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RESPONSE OF SESAME PLANTS GROWN IN LEAD POLLUTED SOIL TO HUMIC ACID AND MAGNETIC SEEDS TREATMENTS

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ABSTRACT: *Two pots experiments were carried out in the Experimental Farm, Fac. of Agric., Shibin El-Kom, through the successive summer seasons of 2008 and 2009 to study the individual and combined effect of magnetic seeds (MS), humic acid (HA) and lead (Pb) on sesame plant growth, photosynthetic pigments, yield and yield quality. The experimental soil in the experiments was non-saline and characterized by clay texture, low contents of OM and $CaCO_3$ (%). Humic acid was used at rates of 0 and 500 mg/kg, the Pb was applied at rates of 0, 500, 1000 and 1500 mg Pb/kg as acetate form. Plant samples were taken after 90 days from planting and at harvest. The obtained results indicated that lead treatments negatively affected plant height, number of capsules, dry weight of roots and shoots. Photosynthetic pigments (chl. a + b and carotenoids), seed yield, oil yield and the contents of N, P and K were sharply decreased by increasing lead levels On the other hand, height of the first capsule and the content of Pb were increased with the increase of added Pb where its decreased with the treatments of magnetic seed and HA.. The magnetic seed and humic acid treatments individual and combined significant increase in most tested parameters compared with zero Pb. With different treatments under study, oil was free from Pb. Humic acid, magnetic seeds and its combination not only alleviated the deleterious effects of lead and improved seed productivity and its quality.*

Key words: *Sesame, Magnetic seeds, Humic Acid, Lead, Yield, Oil and Chemical composition.*

INTRODUCTION

Sesame (*Sesamum indictum*, L) is one of the most important crops grown for oil production in Egypt. The crop is grown for its seeds, which contain more than 50% of excellent edible semi-drying oil (Abo El-Wafa and Abd El-Lattief, 2006).

Humic acid is one of main fractions of soil organic matter contains many essential nutrients which improve the soil fertility and increasing the availability of these nutrients and consequently affected plant growth, yield and its chemical composition (Stevenson, 1994). Humic acid particularly is used to remove or decrease the negative effects of chemical fertilizers and some chemical form in the soil (Alloway, 1995). Also, humic acid reduces other fertilizer requirements, increases yield in crops, improved drainage, increases aeration of the soil, increase the protein and mineral contents of most crops and establish a desirable environment for microorganisms development (Salman *et al.,* 2005). The application of humic acid has been reported also to improve plant growth, increase fruit yield and quality in squash plants (Hafez, 2004).

The toxicity of heavy metals is a problem for ecological, evolutionary and environmental reasons (Nagajyoti *et al.,* 2008 and El-Shall, 2010). Inhibition of germination and retardation of plant growth are commonly observed due to lead toxicity (Iqbal and Shazia, 2004 and Tantawy, 2004). Lead produced highly significant effects on shoot, root lengths and seedling dry biomass of *Lythrum salicaria* (Joseph *et al.,* 2002). Rense traffic releases detrimental exhaust gases and toxic pollutants like unburnt and partially burnt hydrocarbons, lead compounds and other elements that are contained in petrol polluting the city environment (Iqbal *et al.,* 2001).

Heavy metals tend to form complexes with organic matter (humic and fulvic acids) in the soil that are different for each metal. Organic matter plays an important role not only in forming complexes but also in retaining heavy metals in an exchangeable form (Barancikovà and Makovniková, 2003 and Abou El-Khir *et al.,* 2005).

Magnetic energy is one type of the energy which exists in the universe. The earth is surrounded by magnetic variable which has an effect on all things with leveled markers and this energy is very important for living on the land to the living parts. It was found that, the magnetic treatments alter the water relations in seeds, in the ionic concentration and osmotic pressure and water uptake rate by seeds and this affects the germination rate of seeds (Garcia-Reina *et al.,* 2001).

So, the aim of this work was carried-out to investigate the individual or combined effect of both humic acid and magnetation seeds of sesame plant grown in high contamination of lead on plant growth, chemical composition and oil yield.

MATERIALS AND METHODS

Two pots experiments were conducted at the Experimental Farm, Faculty of Agriculture, Minufiya University during the summer seasons of 2008 and 2009. The investigation was carried out to study the individual and combined effects of humic acid, lead and magnetic seeds on plant growth, photosynthetic pigments chemical constituents, yield of seeds and oil yield of sesame (*Sesamum indictum,* L.) plant.

The used soil in this study represented a fertile clay soil which collected from the surface layer (0 – 20 cm) of Experimental Farm, Faculty of Agricultural, Minufiya University, Shibin El-Kom, Egypt. The collected soil samples air-dried, ground, good mixed and sieved through a 2 mm sieve. The main physical and chemical properties of this soil and also its content of total and available Pb were determined according to the international methods described by Black *et al.* (1965), Cottenie *et al.* (1982) and Page (1982). The obtained data were recorded in Table (1). Also, the chemical composition of the used humic acid (HA) in this study was listed in Table (2). This humic acid was isolated from alluvial soil and characterized according to the methods described by Kononova (1966) and Stevenson (1982 and 1994).

Table (1): Some physical and chemical properties of the used soil.

Particles size distribution (%)				Teatural grade	OM%	CEC meq/100 g	$CaCO_3$ %	pH (1 : 2.5) soil : water susp.
C. sand	F. Sand	Salt	Clay					
7.8	131	33.1	46.0	Clayey	2.15	40.3	1.58	7.15

EC dSm^{-1}	Soluble cations (meq/100g)				Soluble anions (meq/100 g)				Pb content (mg/kg)	
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	CO_3^{2-}	HCO_3^{-}	$SO_4^{=}$	Total	Available
0.64	1.36	0.91	1.29	2.84	4.55	0.00	0.65	1.20	24.5	1.46

Table (2): The chemical composition of one used humic acid.

Elemental composition (%)						Elemental ratio			Ash content (%)
C	N	H	O	P	Pb	C/N	C/H	C/P	
40.50	3.11	6.25	43.63	0.51		19.95	7.44	91.18	3.05

Total acidity	Functional groups				CEC meq/100 g acid
	COOH	Total OH	Phenolic OH	Alcoholic OH	
890.5	440.2	664.8	450.3	214.5	692.5

A plastic pots (48 pot) with 50 cm diameter and 30 cm depth were used in this study. Each pot was filled by 14 kg of the used fine soil. Then all pots were fertilized by ordinary superphosphate (15.5% P_2O_5) at rate of 300 kg / fed (4.2 g/pot). These pots were divided into two equal main groups (24 pot/main group). The pots of the first main group were planted by unmagnetuted seeds, where the pots of the second main group were planted by magnetuted seeds. Magnetic funnel (Fig. 1) for treating seeds (Magnetic Technologies L.L.C at. Dubai) as described by Hilal and Hilal (2000). The pots of each main group were divided into two equal sub group (12 pot / sub group). The pots of the first sub group were untreated by humic acid (HA) and the pots of the second sub group were treated by HA at rate of 500 mg / kg^{-1}. After that, the pots of each sub group were divided into equal four sub sub groups (3 pots / sub sub group). The pots of each sub sub group were treated by one of the tested lead (Pb) levels which were 0, 500, 1000 and 1500 mg / kg in Pb-acetate form. The tested levels of Pb were equal 0, 100, 200 and 300% of Pb toxic lead (Kabata-Pendias and Pendias, 1992). The pots were arranged in a split split design with three replicates. Each pot was planted by 10 seeds of unmagnetated or magnetated seeds of sesame (*Sesamum indictum* L.).

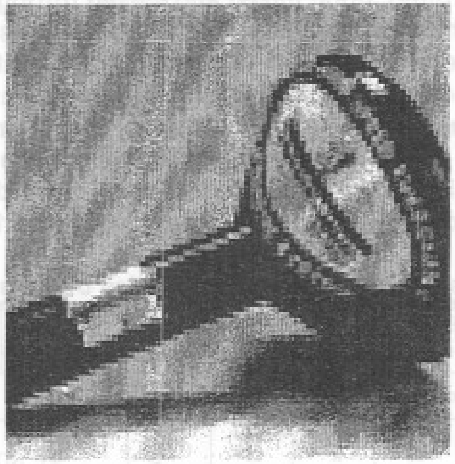

Fig. 1 : Magnetic funnel.

The pots were irrigated by tap water at 60% of WHC (water holding capacity) of the used soil. Both HA and Pb were applied to the soil in solution form with irrigation water at the first irrigation. The irrigation process was carried out every three days to kept the moisture content at 60% of WHC. After 20 days of planting, the plants of each pot were thinned at 5 plants / pot. Then all pots were fertilized by ammonium nitrate (33.5% N) as N fertilizer at rate of 200 kg/fed (2.8 g/pot) and also the pots were fertilized by potassium sulphate (48% K_2O) as K fertilizer at rate of 150 kg/fed (2.1 g/pot).

Plant samples were successively taken randomly from every treatment at 90 days after sowing. Three plants were taken out carefully from each treatment and the following determinations were carried out.

Growth Characters:

Growth characters such as plant height (cm), number of the capsules/plant, the height of the first capsule (cm) and dry weight of roots and shoots (dried at 70°C for 72 hrs.), g/plant were estimated.

Photosynthetic Pigments:

Photosynthetic pigments were estimated in fresh leaves as described by Witham *et al.* (1971).

Minerals Content:

Oven-dried of plant samples were ground. A 0.5 g of each plant sample (roots, shoots and seeds) was digested by mixture of H_2SO_4 + $HClO_4$ at ratio of 3 : 1 according to the method described by Chapman and Pratt (1961) until the digestion become colorless. Then this digestion was diluted by distilled water up to 50 ml. The digestion contents of N, P, K and Pb were determined using the methods described by Cottenie *et al.* (1982) and Page (1982).

Yield:

At harvest time (about 150 days after sowing), the plants of each pot were harvested as a whole. The seed yield g/plant were weighted . Also, the weight (g) of 1000 seed was measured

Oil Seeds Yield And Its Content of Pb:

Oil seeds content was extracted from the seeds and determined using Sothlet method (AOAC, 1990). Portion of extracted oil was digested using the acid mixture of conc. H_2SO_4 : $HClO_4$ at mixed ratio of 3 : 1 according to the method described by (Chapman and Pratt, 1961). The digestion content of Pb (oil) was determined using atomic absorption spectrophotometer according to the methods described by Page (1982).

The obtained data were statistically analysis using the CO - STAT program and L.S.D test at the probability level of 5% was calculated according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth Characters:

The presented data in Table (3) showed that individual and combined effect of magnetic treatments and different applications of humic acid in soil polluted with lead on the studied characters of vegetative growth. The recorded data showed that, the treatments of magnetic seeds and humic acid individually or in combination resulted in a significant increase of both plant height, number of capsules and dry weight of roots and shoots in the two growth seasons. These increases revealed that, the treatments of magnetic seeds played a major role in increasing rate of seeds germination. This may be due to that magnetic treatments have an enhancing effect on water relations in the rhizosphere area, hence the availability and absorption of nutrients could be enhanced leading to more initiation and elongation of stem cells (Mostafa, 2002). On the other hand, the positive effect of humic acid on plant height, number of capsules and dry weight of roots and shoots was attributed to its content of nutrients and also to its effect on the increase of nutrition availability, humic acid plays an important role as a synthesis material for plant growth (Abou Hussien, 1997 and 2000 and Hafez, 2004). Other studies by El-Gundy (2005) mentioned that, humic acid application improved soil physical and chemical properties. The similar results were obtained by Hartwigson and Evans (2000).

Table (3): Combined effect of magnetic seeds (MS), humic acid (HA) and lead (Pb) on some vegetative growth characters of sesame plants in the two growth seasons (2008 – 2009).

Treatments			Plant height (cm)		Height of the first capsulate (cm)		Number of capsules / plant		Dry weight of Roots (g/plant)		Dry weight of Shoots (g/plant)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	0	88.30	84.00	39.00	33.30	39.00	35.70	0.78	0.61	5.38	6.36
		500	91.00	80.70	41.00	36.00	34.00	34.00	0.78	0.60	5.41	6.02
		1000	78.30	75.70	45.00	40.00	30.00	30.00	0.59	0.38	3.98	5.12
		1500	70.30	70.70	48.00	41.70	27.00	26.00	0.53	0.32	3.19	4.19
		Mean	82.00	77.80	43.30	37.80	32.50	31.43	0.67	0.48	4.49	5.42
	500	0	100.00	86.00	36.30	30.30	40.22	40.70	0.90	0.85	6.34	7.05
		500	100.00	92.70	36.30	30.00	41.00	40.30	0.91	0.86	6.12	7.11
		1000	90.00	81.00	39.30	38.70	35.40	35.30	0.80	0.70	5.85	6.06
		1500	80.00	75.00	41.30	40.00	30.55	33.00	0.70	0.65	4.74	5.80
		Mean	92.50	83.70	38.30	34.75	36.80	37.30	0.83	0.77	5.76	6.51
	Mean		87.30	80.75	40.80	36.28	34.65	34.38	0.75	0.63	5.13	5.97
Magnetic seeds (MS)	0	0	100.00	95.60	34.70	31.70	44.30	40.70	0.84	0.76	5.97	7.32
		500	100.00	93.70	37.70	38.70	42.70	40.00	0.80	0.70	5.11	7.11
		1000	90.00	90.00	39.30	40.00	30.70	32.00	0.67	0.46	4.36	5.81
		1500	80.00	70.30	41.30	41.30	27.30	29.30	0.63	0.40	3.97	6.06
		Mean	92.50	87.40	38.25	37.93	36.85	35.50	0.74	0.58	4.85	6.32
	500	0	112.00	110.00	31.70	34.00	48.30	43.00	0.96	0.89	6.73	7.77
		500	115.00	113.70	33.70	34.00	48.30	44.70	0.96	0.90	6.80	7.89
		1000	104.70	100.00	33.70	35.00	40.00	40.30	0.86	0.80	5.21	6.25
		1500	90.70	90.50	36.00	36.30	35.30	35.30	0.70	0.75	4.24	5.20
		Mean	105.60	103.55	33.78	34.83	42.98	40.83	0.87	0.84	5.75	6.78
	Mean		99.10	95.48	36.02	36.38	39.62	38.17	0.81	0.71	5.30	6.55
LSD at 0.05 level	M		3.48	6.96	2.71	N.S	2.71	3.29	0.05	N.S	0.06	0.26
	HA		3.20	1.70	3.34	0.70	3.34	3.30	0.06	0.04	0.21	0.55
	Pb		4.18	5.27	2.80	2.12	2.80	1.82	0.15	0.06	0.59	0.45
	M . HA		5.10	7.23	3.50	2.52	N.S	3.50	0.16	0.07	0.60	0.60
	M . Pb		4.90	7.50	3.60	N.S	3.70	4.00	0.17	0.08	0.62	0.59
	HA . Pb		5.23	7.60	3.80	2.62	3.80	3.80	0.19	0.10	0.70	0.61
	M . HA . Pb		6.00	7.80	4.00	2.97	N.S	4.20	0.20	0.11	0.71	0.63

Regarding to the effect of added Pb on plant height, number of capsules and dry weight of roots and shoots. The recorded data in Table (3) showed that a negative effect of different levels of added Pb on these characters which decrease with increasing the level of lead until 1500 mg/kg. This negative effect was significant in the two growth seasons. Seeds germination and seedling growth inhibition by the treatments of heavy metals (such as Pb). These data has been reported by many studies (Tantawy, 2004 and Azmat *et al.,* 2005). Root elongation, plant height, roots, shoots, leaf fresh and dry biomass and leaf area were negatively affected by increasing lead concentrations (Farooqi *et al.,* 2009 on *Albizia lebbeck* (L.) and Cimrin *et al.,* 2007 on *Zea mays*). This may be due to the inhibition of sesame plant metabolism by lead metal, the effect of lead especially at higher rates on physiological process of sesame plants and inhibition of some enzymes within the plant tissues.

The positive effect of either of magnetic and humic acid treatments and also the decrease effect of Pb treatments on plant height, number of capsules and dry weight of roots and shoots were cleared and supported by the calculated values of relative change (RC, %) for these parameters (Table 4).

The presented data in Tables (3 and 4) showed that combined effect of the three studied factors on plant height, number of capsules and dry weight of roots and shoots its relative change. Most of these interactions have a significant effect on these characters. The same tables showed that, magnetic seeds or/and humic acid treatments reduced the toxic effects of Pb on these characters. So, HA is compound contains many elements which improve and furnch the soil fertility and increasing the availability of nutrients and consequently affected plant growth (Azenjio *et al.,* 2000). Also, magnetic technologies has provided effective units to magnetize seed and also it's has very efficient to increase the number of germinating seeds and the best on germination processes (De Souza *et al.,* 2006). David *et al.* (1994) stated that, HA may be used to remove or decrease the negative effect of chemical fertilizers and some chemical forms in the soil.

The individual and combined effects of magnetic seeds, HA and Pb on the height of the first capsule of sesame plants as recorded in Tables (3) and (4) showed that, the lowest height (best effect) was found in the plants treated by magnetic and / or humic acid. On the other hand, the treatments of Pb resulted in an increase of first capsule height. Both individual and combined effects of the studied three factors on the height of the first capsule were significant. These significant effects were found in the two growth seasons. These data concluded that, the soil contaminated by Pb must be treated by HA and the seeds of plants must be magnetated before planting. In this respect Lamelas *et al.* (2009) obtained similar results.

Table (4): Relative change* (RC, %) of the studied vegetative growth characters of sesame plants as affected by added Pb levels under different treatments of seeds magnetic and HA application in the two growth seasons (2008 – 2009).

Treatments			Plant height (cm)		Height of the first capsulate (cm)		Number of capsules / plant		Dry weight of Roots (g/plant)		Dry weight of Shoots (g/plant)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	500	3.06	-3.93	5.13	8.11	-12.82	-4.76	0.00	-1.60	0.56	-5.35
		1000	-11.33	-9.88	15.38	20.12	-23.08	-15.97	-24.36	-37.70	-26.02	-19.50
		1500	-20.39	-15.83	23.08	25.22	-30.77	-27.17	-32.05	-47.54	-40.71	-34.12
	500	500	0.00	7.79	0.00	0.00	1.94	-0.98	1.11	1.18	-3.47	0.85
		1000	-10.00	-5.81	8.26	27.73	-11.98	-13.27	-11.10	-17.60	-7.73	-14.00
		1500	-20.00	-12.79	13.77	32.01	-24.04	-18.92	-22.20	-23.50	-25.20	-17.70
Magnetic seeds (MS)	0	500	0.00	-1.99	8.65	22.08	-3.61	-1.72	-4.80	-7.90	-14.40	-2.87
		1000	-10.00	-5.86	13.26	26.18	-30.70	-21.38	-20.24	-39.50	-27.00	-20.60
		1500	-20.00	-26.46	19.02	30.28	-38.37	-28.01	-25.00	-47.40	-33.50	-31.00
	500	500	2.68	3.36	6.31	0.00	0.00	3.95	0.00	1.12	1.04	1.54
		1000	-6.52	-9.09	6.31	2.94	-17.18	-6.28	-10.42	-10.11	-22.59	-19.56
		1500	-19.02	-17.73	13.56	6.76	-26.92	-17.91	-27.08	-15.73	-37.00	-33.08

$$* \text{R.C} = \frac{\text{Character value in the treatment} - \text{Character value in the control}}{\text{Character value in the control}} \times 100$$

Photosynthetic Pigments:

The presented data in Table (5) showed that, the individual and combined effects of magnetic seeds and HA applications resulted in a significant increase of leaves of sesame plants content of both chlorophyll (a + b) and carotenoids. These increases were found in the two growth seasons. These increases stated that, the treatments of HA applications activated the photosynthesis and chlorophyll content (O'Donnell, 1973). Enhanced the chlorophyll content due to humic acid effect was inferred from its role in enhancing leaves nutritional status especially, N as an important element of chlorophyll molecule (Rady and Migawer, 2010). Moreover, as reported by Marschner (1995) humic acids leads to raise k element uptake leading to corresponding increase in the chlorophyll fluorescence which can serve as an indicator of stress induced accompanied with alteration of the endogenous hormones balance reflecting in more biosynthesis of sugars and other photosynthates.

On the other hand, the obtained data (Table 5) showed that, except the treatment of Pb at rate of 500 mg / kg, other application rates of Pb resulted in a decrease of sesame leaves content of chlorophyll and carotenoids compared with zero Pb treatment. The inhibition of chlorophyll synthesis by heavy metals often manifesting on chlorosis. This chlorosis produced by Pb dramatically modify plant growth and development. The change in structure of chlorophyll which included that, absorption of Pb as compared to essential mineral ions was higher. Pb replaces the other minerals or magnesium. It may be attributed with less concentration of Mg in chlorophyll (Haider *et al.,* 2006 and Akinci *et al.,* 2010). The presented data in Table (5) showed that interaction between the three studied factors on the physiological pigments. It is evident to say that, the treatments of magnetic seeds with humic acid gave a greater content of both chlorophyll and carotenoids. Also, these data showed that, the treatments of magnetic seeds and HA individual or in together reduced inhibition or toxic effect of Pb. Most of the combined treatments under study have a positive and significant effect on the leaves of sesame plants content of chlorophyll and carotenoids. These significant effects were found in the two growth seasons.

Table (5): Combined effect of magnetic seeds(MS), humic acid (HA) and lead (Pb) on photosynthetic pigments of sesame leaves in the two growth seasons (2008 – 2009).

Treatments		Non magnetic seeds (NMS)				magnetic seeds (MS)			
		Chl.(a+b) mg/g Dwt		Carotenoids mg/g Dwt		Chl.(a+b) mg/g Dwt		Carotenoids mg/g Dwt	
Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009
0	0	3.39	4.47	1.64	1.85	3.25	4.19	1.75	1.89
	500	3.69	4.60	1.82	1.95	4.73	4.57	1.95	1.97
	1000	2.21	3.14	1.24	1.35	2.37	3.88	1.54	1.52
	1500	1.81	2.22	1.17	1.15	2.23	3.46	1.48	1.42
	Mean	2.78	3.61	1.47	1.58	3.15	4.03	1.68	1.70
500	0	4.21	5.31	2.03	2.05	6.73	4.84	2.66	2.55
	500	4.51	5.98	2.37	2.29	6.09	5.42	2.80	2.66
	1000	3.66	4.05	1.78	1.86	4.70	4.43	1.95	1.99
	1500	3.05	3.83	1.63	1.55	4.89	4.45	1.94	1.92
	Mean	3.86	4.79	1.95	1.94	4.85	4.79	2.00	2.28
Mean		3.32	4.20	1.71	1.76	4.00	4.41	1.84	1.99
LSD at 0.05 level	M	0.32	Ns	Ns	0.02	0.32	Ns	Ns	0.02
	HA	0.19	0.27	0.04	0.04	0.19	0.27	0.04	0.04
	Pb	0.32	0.27	0.06	0.08	0.32	0.27	0.06	0.08
	M . HA	0.35	0.29	0.07	0.09	0.35	0.29	0.07	0.09
	M . Pb	0.36	0.30	0.07	0.10	0.36	0.30	0.07	0.10
	HA . Pb	0.40	0.31	0.08	0.11	0.40	0.31	0.08	0.11
	M . HA . Pb	Ns	0.32	0.09	0.12	Ns	0.32	0.09	0.12

Mineral Content:

The presented data in Tables (6 - 8) show N, P and K concentration (%) and uptake (mg / pot) by roots, shoots and seeds of sesame plants as affected by the studied three treatments individually or in together. The data in these tables show, N, P and K contents were increased significantly with the treatments of magnetic seeds and HA as alone or in together. On the other hand, this content was decreased significantly with the increase of added Pb. The previous trends were found with the three organs of sesame plants in the two growth seasons. Salman *et al.* (2005) and Aiad (2010) pointed out that, applications of humic acid and other organic manures resulted in an increase of N, P and K availability and its uptake by plants. On another study, Akinci *et al.* (2010) showed that, N, P, K and other elements uptake by roots, shoots and leaves of tomato plants were negatively affected by increased of Pb concentration. In the two growth seasons and also with different organs of sesame plants, the negative effect of Pb on the content of N, P and K was clearly decreased with the treatments of magnetic seeds and HA as alone or in together. So, the high content of N, P and K was found in the plants under treatments of magnetic seeds plus HA without Pb or at level of 500 mg Pb / kg. Also, the content of the determined macronutrients with the same treatment of the three studied factors was varied from nutrient to another and also from origin to another.

The presented data in Table (9) showed that effect of the three studied factors on Pb concentration (mg / kg) and its uptake (mg / pot) in the different organs of sesame plants in the two growth seasons. These data show that, significant increases were found in Pb content with the increase of added Pb. The high content of Pb was found in shoots where the lowest one was recorded with seeds. There are unclear differences in the content of Pb during the two growth seasons. The studies of Tantawy (2004) confirmed these findings. On the other hand, the treatments of magnetic seeds and HA individually or in together resulted in a clear decrease of sesame organs content of Pb (Table 9). The high decreases were found in the treatments including magnetic seeds and HA together. This negative effect recorded with the treatments of magnetic seeds was in agreement with the finding of Mostafa (2002) and Zalidis and Matsi (1999) and Barancikova and Makovnikova (2003), where they pointed out that, organic matter such as HA plays an important role not only in forming complexes but also in retaining heavy metals (Pb) in an exchangeable form.

Table (6): Nitrogen (N) concentration (%) and its uptake (mg / pot) by different organs of sesame plants as affected by the studied treatments in the two growth seasons (2008 – 2009).

Treatments			Roots				Shoots				Seeds			
			Concentration (%)		Uptake (mg/pot)		Concentration (%)		Uptake (mg/pot)		Concentration (%)		Uptake (mg/pot)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	0	1.33^{b}	1.25^{c}	51.90^{cd}	38.10^{d}	3.30^{b}	4.10^{b}	887.70^{d}	1303.8^{d}	1.60^{c}	2.20^{c}	524.00^{d}	665.50^{c}
		500	1.10^{c}	1.20^{c}	42.90^{d}	36.00^{d}	3.30^{b}	3.70^{c}	892.70^{e}	1113.7^{e}	1.50^{c}	2.00^{c}	498.00^{d}	614.00^{c}
		1000	1.00^{c}	1.08^{d}	29.50^{e}	20.50^{e}	2.40^{c}	2.90^{d}	477.60^{g}	742.40^{g}	1.30^{d}	1.70^{d}	359.50^{e}	427.60^{d}
		1500	088^{d}	0.96^{e}	23.30^{f}	15.40^{f}	1.60^{d}	1.80^{e}	255.20^{h}	377.10^{i}	1.00^{d}	1.40^{e}	253.50^{f}	329.00^{e}
		Mean	108^{D}	1.12^{D}	36.9^{D}	27.50^{D}	2.65^{E}	3.13^{D}	628.30^{D}	884.3^{D}	1.35^{E}	1.83^{D}	406.80^{D}	509.00^{C}
	500	0	1.55^{a}	1.36^{a}	69.75^{a}	57.8^{a}	3.10^{a}	4.00^{a}	982.70^{d}	1410.00^{c}	2.00^{a}	2.60^{b}	722.00^{c}	873.60^{b}
		500	1.45^{b}	1.35^{b}	66.00^{c}	58.1^{b}	3.50^{b}	3.90^{b}	1071.00^{c}	1386.50^{d}	1.80^{ab}	2.40^{b}	684.00^{c}	850.80^{b}
		1000	1.33^{b}	1.34^{b}	53.20^{c}	46.9^{c}	3.00^{e}	3.60^{c}	877.60^{e}	1090.80^{e}	1.50^{c}	1.70^{d}	487.50^{d}	544.90^{b}
		1500	1.30^{b}	1.22^{c}	45.50^{d}	39.7^{d}	2.90^{e}	3.30^{c}	687.30^{f}	957.00^{f}	1.40^{c}	1.70^{d}	420.00^{e}	535.50^{b}
		Mean	1.41^{A}	1.32^{B}	58.60^{B}	50.6^{B}	3.13^{B}	3.70^{B}	904.60^{B}	1211.10^{B}	1.68^{C}	2.10^{C}	578.40^{B}	701.15^{C}
	Mean		1.24^{C}	1.22^{B}	47.80^{C}	39.1^{C}	2.89^{D}	3.42^{B}	766.50^{C}	1047.70^{C}	1.51^{D}	1.96^{D}	493.60^{C}	605.15^{C}
Magnetic seeds (MS)	0	0	1.45^{b}	1.36^{b}	60.90^{c}	51.7^{c}	3.50^{b}	4.00^{b}	1044.80^{c}	1464.00^{c}	2.20^{a}	2.50^{b}	776.60^{b}	820.00^{b}
		500	1.40^{b}	1.30^{b}	56.00^{c}	45.5^{c}	3.50^{b}	4.00^{b}	894.30^{e}	1422.00^{c}	2.00^{a}	2.40^{b}	722.00^{c}	806.40^{b}
		1000	1.15^{d}	1.27^{c}	38.50^{d}	29.2^{d}	3.10^{a}	2.60^{d}	675.80^{f}	755.30^{g}	1.60^{c}	2.00^{c}	493.60^{d}	607.00^{c}
		1500	1.05^{d}	1.09^{d}	33.10^{e}	21.8^{e}	2.00^{c}	2.30^{d}	397.00^{g}	580.80^{h}	1.20^{d}	1.60^{d}	394.80^{e}	404.00^{d}
		Mean	1.26^{C}	1.26^{B}	47.10^{C}	37.1^{C}	3.03^{C}	3.23^{B}	753.00^{C}	1055.60^{C}	1.75^{C}	2.13^{C}	596.80^{A}	659.40^{C}
	500	0	1.63^{a}	1.45^{a}	78.20^{a}	64.5^{a}	4.00^{a}	4.50^{a}	1346.00^{b}	1748.30^{b}	2.50^{a}	2.90^{a}	948.60^{a}	1028.10^{a}
		500	1.52^{a}	1.55^{a}	73.00^{b}	69.8^{a}	4.30^{a}	4.60^{a}	1462.00^{a}	1814.70^{a}	2.30^{a}	3.00^{a}	883.20^{b}	1182.00^{a}
		1000	1.42^{b}	1.35^{b}	61.10^{c}	54.0^{b}	3.30^{b}	3.60^{c}	859.70^{e}	1125.00^{e}	2.10^{a}	2.60^{b}	755.00^{c}	884.00^{b}
		1500	1.34^{d}	1.25^{c}	46.90^{d}	46.9^{c}	3.00^{e}	3.30^{c}	636.00^{f}	858.00^{f}	1.80^{ab}	2.41^{b}	639.00^{cd}	673.60^{c}
		Mean	1.48^{A}	1.40^{A}	64.80^{A}	58.8^{A}	3.65^{A}	4.00^{A}	1075.90^{A}	1386.50^{A}	2.18^{A}	2.73^{A}	806.50^{A}	941.90^{A}
	Mean		1.37^{B}	1.33^{B}	56.00^{B}	48.0^{B}	3.34^{B}	3.61^{B}	914.50^{B}	1221.00^{B}	1.97^{B}	2.43^{B}	701.70^{B}	800.70^{B}

Table (7): Phosphorus concentration (%) and its uptake (mg / pot) by different organs of sesame plants as affected by the studied treatments in the two growth seasons (2008 – 2009).

Treatments			Roots				Shoots				Seeds			
			Concentration (%)		Uptake (mg/pot)		Concentration (%)		Uptake (mg/pot)		Concentration (%)		Uptake (mg/pot)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	0	0.242^{c}	0.230^{e}	9.44^{d}	7.02^{d}	0.360^{c}	0.365^{c}	96.80^{c}	116.10^{d}	0.662^{d}	0.666^{e}	216.80^{c}	201.50^{bc}
		500	0.232^{c}	0.200^{d}	9.05^{d}	6.00^{e}	0.360^{c}	0.360^{c}	97.40^{c}	108.40^{d}	0.568^{f}	0.560^{f}	188.60^{d}	171.90^{c}
		1000	0.210^{d}	0.200^{d}	6.20^{g}	3.80^{f}	0.305^{d}	0.300^{d}	60.70^{e}	76.80^{f}	0.491^{g}	0.407^{g}	1.35.80^{e}	102.40^{d}
		1500	0.200^{d}	0.160^{e}	5.30^{h}	2.56^{g}	0.260^{d}	0.260^{e}	41.50^{f}	54.50^{g}	0.355^{i}	0.343^{h}	90.00^{j}	80.60^{e}
		Mean	0.221^{BC}	0.198^{D}	7.50^{E}	4.75^{D}	0.321^{C}	0.321^{C}	74.10^{E}	89.00^{D}	0.519^{E}	0.494^{E}	157.80^{D}	139.10^{E}
	500	0	0.280^{a}	0.341^{a}	12.60^{b}	14.49^{a}	0.370^{c}	0.380^{b}	117.30^{b}	134.00^{c}	0.763^{c}	0.723^{d}	275.40^{b}	242.00b
		500	0.235^{c}	0.242^{c}	10.69^{c}	10.41^{b}	0.370^{c}	0.370^{bc}	113.20^{b}	131.50^{c}	0.711^{c}	0.651^{e}	270.20^{b}	230.80^{b}
		1000	0.220^{d}	0.233^{c}	8.80^{e}	8.16^{c}	0.360^{c}	0.360^{c}	105.30^{b}	109.10^{d}	0.683^{d}	0.666^{e}	222.00^{c}	213. 50^{b}
		1500	0.203^{d}	0.220^{cd}	7.11^{f}	7.15^{d}	0.350^{c}	0.350^{c}	83.00^{cd}	101.50^{d}	0.600^{e}	0.610^{f}	180.00^{d}	192.20^{c}
		Mean	0.235^{B}	0.259^{B}	9.80^{C}	9.97^{B}	0.363^{B}	0.365^{B}	104.70^{A}	119.00^{B}	0.689^{C}	0.663^{C}	237.10^{B}	219.90^{C}
	Mean		0.228^{B}	0.229^{C}	8.70^{D}	7.18^{C}	0.342^{C}	0.343^{C}	89.40^{C}	104.00^{C}	0.604^{D}	0.579^{D}	197.50^{C}	179.50^{D}
Magnetic seeds (MS)	0	0	0.262^{b}	0.237^{c}	11.00^{c}	9.01^{b}	0.370^{c}	0.370^{bc}	110.50^{b}	135.40^{c}	0.796^{c}	0.777^{d}	281.00^{b}	254.90^{b}
		500	0.259^{b}	0.234^{c}	10.36^{c}	8.19^{c}	0.360^{c}	0.370^{bc}	92.00^{c}	131.50^{c}	0.580^{e}	0.670^{e}	209.40^{c}	225.10^{b}
		1000	0.234^{c}	0.230^{c}	7.84^{f}	5.29^{e}	0.340^{c}	0.305^{d}	74.10^{d}	88.60^{e}	0.511^{g}	0.595^{f}	157.60^{d}	180.60^{c}
		1500	0.200^{d}	0.200^{d}	6.30^{g}	4.00^{f}	0.230^{e}	0.225^{f}	45.70^{f}	56.81^{g}	0.465^{h}	0.465^{g}	141.40^{d}	117.40^{d}
		Mean	0.239^{B}	0.225^{C}	8.90^{D}	6.60^{C}	0.325^{C}	0.318^{C}	80.60^{D}	103.10^{C}	0.588^{D}	0.627^{C}	197.40^{C}	194.50^{C}
	500	0	0.285^{a}	0.350^{a}	13.68^{a}	15.58^{a}	0.395^{a}	0.461^{a}	132.90^{a}	179.10^{a}	0.865^{b}	0.889^{b}	328.30^{a}	315.20^{a}
		500	0.281^{a}	0.292^{b}	13.49^{a}	13.14^{a}	0.393^{a}	0.395^{b}	133.60^{a}	155.80^{b}	0.974^{a}	0.980^{a}	374.00^{a}	378.20^{a}
		1000	0.268^{b}	0.242^{c}	11.52^{c}	9.68^{b}	0.420^{a}	0.380^{b}	109.40^{b}	118.80^{d}	0.840^{b}	0.802^{c}	302.00^{a}	272.70^{b}
		1500	0.236^{c}	0.230^{c}	8.26^{c}	8.63^{c}	0.360^{c}	0.360^{c}	76.30^{d}	93.60^{e}	0.723^{c}	0.700^{d}	256.70^{b}	195.70^{c}
		Mean	0.268^{A}	0.279^{A}	11.80^{A}	11.80^{A}	0.392^{A}	0.399^{A}	113.10^{A}	136.80^{A}	0.851^{A}	0.838^{A}	315.30^{A}	290.50^{A}
	Mean		0.253^{B}	0.252^{B}	10.40^{B}	9.20^{B}	0.359^{B}	0.359^{B}	96.90^{B}	120.00^{B}	0.720^{B}	0.733^{B}	256.40^{B}	242.50^{B}

Table (8): Potassium concentration (%) and its uptake (mg / pot) by different organs of sesame plants as affected by the studied treatments in the two growth seasons (2008 – 2009).

Treatments			Roots				Shoots				Seeds			
			Concentration (%)		Uptake (mg/pot)		Concentration (%)		Uptake (mg/pot)		Concentration (%)		Uptake (mg/pot)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	*2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	0	1.01^{b}	0.98^{c}	44.00^{c}	29.90^{e}	2.09^{c}	2.20^{e}	562.20^{e}	699.60^{d}	1.23^{d}	1.33^{c}	402.80^{c}	402.30^{c}
		500	1.28^{a}	1.00^{c}	50.00^{b}	30.00^{e}	2.06^{c}	2.17^{e}	557.20^{e}	653.20^{d}	1.23^{d}	1.21^{c}	408.40^{c}	371.50^{cd}
		1000	1.15^{b}	0.90^{c}	34.00^{e}	17.10^{g}	1.98^{d}	1.98^{f}	394.00^{f}	506.90^{e}	1.20^{d}	1.00^{d}	331.80^{d}	251.50^{e}
		1500	0.89^{c}	0.88^{c}	23.60^{f}	14.10^{h}	1.16^{e}	1.52^{g}	185.00^{e}	318.40^{f}	1.00^{d}	0.96^{d}	253.50^{e}	225.60^{e}
		Mean	1.08^{B}	0.94^{C}	73.80^{C}	22.80^{D}	1.82^{F}	1.97^{D}	424.60^{E}	544.50^{F}	1.17^{C}	1.13^{C}	349.10^{C}	312.70^{C}
	500	0	1.32^{a}	1.22^{b}	59.40^{a}	51.90^{c}	2.43^{c}	2.50^{d}	770.30^{c}	881.30^{c}	1.42^{b}	1.45^{b}	512.60^{a}	487.20^{c}
		500	1.38^{a}	1.31^{b}	62.80^{a}	56.30^{c}	2.10^{d}	2.67^{d}	642.60^{d}	949.20^{c}	1.28^{d}	1.50^{b}	486.40^{c}	531.80^{b}
		1000	1.32^{a}	1.20^{b}	52.80^{b}	42.00^{d}	2.60^{b}	2.50^{d}	760.50^{c}	757.60^{d}	1.15^{d}	1.26^{c}	373.80^{d}	403.80^{c}
		1500	1.25^{a}	1.01^{c}	43.80^{d}	32.80^{e}	1.99^{d}	2.11^{e}	471.60^{f}	611.90^{d}	1.15^{d}	1.01^{d}	345.00^{d}	318.20^{d}
		Mean	1.32^{A}	1.19^{B}	54.70^{A}	45.80^{B}	2.28^{D}	2.45^{C}	661.30^{C}	800.00^{D}	1.25^{C}	1.31^{B}	429.50^{C}	435.30^{B}
	Mean		1.20^{B}	1.07^{B}	46.30^{B}	34.30^{C}	2.05^{E}	2.21^{D}	543.00^{D}	672.30^{E}	1.21^{C}	1.22^{C}	389.30^{C}	374.00^{C}
Magnetic seeds (MS)	0	0	1.19^{b}	1.30^{b}	50.00^{b}	49.40^{c}	3.28^{a}	3.10^{a}	979.10^{b}	1134.60^{b}	1.26^{d}	1.42^{b}	444.80^{c}	465.80^{c}
		500	1.18^{b}	1.00^{c}	47.20^{b}	35.00^{e}	3.50^{a}	3.51^{b}	894.30^{b}	1247.80^{b}	1.23^{d}	1.35^{c}	444.00^{c}	453.60^{c}
		1000	1.15^{c}	0.98^{c}	38.50^{c}	22.50^{f}	2.11^{d}	2.30^{e}	460.00^{f}	668.20^{d}	1.20^{d}	1.32^{c}	370.20^{d}	400.60^{c}
		1500	0.97^{b}	0.87^{c}	30.60^{e}	17.40^{g}	2.00^{d}	1.99^{f}	397.00^{f}	502.50^{e}	1.13^{d}	1.21^{c}	343.50^{d}	305.50^{d}
		Mean	1.12^{A}	1.04^{B}	41.60^{B}	31.10^{C}	2.72^{C}	2.73^{C}	682.40^{C}	888.30^{C}	1.21^{C}	1.33^{B}	400.60^{C}	406.40^{B}
	500	0	1.32^{a}	1.70^{a}	63.40^{a}	75.60^{a}	4.10^{a}	4.16^{a}	1379.70^{a}	1616.20^{A}	1.45^{b}	1.63^{a}	550.30^{b}	577.80^{b}
		500	1.36^{a}	1.40^{b}	65.30^{a}	63.00^{b}	3.94^{a}	4.20^{a}	1339.60^{a}	1656.90^{a}	1.57^{a}	1.63^{a}	602.90^{a}	642.20^{a}
		1000	1.25^{a}	1.30^{b}	53.80^{b}	52.00^{c}	3.39^{a}	3.00^{b}	863.10^{b}	937.50^{c}	1.36^{c}	1.53^{b}	489.00^{c}	520.20^{b}
		1500	1.20^{a}	1.28^{b}	42.00^{c}	48.00^{c}	3.07^{b}	2.73^{d}	650.80^{d}	709.80^{d}	1.27^{d}	1.33^{c}	450.90^{c}	371.70^{d}
		Mean	1.28^{A}	1.42^{A}	56.10^{A}	59.70^{A}	3.63^{A}	3.52^{A}	1063.30^{A}	132.10^{A}	1.41^{A}	1.53^{A}	523.30^{A}	528.00^{A}
	Mean		1.20^{B}	1.23^{B}	48.90^{B}	45.40^{B}	3.18^{B}	3.13^{B}	872.90^{B}	1059.20^{B}	1.31^{B}	1.43^{B}	462.00^{B}	467.20^{B}

Table (9): Lead concentration (mg / kg) and its uptake (mg / pot) by different origins of sesame plants as affected by the studied treatments in the two growth seasons (2008 – 2009).

Treatments			Roots				Shoots				Seeds			
			Concentration mg/kg		Uptake (mg/pot)		Concentration mg/kg		Uptake (mg/pot)		Concentration mg/kg		Uptake (mg/pot)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	0	35.50^{e}	35.80^{e}	0.138^{d}	0.109^{f}	40.10^{f}	40.50^{e}	1.079^{d}	1.288^{c}	5.20^{e}	5.20^{e}	0.170^{e}	0.157^{h}
		500	490.80^{d}	490.00^{d}	1.914^{c}	1.470^{e}	550.60^{e}	560.30^{d}	14.894^{c}	16.865^{b}	40.90^{d}	40.60^{d}	1.358^{c}	1.246^{g}
		1000	805.30^{c}	802.50^{c}	2.376^{b}	1.525^{d}	915.00^{c}	923.00^{c}	18.209^{b}	23.629^{a}	63.70^{b}	63.50^{b}	1.761^{b}	1.597^{d}
		1500	1015.00^{a}	1016.30^{a}	2.690^{b}	1.626^{c}	1230.30^{a}	1222.20^{a}	19.623^{b}	25.605^{a}	81.50^{a}	80.20^{a}	2.066^{a}	3.088^{a}
		Mean	586.65^{A}	586.15^{A}	1.780^{D}	1.183^{E}	684.00^{A}	686.50^{A}	13.45^{A}	16.85^{B}	47.83^{A}	47.38^{A}	1.339^{B}	1.522^{A}
	500	0	28.50^{e}	28.60^{e}	0.128^{d}	0.122^{f}	35.90^{f}	36.00^{e}	1.138^{d}	1.269^{c}	3.80^{e}	3.90^{e}	0.137^{e}	0.087^{i}
		500	410.50^{d}	410.50^{d}	1.868^{c}	1.765^{c}	500.30^{e}	498.30^{d}	15.309^{c}	17.725^{b}	37.50^{d}	36.50^{d}	1.425^{c}	1.294^{g}
		1000	776.00^{c}	766.00^{c}	3.104^{a}	2.678^{b}	810.10^{d}	808.40^{c}	23.695^{b}	24.495^{a}	55.10^{c}	54.20^{c}	1.791^{b}	1.737^{d}
		1500	915.50^{b}	917.20^{b}	3.204^{a}	2.981^{b}	1100.40^{b}	1105.30^{b}	31.912^{a}	33.159^{a}	74.50^{a}	75.80^{a}	2.235^{a}	2.388^{b}
		Mean	532.63^{B}	530.33^{B}	2.076^{A}	1.887^{B}	611.68^{C}	612.00^{B}	18.014^{A}	19.162^{A}	42.73^{A}	42.60^{B}	1.397^{B}	1.377^{C}
	Mean		559.64^{B}	558.24^{B}	1.928^{B}	1.535^{C}	647.84^{B}	649.25^{A}	15.732^{A}	18.006^{A}	45.28^{A}	44.99^{B}	1.368^{B}	1.450^{B}
Magnetic seeds (MS)	0	0	31.10^{e}	31.10^{e}	0.131^{d}	0.118^{f}	38.60^{f}	39.00^{e}	1.152^{d}	1.427^{c}	4.90^{e}	4.80^{e}	0.173^{e}	0.157^{h}
		500	405.70^{d}	405.70^{d}	1.623^{c}	1.420^{e}	525.50^{e}	520.50^{d}	13.426^{c}	18.50^{b}	38.70^{d}	39.00^{d}	1.397^{c}	1.310^{f}
		1000	800.40^{c}	795.30^{c}	2.681^{b}	1.829^{c}	870.50^{d}	876.30^{c}	18.977^{b}	25.427^{a}	60.30^{b}	59.50^{b}	1.860^{b}	1.806^{d}
		1500	940.90^{b}	942.50^{b}	2.964^{b}	1.885^{c}	1153.50^{b}	1150.10^{b}	22.897^{b}	29.040^{a}	75.40^{a}	76.10^{a}	2.292^{a}	1.922^{c}
		Mean	544.53^{B}	543.65^{B}	1.850^{C}	1.313^{D}	647.03^{B}	646.23^{A}	14.113^{A}	18.599^{A}	44.825^{A}	44.85^{B}	1.431^{A}	1.299^{C}
	500	0	24.60^{e}	24.80^{e}	0.118^{d}	0.110^{c}	37.70^{f}	38.00^{e}	1.269^{d}	1.476^{c}	3.50^{e}	3.50^{e}	0.133^{e}	0.124^{h}
		500	403.10^{d}	400.10^{d}	1.935^{c}	1.800^{c}	480.10^{e}	483.00^{d}	16.323^{c}	19.054^{b}	35.10^{d}	35.90^{d}	1.348^{c}	1.414^{e}
		1000	758.20^{c}	750.50^{c}	3.260^{a}	3.002^{a}	802.50^{b}	805.30^{c}	20.905^{b}	25.166^{a}	52.80^{c}	51.50^{c}	1.898^{b}	1.751^{d}
		1500	905.30^{b}	902.50^{b}	3.169^{a}	3.384^{a}	1080.40^{b}	1076.60^{b}	22.904^{b}	27.966^{a}	70.10^{a}	70.10^{a}	2.489^{a}	1.959^{c}
		Mean	522.80^{B}	519.48^{B}	2.121^{A}	2.074^{A}	600.18^{C}	600.48^{B}	15.350^{A}	18.416^{A}	40.38^{A}	40.25^{B}	1.467^{A}	1.312^{C}
	Mean		533.67^{B}	531.565^{B}	1.986^{B}	1.694^{C}	623.61^{C}	623.355^{B}	14.732^{A}	18.508^{A}	42.60^{A}	42.55^{B}	1.449^{A}	1.306^{C}

Yield:

The presented data in Table (10) showed that, the seed yield (g/plant) and weight 1000 seed (g) significantly increased with different treatments of magnetic seeds or / and humic acid. These significant increases were found with yield parameters under study in the two growth seasons. This means that, the high yield of seeds and weight of 1000 seed were found in the treatments of magnetic seeds with humic acid in the first growth season. These findings were supported by the calculated values of RC (%) for these yield parameters compared with control treatment (Table 11). These findings reveal that, magnetic process played an important role in translocation of nutrients and synthesis of soluble sugars and amino acids which leads to fast translocation of photo-assimilate towards the developing seeds. Hafez (2004) pointed out that, humic acid application improved plant growth and increased fruit yield and quality of squash plants. Similar effects of humic acid applications on plant growth were found by Abou Hussein (1997 and 2000) and Azenjio *et al.* (2000).

On the other hand, the data of Pb treatments as alone which recorded in Table (10) show that, except the treatment of 500 mg Pb / kg, other application rates of Pb resulted in a significant decrease of seeds yield and weight of 1000 seed. This significant decrease was found in the two growth seasons. The data of RC (Table 11) show clearly this decrease or negative effects of high application rates of Pb, where these values were negative. Excess Pb caused a number of toxicity symptoms and blackening of roots system. Also, Pb inhibits photosynthesis, upsets mineral nutrition and water balance, change hormonal status and affects membrane structure and permeability (Sharma and Dubey, 2005). Confirmed results or the toxic effects of high level of added Pb were pointed out by Tantawy (2004) and Abou El-Khir *et al.* (2005).

The presented data in Tables (10) and (11) showed that, magnetic treatments and HA application decrease the harmful effect of higher rates of pb. This effect was showed clearly from the values of RC which increased with different application rates of Pb under different treatments of magnetic seeds and HA. These results also were supported by the calculated values of agronomic efficiency (AE) as mg/mg Pb for the determined yield parameters as affected by different Pb treatments (Table 11). The obtained values of AE show that, these values were decreased with the increase of added Pb, where these values were increased with treatments of magnetic seeds or / and HA. These findings were found in the two growth seasons. Also, these findings show the beneficial effect of both magnetic seeds and HA treatments on these characters and reduced the toxicity effect of high Pb levels of contaminated soil. In this respect, Lamellas *et al.* (2009) and De Souza *et al.* (2006) obtained similar results.

Table (10): Seed yield (g/plant), weight of 1000 seed (g) and oil yield (%) and its content (mg/l) of Pb as affected by the studied treatments in the two growth seasons (2008 – 2009).

Treatments			Seed yield (g/plant)		1000-seed weight (g)		Oil content (%)		Pb content (mg/l)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	0	6.55	6.05	4.00	4.09	38.50	38.10	Non	Non
		500	6.64	6.14	4.00	3.87	35.30	36.00	Non	Non
		1000	5.53	5.03	3.50	3.50	30.50	30.50	Non	Non
		1500	5.07	4.7	3.00	3.00	29.80	30.00	Traces	Traces
		Mean	5.95	5.48	3.63	3.62	33.53	33.65		
	500	0	7.22	6.72	4.21	4.23	43.70	44.10	Non	Non
		500	7.60	7.09	4.80	4.30	42.50	42.90	Non	Non
		1000	6.50	6.41	3.80	3.80	40.10	39.70	Non	Non
		1500	6.00	6.30	3.80	3.70	33.50	33.20	Non	Non
		Mean	6.83	6.63	4.15	4.01	39.95	39.98	Non	Non
	Mean		6.39	6.06	3.89	3.82	36.74	36.82		
Magnetic seeds (MS)	0	0	7.06	6.56	4.20	4.13	39.80	40.00	Non	Non
		500	7.22	6.72	4.00	4.00	41.30	41.30	Non	Non
		1000	6.17	6.07	3.90	3.77	38.70	38.10	Non	Non
		1500	6.08	5.05	3.77	3.47	32.10	31.70	Traces	Traces
		Mean	6.63	6.10	3.97	3.84	37.98	37.78		
	500	0	7.59	7.09	4.29	4.33	47.50	48.00	Non	Non
		500	7.68	7.88	4.87	4.40	46.80	46.50	Non	Non
		1000	7.19	6.80	3.87	4.10	43.80	43.50	Non	Non
		1500	7.10	5.59	3.87	3.90	40.50	40.50	Non	Non
		Mean	7.39	6.84	4.23	4.18	44.65	44.63	Non	Non
	Mean		7.01	6.47	4.10	4.01	41.32	41.21		
LSD at 0.05 level	M		NS	NS	0.06	0.10	1.87	1.91		
	HA		0.48	0.35	0.10	0.04	1.98	1.99		
	Pb		0.54	0.28	0.07	0.07	2.00	2.10		
	M.HA		0.60	0.40	0.10	0.09	NS	2.30		
	M.Pb		0.80	0.36	0.09	0.08	2.10	2.40		
	HA.Pb		0.80	0.39	0.08	0.10	2.20	2.50		
	M.HA. Pb		0.90	0.41	NS	0.10	2.40	2.60		

Table (11): Combined effect of the studied treatments on seeds yield (g/plant), weight of 1000 seed (g) and their relative change (RC, %) and pb agronomic efficiency* (AE, mg/mg pb) in the two growth seasons (2008 – 2009).

Treatments			Relative change (RC, %)				Agronomic efficiency (AE, mg / mg Pb)			
			Seed yield (g/plant)		1000- seed weight (g/plant)		Seeds yield (g/plant)		1000 seeds weight (g/plant)	
Magnetic	Added HA (mg/kg)	Added Pb (mg/kg)	2008	2009	2008	2009	2008	2009	2008	2009
Non magnetic seeds (N MS)	0	500	1.37	1.49	0.00	-5.38	0.018	0.018	0.00	-0.044
		1000	-15.57	-16.86	-12.50	-14.43	-0.102	-0.102	-0.05	-0.059
		1500	-22.60	-22.31	-25.00	-26.65	-0.099	-0.09	-0.67	-0.073
	500	500	5.26	5.51	14.00	1.65	0.076	0.074	0.118	0.014
		1000	-9.97	-4.61	-9.74	-10.17	-0.072	-0.031	-0.041	-0.043
		1500	-16.90	-6.25	-9.74	-12.53	-0.081	-0.028	-0.027	-0.035
Magnetic seeds (MS)	0	500	2.27	2.44	-4.76	-3.15	0.032	0.032	-0.04	-0.026
		1000	-12.60	-7.47	-7.14	-8.72	-0.089	-0.049	-0.03	-0.036
		1500	-13.90	-23.02	-10.24	-16.00	-0.065	-0.101	-0.029	-0.044
	500	500	1.19	11.10	13.52	1.62	0.018	0.158	0.116	0.014
		1000	-5.30	-4.09	-9.80	-5.32	-0.04	-0.029	-0.042	-0.023
		1500	-6.46	-21.20	-9.80	-9.93	-0.03	-0.10	-0.028	-0.029

$$* AE = \frac{\text{Yield value in the treatment} - \text{Yield value in the control}}{\text{Added Pb (mg / kg)}} \times 100$$

Oil Yield and its content of Pb:

The presented data in Table (10) showed that, the sesame seeds content of oil (%) was greater affected by the studied treatments. For example, this content was increased significantly with treatments of magnetic seeds and HA individually or in together in the two growth seasons. On the other hand, increasing added Pb resulted in a significant decrease of oil content. So, the high content of oil was found with the treatments of magnetic seeds plus HA at zero level of added Pb. The beneficial effect of HA on oil content was found by Rady and Migawer (2010) on canola plant.

Oil content of Pb (mg/l) as affected by the studied treatments as recorded in Table (10) show that, oil was free from Pb with different treatments under study. These findings gave and showed the major aim of this study, where from these data may be concluded that, under conditions of soil contamination by Pb, such this soil may be cultivated by sesame plant where it's used as oil crop production uncontaminated by Pb.

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استجابة نباتات السمسم النامية في أرض ملوثة بالرصاص لحامض الهيوميك ومغنطة البذور

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الملخص العربى :

أجريت تجربتي أصص بمزرعة كلية الزراعة بشبين الكوم فى موسمين متتالين خلال صيفى ٢٠٠٨ و ٢٠٠٩ لدراسة التأثير الفردي والمشترك لكلٍ من مغنطه البذور وحامض الهيوميك فى ارض ملوثة بالرصاص على نمو نبات السمسم وبعض القياسات الفسيولوجية والمحصول وجودته . وتميزت الأرض المستعملة فى التجربتين بقوام طينى وانخفاض المحتوى من المادة العضوية وكربونات الكالسيوم كما أنها كانت غير ملحية واستخدم حامض الهيوميك عند معدلي صفر و ٥٠٠ مجم / كجم بينما أضيف الرصاص على صورة خلات عند معدلات صفر و ٥٠٠ و ١٠٠٠ و ١٥٠٠ مليجرام / كيلوجرام تربة . ولقد أخذت العينات النباتية بعد تسعين يوماً من الزراعة وكذلك عند الحصاد وكانت النتائج المتحصل عليها كالآتى :

- كان للمعاملة بالرصاص تأثيرها السلبى على صفات النمو الخضرى ممثلة فى طول النبات وعدد الكبسولات والوزن الجاف لكلٍ من الجذور والمجموع الخضرى .
- أدت زيادة تركيز الرصاص إلى حدوث نقص معنوى فى تركيز كل من كلوروفيل (أ + ب) والكاروتينيدات والعناصر الكبرى (النيتروجين والفوسفور والبوتاسيوم) فى الجذور والمجموع الخضرى والبذور لنبات السمسم .
- أدت المعاملة بالرصاص إلى حدوث زيادة معنوية فى تركيز الرصاص داخل أنسجة النباتات المعاملة ، وكانت الزيادة كبيرة فى المجموع الخضرى .
- أشارت النتائج إلى حدوث نقص معنوى فى محصول البذرة ووزن الـ ١٠٠٠ بذرة وكذلك محصول الزيت فى النباتات المعاملة بالرصاص .
- أدت المعاملة بحامض الهيوميك أو مغنطة البذور أو الإثنين معاً إلى زيادة معنوية فى

صفات النمو الخضرى ومحتوى النبات من العناصر الكبرى والصبغات وكذلك محصول البذور والزيت ، وكان الزيت خالى تماماً من الرصاص .

وخلاصة هذه الدراسة وجد أن المعاملة بحامض الهيوميك أو مغنطة البذرة لنبات السمسم المنزرع فى أرض ملوثة بالرصاص أدت إلى تحسن واضح فى صفات النمو الخضرى وكذلك المحصول .