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EFFECT OF SOME SOURCES OF POLLUTION ON TOMATO PLANTS. II-Chemical Constituents

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ABSTRACT

This study was carried out in the Faculty of Agriculture, Menofiya University during the summer seasons of 1989 and 1990, to detect the effect of lead (0, 50, 100 and 200 ppm), dimethoate (0.0, 0.2, 0.4 and 0.8%) and sulfuric acid (0.0, 0.02, 0.04 and 0.08 N) on the chemical compositions of tomato plants (cv. Ace) grown in sand culture. Each pollutant was introduced in two different methods, soil treatment and foliar spray.

The chemical analysis for plant leaves showed that all pollutants had deleterious effects on chlorophyll a, chl b, and total chl (a+b), but carotenoids were increased. Soluble sugars, total carbohydrates and mineral contents (N, P, K) were reduced by all pollution sources. There was a significantly positive correlation between total chl (a+b) content and soluble sugars and insignificant correlation between total chl and total carbohydrate. The foliar spray method was more harmful in reducing chl and carbohydrate fractions than the soil application, while the reverse was true for the mineral contents.

INTRODUCTION

The existence of pollution in the environment was recently recognized, as a national and a world problem, and it may got worse in the future because of its responsibility for dirty streams, rivers, soil, atmospheric contamination and deterioration in the quality of the environment. Early studies indicated that pollutants are directly taken up by injured plants (Thomas, 1986).

Lead is a major pollutant arising from industry, motor vehicles, and sewage. The problem in Egypt, as in most developing countries, is that most industrial areas and highways are located adjacent to the cultivated lands. Consequently, there is a real danger that lead uptake by plants enters human food chain. Moreover, it may accumulate in the soil to reach undesirable level causing plant toxicity and vegetation damage (Ali, 1982). In this concern, lead pollution decreases chlorophyll, P and K contents of pepper, Jaw's Mallow and barley plants (Ali, 1982 and Salisbury and Ross, 1992); and sugar and amino acid contents of pea (Poskuta et al., 1987).

Dimethoate is widely used for crop protection and, consequently, considerable amounts reach irrigation and drainage water systems, that may be absorbed into the plant, causing changes in hormone and enzyme action (Dix, 1981). The physiological processes in plants may be altered and the chemicals may stay until the crop is harvested for animal or human food. Dimethoate, as foliage spray or soil treatments, caused scorch and discoloration of plant leaves and reduced the chlorophyll content of tomato plants (Abdel-Halim and El-Hadidy 1978). In this concern, Hussein et al. (1975) found that low concentrations of dimethoate reduced the total soluble solids content of Valencia orange. It was found that dimethoate decreased N, P and other elemental contents in several species including cucumber and okra (Hanker et al., 1977 and Sithanantham et al., 1977).

Acidity is considered to be a dangerous cause of pollution. In this concern, SO_2 gas was referred to be an ubiquitous industrial by-product that causes a significant damage to field crops. Dew and fogs often dissolve sulphuric dioxide (SO_2) gas to produce sulfuric acid causing harmful effects to plant foliage. The deleterious effects of acidity on the photosynthetic pigments were reported by Guo and Zhang (1985) on several vegetable crops. Acidity, negatively, affected the nitrogenous-compounds and elements uptake (Haines, 1979 and Agrawal et al., 1985). In contrast, Adams and Hutchinson (1987) found that acidic raindrops, left on leaves for 75 min, increased the K concentration.

Therefore, it appears important to study the effects of pollution not only because of its economic losses from damaging plants and crops, but also because plant injuries may provide an indication for the existence level of the pollutant materials in the environment and, eventually their effect on human life. The aim of this study is to investigate the effects of lead, dimethoate and sulfuric acid on the chemical compositions of tomato plants.

MATERIALS AND METHODS

The present investigation was performed at the Agricultural Experimental Station Farm of the Faculty of Agriculture, Menofiya University, during 1989 and 1990 summer seasons. Tomato (Lycopersicum esculentum Mill) seeds of Ace cultivar were used in this study.

Sowing, experimental procedures, agricultural practices and sampling were performed as reported in part-I (Moftah et al., 1992). Briefly, 40 days old uniform-seedlings were transplanted in clay pots of 30 cm diameter. Sand culture and a nutrient solution, similar to that recommended by Hoagland and Arnon (1950), were used in this experiment. Each pot received an equal amount of the solution twice a week. Distilled water was used for irrigation whenever needed. Treatments were arranged in a randomized complete blocks design with 8 replicates.

Thirty days after transplanting, treatments were performed as follows: Lead Chloride at concentrations of 00, 50, 100 and 200 ppm (these levels are very close to those found in normal, 25-100 ppm, in extremely polluted soils, 200 ppm, as reported by Ali, 1982). Dimethoate emulsion was introduced at concentrations of 00, 0.2, 0.4 and 0.8% (similar and exceed those recommended by the Ministry of Agriculture). Sulfuric acid solutions at concentrations of 0.0, 0.02, 0.04 and 0.08 N (to give pH similar to that estimated in the acid rain and collected fogs around industrial areas, Haines, 1979). Pollutants were introduced either in the irrigation water or as foliar spray.

Three plant samples were successively taken at random, starting 45 days after transplanting and, then, every two weeks (i.e. 60 and 75 days after transplanting). Chlorophyll a, b and carotinoids were determined colorimetrically in the middle fresh-leaves using the acetone method. Total soluble sugars and total carbohydrates were determined in the dry materials, using colorimetric methods reported in A.C.A.C. (1975). Nitrogen was determined using micro-kjeldahl method. Phosphorus and potassium were estimated calorimetrically and by Flame-photometer, respectively (A.O.A.C., 1975).

All data were statistically analyzed according to Snedecor and Cochran (1973). The differences among treatment means were tested, using Least Significant Differences Test (L.S.D).

RESULTS AND DISCUSSION

Photosynthetic pigments:

The successive changes for chlorophyll (Table 1) indicated that chl a, b and total chl (a+b) increased with plant age to reach a peak at 60 days after transplanting, then decreased in later growth stages. Carotenoids, on the other hand, showed a gradual increase to reach maximum values at the third sampling date.

Data in Table (2) showed clearly that chl contents decreased as lead, dimethoate or sulfuric acid levels increased. Carotenoids content went up with any pollutant treatment, particularly at high concentrations. In this respect, foliar spray seemed to be more effective than soil application. It was clear that data of the second season followed the same trend of the first one.

The harmful effect of lead on the photosynthetic pigments was reported also by Ali (1982). The reduction in chlorophyll content, caused by lead treatments, is apparently due to the inhibition of chl biosynthesis in treated plants, as suggested by some early published reports, which indicated that lead accumulated in chloroplast, disorganized their ultrastructure and decreased the biosynthesis of chloroplasts (Burzynski, 1987).The negative effect of high levels of dimethoate on chlorophyll biosynthesis was also reported by Abdel Halim and El-Hadidy (1978) on tomato plants. The unfavorable effect of acidity to chl contents in vegetable species was reported by Silvius et al. (1975). The deleterious effect of acids on membrane permeability was found to be the main reason for the observed disruption of the plastids and, consequently, the decrease in the chl content in plant tissues (Guo and Zhang, 1985).

Table (1): Successive changes in the chemical compositions of tomato leaves with plant age, in the two seasons of the study.

chem comp	first season 45	60	75	second season 45	60	75
			day after transplanting			
			chl (mg/g d.wt)			
a	2.58±0.07	3.17±0.11	2.99±0.03	3.12±0.16	3.91±0.30	3.42±0.38
b	1.71±0.09	2.25±0.38	1.95±0.18	2.06±0.20	2.73±0.20	2.95±0.40
a+b	4.63±0.14	4.94±0.29	4.91±0.20	5.18±0.25	6.68±0.52	5.80±0.34
car	2.25±1.06	2.44±1.08	2.66±1.08	2.74±1.36	3.48±1.94	3.21±1.33
			carbohydrates (mg/g d.wt)			
S.S	7.67±0.32	9.77±0.15	9.07±0.12	8.47±0.33	11.27±0.41	10.23±0.34
N.S	5.30±0.21	9.67±1.04	10.70±1.75	5.43±0.22	10.50±0.15	11.17±1.65
T.S	12.97±0.32	19.43±0.92	19.77±1.84	13.90±0.46	21.77±0.44	21.40±1.91
			elemental concentration (%)			
N	2.08±0.07	2.18±0.04	1.67±0.04	2.98±0.10	2.48±0.072	2.01±0.05
P	0.53±0.15	0.40±0.01	0.31±0.01	0.37±0.07	0.40±0.003	0.32±0.01
K	3.15±0.14	3.15±0.28	2.58±0.22	3.96±0.03	3.59±0.090	2.76±0.18

car: carotenoids
S.S: soluble sugars
N.S: non-soluble sugars
T.S: total sugars

Table (2): Effect of lead, dimethoate and sulfuric acid on the photosynthetic pigments (mg/g d.wt.) of tomato leaves. (Data are the averages of the three samples).

Method of appl. & treat.	first season Chl a	b	(a+b)	crt	second season Chl a	b	(a+b)	crt
Control	3.54	2.24	5.78	1.12	3.98	2.86	6.84	1.39
Lead (ppm)								
soil								
50	3.09	2.31	5.40	1.44	3.19	2.67	5.86	1.59
100	2.68	1.95	4.63	1.70	2.79	1.89	4.68	1.96
200	2.52	1.90	4.42	1.88	2.46	1.83	4.29	1.99
foliar								
50	2.98	2.19	5.17	1.46	3.02	2.28	5.30	1.60
100	2.88	2.15	5.03	1.49	2.55	2.33	4.88	1.64
200	2.45	1.63	4.08	1.90	2.63	1.69	4.32	1.95
LSD(5%)	0.52	0.57	0.73	0.21	0.61	0.73	0.62	0.40
Dimethoate								
soil								
0.2	3.05	1.82	4.87	0.96	3.79	2.73	6.52	1.19
0.4	2.71	1.51	4.23	1.06	3.79	2.76	6.55	1.40
0.8	2.35	1.15	3.50	1.29	3.38	2.48	5.86	1.55
foliar								
0.2	2.96	1.86	4.82	0.89	3.69	2.68	6.30	1.18
0.4	2.52	1.33	3.85	1.08	3.55	2.59	6.14	1.36
0.8	1.99	1.05	3.04	1.58	2.95	2.23	5.18	1.87
LSD(5%)	0.81	0.59	1.67	0.22	0.67	0.37	0.74	0.48
Sulfuric aci								
soil								
0.02	3.52	2.23	5.75	0.62	4.39	2.88	7.27	1.01
0.04	2.82	1.96	4.78	0.94	3.90	2.59	6.49	1.30
0.08	2.45	1.42	3.87	1.28	3.58	2.33	5.91	1.59
foliar								
0.02	3.01	2.07	5.08	0.68	3.91	2.69	6.60	0.92
0.04	2.64	1.72	4.36	0.96	3.68	2.45	6.13	1.11
0.08	2.53	1.28	3.81	1.20	3.49	1.76	5.25	1.69
LSD(5%)	0.44	0.58	1.5[illegible]	0.40	0.22	0.42	0.66	0.52

Carbohydrate fractions:

The successive changes of data in Table (1) illustrated that soluble and total sugar contents were increased with plant age to reach a peak at 60 days after transplanting, then decreased at the last sampling date (75 days after transplanting). The non soluble sugars increased gradually to reach maximum values at the third sampling time. These results seemed to be reliable, since the soluble sugars to be transported from leaves to the fruits are produced by that time; whereas the continuous build up of the cellulose and other cell wall and organelles materials with plant age caused a continuous increase in the non-soluble fraction. The decrease in soluble sugars observed at the third sampling time might be attributed to its movement from the leaves to fruits and other reproductive organs which might be active at that stage of growth.

The negative effects of the medium and high concentrations of lead, dimethoate and sulfuric acid on carbohydrate fractions were indicated in Table (3). In this concern, lead pollutant was more effective in reducing the soluble sugars than the other pollutants; while sulfuric acid caused a more negative effect on the non-soluble and total sugar fractions than others. In all cases, foliar application was more harmful to sugar synthesis than soil application method. This was true in both seasons.

The negative effect of lead on soluble sugar content might be attributed to its deleterious effect on the rate of sugar biosynthesis and flow of photoassimilates (Poskuta et al., 1987). The inhibitory effect of lead on the photosynthetic enzyme ribulose bisphosphate carboxylase (RuBPC), reported by Salisbury and Ross (1992), and on gaseous exchange, reported by Carlson et al. (1975), might be good reasons for altering the formation of soluble and total sugars in plant leaves. This conclusion is in a harmony with that of Poskuta *et al*. (1987), who found that lead decreased the photosynthesis and sugar content in pea plants. Lead accumulated in chloroplast was reported to inhibit the photosystem II as well as photophosphorylation beside the activity of several other enzymes of the reductive pentose phosphate cycle (Hampp *et al*., 1973). The reduction in sugars and total solid contents, resulted from high levels of dimethoate, was also reported by Hussein *et al*. (1975).

The inhibitory effect of H_2SO_4 on the sugar formation seemed to be related to its negative effect on plant photosynthesis and energy products. In this concern, Silvius *et al*. (1975), reported that H_2SO_4 dissociated in the leaves and gave anions such as HSO_3 and SO_3, which accumulated in the cells and caused severe toxicity because these anions uncoupled the photophosphorylation and disrupted the chloroplast, thus, inhibited the photosynthesis of the plants.

As Salisbury and Ross (1992) reported, present data indicated that the effect of pollutants on carbohydrate fractions seemed to be related, at least partially, to the effect on chlorophyll content. For this reason, the relationship between chlorophyll and carbohydrate fractions was traced and the correlation coefficient study was performed (Table 4) and showed some interesting remarks. In this respect, their was a highly significant positive correlation between the content of chl a and the soluble sugars. Moreover, their was a highly significant positive correlation between chl b and the non-soluble sugar content. The total chl (a+b) showed a good correlation with the soluble sugar. On the other side, the total sugar content showed insignificant correlation with any of the chl fractions.

Table (3): Effect of lead, dimethoate and sulfuric acid on the carbohydrate contents (mg/g d.wt.) of tomato leaves. (Data are averages of the three samples).

Method of appl. & treat.	first season			second season		
	carbohydrate contents					
	S.S	N.S	T.S	S.S	N.S	T.S
Control	10.7	11.3	22.0	11.4	11.6	23.0
Lead (ppm)						
soil						
50	10.0	10.6	20.6	10.9	10.5	21.4
100	9.1	8.9	18.0	10.0	9.2	19.2
200	6.5	9.5	16.0	8.3	8.1	16.4
foliar						
50	9.7	10.6	20.3	10.5	11.5	21.0
100	7.9	9.1	17.0	9.0	9.0	18.0
200	5.5	9.5	15.0	6.9	8.3	15.2
LSD(5%)	1.8	1.4	3.4	1.9	1.7	3.6
Dimethoate (%)						
soil						
0.2	11.4	10.2	21.6	11.8	10.6	22.4
0.4	8.8	10.8	19.6	11.5	10.3	21.8
0.8	7.5	8.8	16.3	9.0	9.9	18.9
foliar						
0.2	11.9	9.7	21.6	12.7	10.4	23.1
0.4	7.6	10.4	18.0	9.7	10.7	20.4
0.8	6.0	5.0	11.0	8.0	6.3	14.3
LSD(5%)	2.6	2.8	4.4	2.1	1.6	4.6
Sulfuric acid (N)						
soil						
0.02	10.6	7.4	18.0	11.4	7.9	19.3
0.04	9.5	5.8	15.3	11.0	5.6	16.6
0.08	6.9	5.9	12.8	8.3	5.8	14.1
foliar						
0.02	9.9	5.7	15.6	11.0	6.5	17.5
0.04	7.9	5.7	13.7	8.9	6.2	15.1
0.08	5.9	4.4	10.3	6.9	4.9	11.8
LSD(5%)	2.3	1.2	3.1	2.7	1.3	3.6

S.S: soluble sugars
N.S: non-soluble sugars
T.S: total sugars

Table (4): The correlation coefficient (R) between chlorophyll content and carbohydrate fractions at the first season.

	chl a	chl b	chl (a+b)	S.S	N.S	T.S
chl a	1.000					
chl b	0.954**	1.000				
chl (a+b)	0.951**	0.952**	1.000			
S.S	0.958**	0.884*	0.919**	1.000		
N.S	0.873*	0.934**	0.896*	0.879*	1.000	
T.S	0.574	0.622	0.627	0.574	0.611	1.000

*,** = significant at 5% and 1% levels, respectively.
S.S: soluble sugars
N.S: non-soluble sugars
T.S: total sugars

Elemental percentage:

Looking to the successive changes data of Table (1), it was interesting to find that nitrogen and phosphorus percentages increased at the second sampling date, then decreased at the third. Potassium concentration achieved a high level at 45 days from transplanting, then, decreased gradually with plant age to reach its minimum concentration at the third sampling date (Table 1). The decrease of N with tomato plant age was also reported by Radwan et al. (1979). This reduction in N and K concentration, observed at later stage of growth, coincided with fruit set and early fruit development; Thus, a rapid translocation of soluble nitrogen to fruits occurred during that period of development.

Data recorded in Table (5) showed that Nitrogen (N), Potassium (K), and phosphorus (P) concentrations were negatively affected by lead, dimethoate and sulfuric acid treatments. In this respect, it was evident that sulfuric acid and dimethoate were more effective than lead treatments. It was clear that soil application method with any of these pollutants showed more negative effects than foliar spray one.

The highly negative effects of lead polluted soil on N, P and K were also reported by Ali (1982) on pepper and Jaw's mallow. This reduction was attributed to the inhibitory effect of the heavy metals on the uptake and translocation of these elements by plant roots (Mengel and Kirkby, 1987). Moreover, the effect of the pollutants on elemental content might be ascribed to their indirect factors such as their effects on the water uptake and transpiration and, consequently, decreasing mineral uptake by plants (Burzynski, 1987).

The harmful effects of dimethoate on the elemental and other chemical compositions of tomato and other plant species; reported by

Table (5): Effect of lead, dimethoate and sulfuric acid on N, P, and K (%) in tomato leaves. (Data are averages of the three samples).

Method of appl. & treat.	first season			second season		
	elemental conc. (%)					
	N	P	K	N	P	K
Control	2.27	0.40	3.38	2.83	0.42	3.77
Lead (ppm)						
soil						
50	2.10	0.38	3.24	2.42	0.39	3.57
100	1.94	0.36	3.14	2.27	0.36	3.37
200	1.74	0.33	2.81	2.17	0.33	3.02
foliar						
50	2.15	0.39	3.26	2.52	0.38	3.70
100	2.05	0.37	3.09	2.40	0.37	3.57
200	1.89	0.35	2.82	2.25	0.36	3.28
LSD(5%)	0.35	0.05	0.32	0.31	0.07	0.30
Dimethoate (%)						
soil						
0.2	1.99	0.38	2.93	2.57	0.40	3.65
0.4	1.86	0.34	2.69	2.36	0.36	3.52
0.8	1.62	0.29	2.40	2.03	0.29	3.40
foliar						
0.2	2.19	0.40	2.98	2.75	0.39	3.68
0.4	1.99	0.35	2.69	2.54	0.35	3.47
0.8	1.86	0.31	2.44	2.25	0.30	3.30
LSD(5%)	0.45	0.08	0.40	0.29	0.09	0.31
Sulfuric acid (N)						
soil						
0.02	2.03	0.36	3.13	2.66	0.38	3.48
0.04	1.74	0.34	2.63	2.51	0.35	3.23
0.08	1.53	0.32	2.26	2.40	0.33	2.91
foliar						
0.02	2.14	0.38	3.21	2.76	0.39	3.68
0.04	2.00	0.35	2.35	2.66	0.36	3.50
0.08	1.87	0.33	2.06	2.55	0.33	3.21
LSD(5%)	0.41	0.04	0.60	0.11	0.04	0.33

Hanker *et al.* (1977), Sithanantham *et al.* (1977) and Rozek (1981), and Abdel-Halim and El-Hadidy (1978); were attributed to their inhibitory effect on respiration, since most of nutrient elements require energy for their movement and uptake.

The impairing effect of acids to the elemental uptake was reported earlier by Haines (1979) who found that the acidic mist of pH < 5.6 decreased the rates of elemental uptake by plant roots. Potassium (K) content of *Vicia faba* plants was also decreased by acidity (Agrawal *et al.*, 1985). This deleterious effect of acidity on elemental uptake and composition was found to be due to the damaging effect on cell membrane composition and permeability (Guo and Zhang, 1985).

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تاثير بعض مصادر التلوث البيئى على نباتات الطماطم

١- التاثير على المكونات الكيماويه

اجرى هذا البحث بكلية الزراعة جامعة المنوفيه فى الموسم الصيفى لعامى ١٩٨٩، ١٩٩٠ لدراسة تاثير بعض الملوثات البيئية المنتشره فى البيئة المصريه.وقد اختير الرصاص (ممثلا لتاثير التلوث بالعناصر الثقيلة) بتركيز ٥٠ و ١٠٠ و ٢٠٠ جزء فى المليون ، الفايمثويت (ممثلا لتاثير التلوث بالمبيدات الحشرية) بتركيز ٤ر و ٨ر و ٨ر في الماله كما اختير حمض الكبريتيك (ممثلا لتاثير التلوث الناتج عن انخفاض رقم الحموضه) بتركيز ٢٠و ٤٠و ٨٠و عيارى على المحتوى الكيماوى لنباتات الطماطم المنزرعه فى بيئة رمليه. وقد استخدم الماء كمعاملة مقارنه. وتم استخدام هذه الملوثات بطريقتين احداهما هى الاضافه مع ماء الرى (تلوث مائى و تلوث التربه) و الاخرى رشا على المجموع الخضرى (تلوث هوائى) وقد اوضحت النتائج المتحصل عليها ان جميع الملوثات التى استخدمت اثرت تاثيرا معنويا على تركيز كل من كلوروفيل أ و كلوروفيل ب وايضا المحتوى الكلى للكلوروفيللات، بينما ازداد تركيز الكاروتينويدات فى الاوراق. بالاضافه الى ذلك ادت جميع المعاملات، خاصه التركيزات العاليه، الى نقص واضح فى تركيز السكريات الذائبه وغير الذائبه وايضا الكربوهيدرات الكليه فى انسجة النباتات المعامله بمقارنتها بالغير معامله. أدت جميع مصادر التلوث الى نقص معنوى فى تركيز النيتروجين و الفوسفور و كذلك البوتاسيوم بالمقارنه بنباتات المقارنة. أظهرت النتائج ان التلوث الورقى كان أشد ضررا على المحتوى الكلوروفيللى والكربوهيدراتى بالمقارنه بتلوث التربه، بينما العكس كان صحيحا بالنسبه لمحتوى النبات من العناصر.
أوضح التحليل الاحصائى وجود علاقة وثيقة بين تركيز الكلوروفيل الكلى وتركيز السكريات الذائبه بينما لم تظهر هذه العلاقة بين الكلوروفيل الكلى وتركيز الكربوهيدرات الكليه.