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The Effect of Different Fertilizers on the Heavy Metals in Soil and Tomato Plant

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Abstract: Field experiment was carried out during 2004 at Banha, Qalubia Governorate, Egypt, to investigate the effect of different rates of mineral fertilizers (NPK) and chicken manure on the distribution of heavy metals in soils and two varieties (GS12 and Alisa) of Tomato organs. The rates of mineral fertilizers and chicken manure were 100% mineral fertilizers, 75% mineral fertilizers, 50% mineral fertilizers, 100% chicken manure, 75% chicken manure, and 50% chicken manure. The lower available iron and lead in soil are found in case of planting Alisa variety compared with Gs12 variety in all treatments. Also it is clear that the high available iron and lead are found in case of using the different rates of chicken manure. Mostly The high contents of iron were found in Alisa organs compared with GS12 under different rates of chicken manure and mineral fertilizers. Also the lower contents of lead are found in Alisa organs compared with GS12. The rates of different fertilizers have significant effect on total yield of two tomato varieties. The high total yield is recorded by using the organic fertilizer as chicken manure in two varieties compared with the mineral fertilizers in different rates.

Key words: soils: tomato, mineral fertilizers, chicken manure, heavy metals, total yield.

INTRODUCTION

Tomato *(Lycopersicon esculentum)* is considered as one of the most essential vegetable crops for human nutrition in most countries. In Egypt, tomato is the First vegetable crop that occupies about one third of the total cultivated area with vegetables. The deficiency of plant nutrients causes different changes in the physiological and biochemical processes within the plant cell resulting in a reduction of growth, delay of development and qualitative and quantitative decrease of yield, (Abd – Alla et al 1999; El – Hady et al 2001& 2002 and Wahba 2004).

Heavy metal contamination of soils has markedly increased in the past few decades. Many factors such as metal-enriched parent materials, mining or industrial activities, non-point sources of metals, especially automotive emission, and use of metal-enriched materials, including chemical fertilizer, farm manures, sewage sludge, and wastewater irrigation, can contribute to this contamination, (Webber, 1981 and freedman and Hutchinson, 1981).

P-fertilizers are among the sources of heavy metal input into agricultural systems. On average, phosphate rock contains 11, 25, 188, 32, 10, and 239 mg kg^{-1} of As, Cd, Cr, Cu, Pb and Zn, respectively (Mortvedt and Beaton, 1995). Phosphate rock from Morocco and other North African countries may contain much higher levels of these elements. Repeated use of

P-fertilizers such as triple superphosphate may result in accumulation of these elements and increase the contamination potential, especially of Cd, in the soil. The aim of this work is to investigate the effect of different fertilizers on the heavy metals in soil and tomato plant.

MATERIALS AND METHODS

Field experiment was carried out during successive season of 2004 at Banha, Qalubia Governorate, Egypt, to investigate the effect of different rates of mineral fertilizers (NPK) and chicken manure on the distribution of heavy metals in soils and organs of two varieties (GS12 and Alisa) of Tomato. The design of the experiments

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Table 1: Heavy metals in samples of poultry manure and mineral fertilizer (NPK)

Fertilizer	Total (µg/g)	
	Zn	Pb
Poultry manure	284.2	110.5
Super Phosphate	266	30
Ammonium nitrate	0.7	20
Potassium Sulphate	1.3	23

Table 2: The soil characteristics of experimental field.

Treatment	EC (ds/m)	pH 1-2.5	$CaCo_3$ %	OM %	ESP meq /100g	CEC meq /100g	Texture	Total (µg/g)		Availsble (µg/g)	
								Zn	Pb	Zn	Pb
Pre-Treatment	2.5	8.4	1.4	1.9	13.5	41.5	Clay loam	378.0	41.5	125.4	24
24	125	42	378	Clay loam		41.5	13.5	1.9	1.4	8.4	2 . 5

Table 3: The effect of different treatments on total yield (ton/ fed)

Fertilizer type	Treatments	Effect	GS12	Alisa
Mineral		Fertilizer Type	18.3	18
Poultry manure			18.69	18.32
LSD			0.33	0.18
	100 %	Rates of application	20.27	20.44
	75 %		18.72	18.43
	50 %		16.25	15.61
LSD			1.23	1.65
Mineral	100 %	Interaction	19.87	20.33
	75 %		18.46	18.12
	50 %		16.06	15.67
Poultry manure	100 %		20.66	20.54
	75 %		18.97	18.74
	50 %		16.43	15.67
LSD			2.46	2.26
Mean			18.41	18.18
LSD Variety			N. S.	N. S.

was split plot with four replicates, where the two varieties were distributed in the main plots and the rates of mineral fertilizers and chicken manure in the sub – plots. Treatments were as follows:

1 - 100% mineral fertilizers
2 - 75% mineral fertilizers
3 - 50% mineral fertilizers
4 - 100% chicken manure
5 - 75% chicken manure
6 - 50% chicken manure

The plot area was 11.2 m^2 included 4 ridges, each with 7.0 Cm width and 4.0 m long Chicken manure and mineral fertilizers were analyzed for total Fe and Pb (table 1). Before cultivation, soil samples, 0-60 cm depth were analyzed for available and total elements (table2) using ammonium acetate- EDTA mixture (pH = 4.65) to extract the available elements form, (Cottenie et al, 1982). Aqua Regia was used to digest soil samples for total contents of the investigated trace and heavy elements (Cottenie et al. 1982). At harvest time, soil samples were collected from each soil treatments to measure the available Fe and Pb. Also plant samples were divided into roots, stem, leaves and fruit and digested by fusion with a mixture of concentrated acids (Cottenie et al, 1982). Heavy elements were measured using Varian SpectrAA 220 Atomic Absorption Spectrometer (AAS). Iron was determined in soil and plant applying micro-sampling technique. This could overcome the material and nebilization difficulties in high salt sample solution, while lead was determined applying graphite furnace –AAS (Ramadan and Al-Ashkar 2001 a & b) at harvest time, total yield as ton/Fed in each treatment was accounted. All the obtained data for total yield were subjected to statistical analysis of variance according to the procedure outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

1-the Available Heavy Metals in Soil under Different Treatment:

Figs 1, 2 show that the lower available iron and lead in soil were recorded in case of planting Alisa variety compared with Gs12 variety in all treatments. Also it is clear that the high available iron and lead are found in case of using the different rates of chicken manure. In all treatments, the available Fe is lower than tolerable limit (500 mg/kg soil), according to Tietjen 1975. The highest Fe and Pb content of the soil was obtained by 100% poultry manure followed by 100% mineral fertilizer treatment. On the other hand, the lowest Fe and Pb content of the soil was of the soil was recorded by 50% of any of poultry manure or mineral fertilizer treatments Also they are higher than adequate amount (4.5 ppm) according to Follet and Lindsay (1970). The available Pb are lower than the critical level (100 to 400 mg Kg^{-1}) mentioned by Kabata- Pendias and Pendias, 1984, while it is in range of common concentration (0.10 to 20 µg/g) and lower than maximum tolerable concentration (100 µg/g) according to Ewers (1991). Also they are in range of international criteria (0.5 to 135 mg Kg^{-1}) reported by Souza et al., 1996, and more than the background level of extractable Pb in nonpolluted soils of Egypt (1.17 to 1.61 µg/g) mentioned by Aboulroos et al (1996).

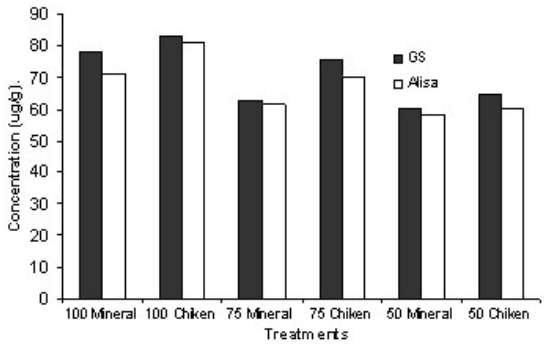

Fig. 1: The concentration of Fe in soil under different treatments

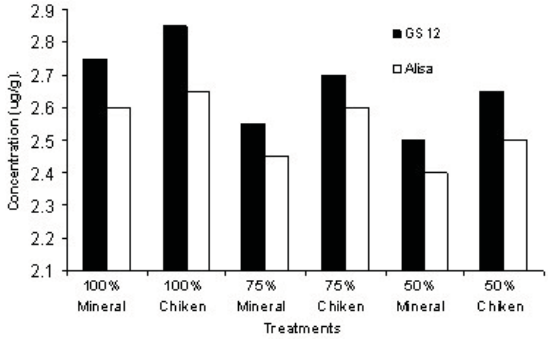

Fig. 2: The concentration of Pb in soil under different treatments (ug/g).

2-1-the Effect of Different Rates of Chicken Manure on Fe and Pb Content of Organs of Two Varieties of Tomato:

From Fig 3, it is clear that the high contents of iron are found in Alisa organs in case of using 100% and 75% chicken manure compared with Gs12 organs, while the lower contents of iron are found in Alisa organs compared with Gs12 organs in case of using 50% chicken manure. The lower contents of Pb are found in Alisa organs except in stems compared with Gs12 organs in case of using 100% and 75% chicken manure, but in case of using 50% chicken manure the high contents of lead are found in Alisa organs except in fruits compared with Gs12. show Fig (4). In general, it was found that the Fe and Pb content of tomato roots was higher compared with other plant organs.

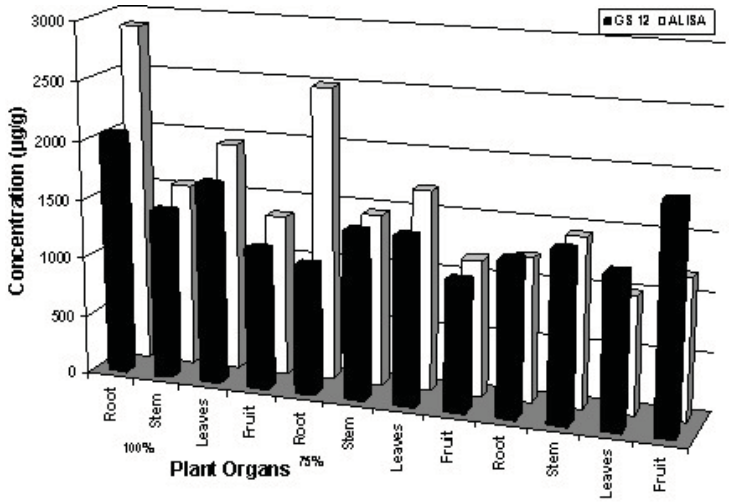

Fig. 3: The conection of Fe under different rates of chicken manure in two Tomato variety organs.

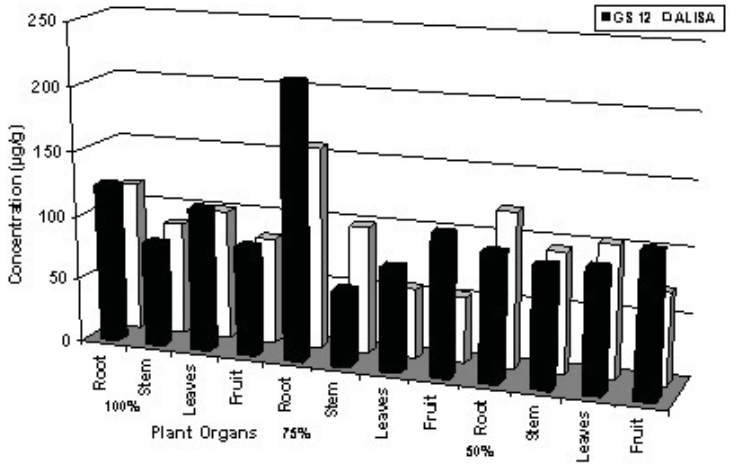

Fig. 4: The concentration of Pb under different rates of chickens manure in two Tomato variety organs.

2-2-the Effect of Different Rates of Mineral Fertilizers on Fe and Pb Content of Organs of Two Varieties of Tomato:

Fig (5 & 6) show that the high contents of iron are found in Alisa organs in all treatments except in stems, leaves and leaves in case of using 100% and 50% mineral fertilizers respectively compared with Gs12 organs. The lower contents of lead are found in Alisa organs except leaves in case of using 100% and 75% mineral fertilizers, also the roots in case of using 50% mineral fertilizers compared with GS12 organs.

3-1-the Contents of Iron in Two Varieties Organs under Different Treatments:

Higher content of Fe was recorded in the roots of tomato compared with other plant organs. Fe content of Alisa organs was higher than that of GS 12 variety. The contents of iron in two varieties organs under different treatments are more than the normal concentration (25 or 30 to 300 mg kg^{1}) according to Beeson, 1941, Chapman, 1973, and Chaney, 1989. Also they are more than the critical toxicity (400- 1000 mg kg^{-1} in plant tissues) mentioned by Romheld and Marschner (1991) and more than the maximum level tolerated by chicken, cattle (1000 mg kg^{-1}) and sheep (5oo mg Kg^{-1}) mentioned by Chaney, 1989.

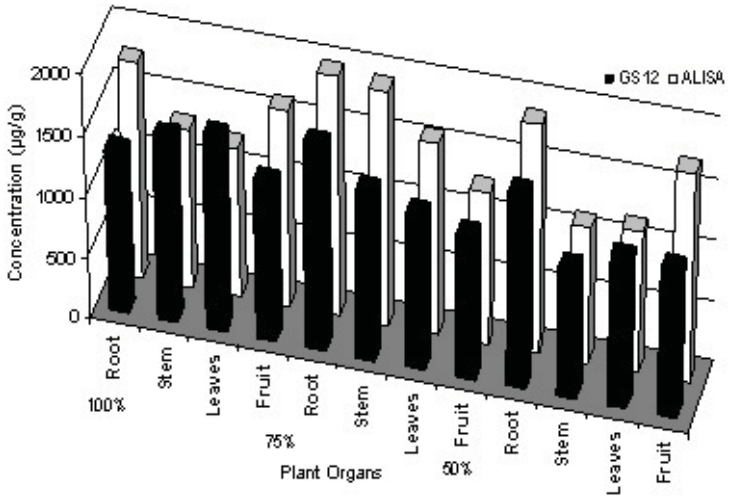

Fig. 5: The contentration of Fe under different rates of mineral fertilizers in two Tomato variety organs.

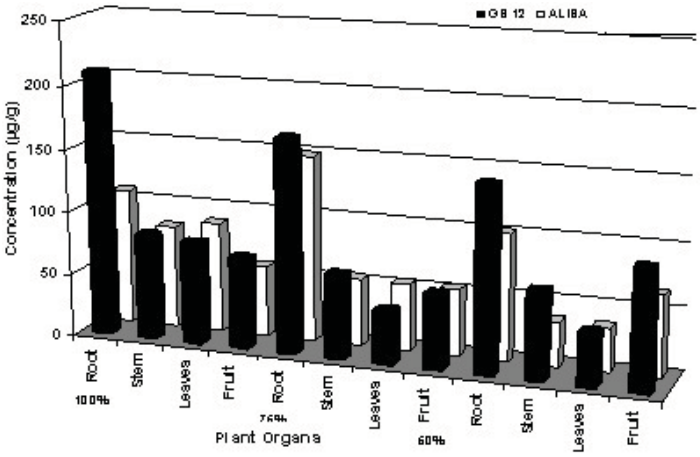

Fig. 6: The concentration of Pb under different rates of mineral fertilize in two Tomato variety organs.

3-2-the Contents of Lead in Two Varieties Organs under Different Treatments:

The lead content of the roots of the two cultivars was higher compared with the other plant organs. In addition, lead content of GS12 roots was higher than its content in Alisa roots. The contents of lead in two varieties organs under different treatments are more than the maximum amounts of Pb that occur in plant under nonpolluted condition (5.0 mg Kg^{-1}) mentioned by Kirkham, 1977, more than normal levels (2-5 mg kg^{-1} day foliage) and toxicity level for livestock (30 mg Kg^{-1}) according to Chaney, 1989. Also they are in rang of toxicity level 30- 300 ppm (Kabata- Pendias and Pendias, 2000) and more than conservative threshold value (3000 µg kg^{-1}) accepted as safe for human consumption (HapKe, 1991).

4- Fruit Yield:

4-1-the Effect of Different Fertilizers Rates:

Table (3), show that the highest fruits yield was obtained by the application of 100% of each of poultry or mineral fertilizer followed by 50% treatment. The lowest fruit yield was obtained by addition of 50% of any of poultry or mineral fertilizer. Differences between treatments were significant in the two cultivars.

4-2-the Effect of Fertilizers Type:

It is clear that the high total yield is recorded by application of the organic fertilizer as poultry manure in two varieties compared with the mineral fertilizers in different rates.

4-3-the Effect of the Interaction:

The interaction effect within levels and source of fertilizers on total yield of two tomato varieties are shown in table 3. The obtained data revealed that, the interaction treatments have significant effect on total yield of two tomato varieties.

The highest total yield of the two tomato varieties were recorded by using the high level of different fertilizers (100 %) with poultry manure and Alisa variety.

Conclusion:

In case of Pb polluted soil, it is recommended to plan Alisa variety of tomato because it showed less accumulation of Pb in its organs compared with GS12 Variety.

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