد فوزي عبد الحميد*، أميرة عبد الفتاح عبد الله النبراوي*، عبد الحميد عبد الحميد جابر ** و أمل محمد كامل**

*** كلية الزراعة بمشتهر – جامعة الزقازيق فرع بنها – قسم النبات الزراعي**

**** مركز البحوث الزراعية – معهد المحاصيل السكرية**

يعتبر كل من الكادميوم و الرصاص من العناصر المعدنية الثقيلة – اللينة- غير الاساسية و هما من المشكلات العالمية الخطيرة علي البيئة و المتزايدة عام بعد الأخر نتيجة لزيادة النشاط البشري. و هما من ملوثات الهواء و التي تتساقط رواسبها علي اسطح الارض بما في ذلك تساقطهما علي أسطح المجموع الخضري الهوائي للكساء الخضري و تمتصها تلك الاعضاء الخضرية للاوراق و يمثل هذا جزءاً هاماً من دخولهما الي داخل الانسجة النباتية مما يؤدي إلى أضرار و تسمم فسيولوجى لهذه النباتات المعرضة لتلك الرواسب. و لما كانت المعلومات المتاحة حالياً عن الامتصاص الورقي لتلك الملوثات المعدنية ضئيل فقد اقيمت تجربتين حقليتين خلال موسمي النمو ١٩٩٩- ٢٠٠١ لإيجاد العلاقة بين الرش الورقي لتركيزات متباينة من هذين العنصرين بجانب الرش الورقي ببعض منظمات النمو للتغلب علي اثارهما الضارة علي صحة النبات مع امكان الحد من امتصاصهما لما في ذلك من اضرار جسيمة علي صحة الإنسان عند تناوله الغذاء الملوث بهما خلال السلسلة الغذائية له.

هذا و قد كانت المعاملات من كل من العنصرين المعدنيين و منظمات النمو كالاتي: ٢٠ و ٥٠ ملجرام/ لتر من كل عنصر علي حدة بجانب معاملة المقارنة صفر خلال الموسم الاول بينما كانت تلك التركيزات في الموسم الثاني هي ٥٠ و ١٠٠ ملجرام/ لتر لكل عنصر علي حدة – بينما كانت تركيزات منظمات النمو في الموسم الاول هي ٥٠ ملجرام/ لتر من كل من حمض الجبريلك او النفثالين حمض الخليك او ثنائي ميثايل حمض السكسنامك (B_9)، بجانب أيضاً معاملة المقارنة. اما في الموسم الثاني فقد كانت تلك التركيزات هي ٥٠ او ١٠٠ ملجرام/ لتر لكل من منظمي النمو الاول و الثالث بجانب معاملة المقارنة و تم استبعاد النفثالين حمض الخليك لما له من تاثير ضعيف خلال الموسم الاول. هذا و قد اضيفت تلك التركيزات علي صورة رش ورقي حيث اضيفت معاملات منظمات النمو أولاً علي اوراق بنجر السكر ثم اعقبها الرش بمعاملات العناصر الثقيلة بعدها بأربع و عشرين ساعة و قد تم رشها عندما بلغ عمر النبات ٦٩- ٧٠ يوم من الزراعة. هذا و قد اعيد الرش مرة اخري بنفس هذا التتابع بعد ٢١ يوم من الرشة الاولي خلال موسمي النمو. هذا و يمكن تلخيص النتائج فيما يلي: (١) تمتص اسطح اوراق نبات بنجر السكر كلا العنصرين بدرجات متفاوتة حسب التركيز المستخدم منهما و يتوقف ذلك حسب العنصر المستخدم ايضاً. و قد تنتقل تلك العناصر الي الجذر. (٢) و تظهر تلك العناصر الممتصة لسميتها علي نمو نبات بنجر السكر علي صورة نقص في النمو خاصة علي المساحة الكلية للاوراق و التي يصاحبها نقص في تركيز صبغات التمثيل الضوئي مع الانخفاض الشديد في المساحة النسبية النوعية للاوراق (SLA) و اضطراب في الاتزان المائي للاوراق (نسبة غضاضة الاوراق) بجانب انخفاض نسبة تراكم السكريات فـ الجذور و نقص في امتصاص كل من العناصر الغذائية التي درست و هي ن، فو، بو، ص، و لذلك فقد استنتج من ذلك ان الفعل السام لتلك العناصر يتركز بصفة اساسية علي الدور الفسيولوجي للاوراق و خواصها حيث يبدو انها اكثر الاعضاء حساسية لسمية تلك العناصر و التي انعكس اثرها الي الإضرار بالعمليات الاخري الفسيولوجية المصاحبة لها و تزداد هذه الاضرار بزيادة تركيز تلك العناصر السامة، هذا و قد تبين ان عنصر الكادميوم اكثر سمية علي نبات بنجر السكر من عنصر الرصاص في كثير من الاحوال. (٣) لقد اظهر الرش باستخدام منظمات النمو خاصة حمض الجبريلك و ربما ثنائي ميثايل حمض السكسنامك تاثيرات نسبية مضادة لسمية عنصري العناصر الثقيلة المستخدمة و يمكن استخدامها كمضادات لسمية هذه العناصر علي نبات بنجر السكر الي حد معين مما يؤثر علي انخفاض سميتها و كذلك امتصاصها و تراكمها و ذلك من خلال واحد او اكثر من مظاهر السمية التي ذكرت من قبل. و يتوقف ذلك علي التركيزات المستخدمة من كلا العنصرين و التركيزات المصاحبة لها من منظمي النمو. (٤) في النهاية لا يمكن التنبؤ بالفعل الاولي الذي ينشأ عنه سمية عنصري المعادن الثقيلة المستخدمة و الفعل النسبي الجابح لمنظمات النمو لهذه السمية حيث ينشأ العديد من التغيرات الثانوية المتعاقبة. (٥) في النهاية ايضاً يمكن ان نوصي باستخدام حمض الجبريلك عند تركيز ١٠٠ ملجرام/ لتر رشاً علي اوراق بنجر السكر كعامل مضاد للتاثير السام للعناصر الثقيلة التي تتساقط رواسبها علي الاوراق. الا انه يجب اجراء المزيد من التجارب في هذا الخصوص حتي يمكن الاجابة علي كثير من التساؤلات التي يجب توضيحها في هذا الشأن.