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COUNTERACTING THE DELETERIOUS EFFECTS OF LEAD AND CADMIUM ON TOMATO PLANTS BY USING YEAST, GARLIC AND EUCALYPTUS EXTRACTS

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ABSTRACT: *Pot experiments were conducted to study the effect of lead (Pb) in different concentrations i.e., 0, 250 and 500 mg / L and cadmium (Cd) at the rate of 0, 100 and 200 mg / L on vegetative growth, chemical constituents, fruit quality as well as yield of tomato plants. The ability of some natural extracts (garlic, yeast and eucalyptus) in a trial to overcome the harmful effects of Pb and Cd on the growth and physiological behaviour of the polluted plants was also investigated.*

Lead and cadmium negatively affected plant growth represented by plant height, leaf number, dry weight of shoots and roots as well as water relations. Photosynthetic pigments, carbohydrates and soluble sugars were also negatively affected. Increasing lead and cadmium concentrations decreased fruit yield and fruit quality. Garlic, yeast and eucalyptus extracts are useful in counteracting the harmful effects exerted by lead and cadmium contamination on tomato plants. Extracts increased markedly plant height, leaf number, dry weights, photosynthetic pigments, total carbohydrate, soluble sugars as well as fruit yield and quality of fruit. Moreover, in the presence of extracts significantly reduced the internal Pb and Cd concentration in tomato fruit compared with Pb or Cd treated alone.

Key words: lead, cadmium, garlic, yeast, eucalyptus extract, growth, water relation, chemical constituents, fruit quality, yield.

INTRODUCTION

Tomato *Lycopersicon esculentum* L. is one of the most important and popular vegetable allover the world. In Egypt, it takes the first rank among the vegetables. In addition, tomato represents one of the most important vegetable crops for local consumption and export.

Pollution with heavy metals and toxic chemicals is one of the greatest environmental problems, which increased heavily during the last decades. In Egypt, emission from automobile exhaust is the greatest source of pollution with lead and cadmium. In addition, many areas show increased levels of different heavy metals as a result of application of large amounts of cattle manures, mineral fertilizers, composts, contaminated harbor, sludge or sewage sludge (Bockhold, 1992).

Accumulation of heavy metals in agricultural soils has become a major concern for food crop production. Lead and cadmium are recognized as one of the most hazardous elements which are not essential for plant growth (Kabata, Pendias and Pendias, 1992)Thomas (1986) indicated that pollutions are directly taken up by injured plants. Also, Stochs and Bagchi (1995) and Taiz and Zeiger (1998) related the toxicity of heavy metals, including lead, to their ability to cause oxidative damage to plant cells. This damage includes enhanced lipid peroxidation, DNA damage, and the oxidation of protein sulfhydryl groups. In this connection, Marrs (1996) reported that the oxidative stress, caused by heavy metals pollution is established through a series of redox reactions initiated by hydrogen peroxide and other free radicals.

During the last few years, concerning the public health, there are many cautions about the use of those synthetic plant growth regulators and also the excess of mineral nutrition on the fresh marketable vegetables and fruits.

The application of natural extracts protects plants against heavy metals pollution. Among these extracts yeast, garlic, and eucalyptus were found to exert positive effect and overcome the harmful effect of some environmental stress on plant growth. Hanafy *et al.* (1994) reported that, garlic antagonized lead toxicity. Garlic contains chelating compounds capable of enhancing elimination of lead and feeding can minimize lead concentrations in meat food animals from a lead polluted environment. El-Desouky *et al.* (1998) and Wanas *et al.* (1998) reported that the natural extract of garlic cloves and the active yeast cells improve the growth, sex expression and fruity yield and quality of squash plant.

Recently, Atawia and El-Desouky (1997) reported that foliar spray with natural yeast extract at the full bloom stage of Washington navel orange trees improve the fruit yield / tree as well as fruit quality.

The objective of this work is to study the effect of Pb and Cd as pollutants on the growth, physiological behaviour and chemical constituents of tomatos. The present study aimed also to determine the prospective use of three natural extracts I.e., garlic, yeast and eucalyptus, extracts. Since, these extracts contain many growth materials and essential requirements at vegetative and reproductive growth of different plants in counteracting or at least reducing the deleterious effects of the environmental pollution caused by Pb and Cd.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of the Faculty of Agric., Minufiya University during two successive seasons of 2001 and 2002.

Clay loam soil was collected from an ordinary agricultural field, Shibin El-Kom district and was analyzed for Pb and Cd by Atomic Absorption Spectrophotometer in ammonium acetate extracts (Jackson, 1956). The physical and chemical analysis of the soil were as follows:

Pb (mg/L)	Cd (mg/L)	Sand (%)	Salt (%)	Clay (%)	pH (1 : 2 w)
0.10	0.08	28.0	44.0	29.8	7.4

Seeds of tomatos Floradade cv. obtained from the Agricultural Research Center of Giza, Egypt were sown in the nursery beds at the 1st of April. Four weeks later, uniform seedlings were transplanted in pots of 30 cm diameter filled with 7 kg clay loam soil. One month after transplanting, treatments were performed as follows: lead acetate at concentration of 0, 250 and 500 mg/L. Cadmium sulphate at concentrations of 0, 100 and 200 mg/L were introduced in the irrigation water.

Yeast (at the rate of 6 g/L), garlic (at the rate of 30 g/L) and eucalyptus extract (at 5%), were applied as foliar spray three times in one week intervals, beginning 5 weeks after transplanting (5, 6 and 7 weeks after transplanting). The untreated plants were sprayed with tap water.

Garlic extract: One kg fresh mature garlic cloves were blended in 1 liter distilled water, frozen and thawed two times then filtered (El-Desouky *et al.*, 1998).

Yeast extract: The dry pure yeast powder was activated by using sources of carbon and nitrogen at the rate of 6 : 1 (Barnett *et al.*, 1990). This ratio is suitable to get the highest vegetative reproduction of yeast (each 1 ml YE contained about 12000 yeast cells). Then the media was frozen and thawed directly before usage. Tween-20 was added as a spread agent for all treatments.

Eucalyptus extract: *Eucalyptus citriodora* L. plants were completely air-dried, then ground to fine powders in a grinder. A known weight of plant powder was extracted with chloroform (3 : 1 v/v) as described by Meisner *et al.* (1970) and Freedman *et al.* (1979). The crude gum of solvent was weighted and redissolved in owning solvent to give concentration 5%.

The usual agricultural practices were followed. One week after the last treatment, samples were taken randomly from each treatment.

The following data were recorded:

1. Growth analysis: Plant height, number of leaves, and dry weights of shoots and roots.
2. Leaf water relations: Total water content (TWC, %), relative water content

(RWC, %) and leaf water deficit (LWD, %), according to the methods described by Kalapos (1995).

3. Chemical analysis: Photosynthetic pigments estimated as described by Wettestein (1957). Total carbohydrates and soluble sugar concentrations in leaves determined colorimetrically using the phenol sulfuric acid method of Dubois *et al.* (1956). The previous parameters were calculated as mg / g dry weight.
4. Yield: Numbers of flowers / plant, number of fruits / plant and fruit yield g / plant.
5. Fruit chemical constituents: Total soluble solids (T.S.S.) estimated by taking a random sample of fire fruits, blended and filtrated through muslin cloth and then through filter paper No. 1, the total soluble solids were determined in the filtrate by carlzeiss refractometer. Vitamin C content and titratable acidity determined according to the procedure reported by the A.O.A.C. (1990). Cadmium and lead determined in the fruit of tomatoes. The concentration of lead and cadmium were measured in the digest by atomic absorption spectrophotometer according to Cottenie (1980).

The data were statistically analyzed using the ANOVA (Analysis of Variance) with the aid of COSTAT computer program test. Differences Indicated to be significant at 5% significance level as described by Snedecor and Cochran (1973).

RESULTS AND DISCUSSION

1. Vegetative growth:

Data presented in Table (1) show that, plant height and leaf number of Pb and Cd-treated plants were significantly reduced, particularly at high levels of pollutants. It is obvious that the highest concentrations of Pb and Cd reduced the height of plants by about 33 and 29.8%, respectively. These results confirm those reported by Gadallah (1995) who reported that the heavy-metal toxicity appears in the reduction of plant height and dry mass accumulation.

As a further sign of growth inhibition by Pb and Cd pollution, it is obvious that the dry matter of plant in the Pb and Cd-treated plants was drastically decreased particularly at high concentrations. In this concern, the obtained data show that, dry matter of shoots and roots was reduced by about 61.8 and 47.0%, respectively at 500 mg/L, and 57 and 42.9%, respectively at 200 mg/L Cd. The obtained results confirm those reported by Begonia *et al.* (1998) who found that, *Brassica juncea* root dry matter was reduced by lead treatment. Moreover, Ghonem *et al.* (1997), working on maize, and Singh *et al.* (1999), on cow peas and mung beans found that the dry matter yield decreased with increasing cadmium concentration. Selim (2001) found that,

vegetative growth characters of carrot roots and shoots were significantly inhibited with increasing the Pb concentration in soil. Recently, El-Shafie and Shikha (2002) on pea, reported that, increasing soil Cd application resulted in reduction of shoot and root dry weight.

Table (1): Effect of yeast, garlic and eucalyptus extracts on some growth characters of polluted tomato plants during 2001 and 2002 seasons.

Pb & Cd (mg/L)	2001				2002			
	Plant height (cm)	Leaf number / p	d.wt of shoots (g) / p	d.wt of roots (g) / p	Plant height (cm)	Leaf number / p	d.wt of shoots (g) / p	d.wt of roots (g) / p
	Pb-polluted plants							
Pb 250	35.7	7.3	2.46	0.33	45.0	9.7	3.47	0.41
+ y	48.5	12.0	5.97	0.66	57.7	13.0	6.96	0.83
+ g	46.7	11.3	5.18	0.58	55.4	11.0	6.58	0.81
+ e	45.6	10.9	4.48	0.53	55.3	12.7	6.38	0.78
Pb 500	28.7	5.7	1.67	0.26	38.3	7.0	2.2	0.36
+ y	45.5	9.6	4.41	0.52	46.3	11.3	4.5	0.52
+ g	41.7	9.0	4.21	0.45	44.0	11.0	3.9	0.49
+ e	40.3	8.0	4.11	0.41	45.4	11.4	4.0	0.48
Control	43.0	11.3	4.37	0.49	48.3	12.3	4.26	0.55
LSD 5%	3.8	3.2	2.0	0.18	4.9	n.s.	1.1	0.22
	Cd-polluted plants							
Cd 100	36.7	7.3	2.99	0.36	42.3	10.0	3.61	0.40
+ y	52.3	11.3	5.12	0.86	52.7	13.7	6.21	0.84
+ g	49.7	11.0	4.25	0.69	50.7	12.3	5.61	0.84
+ e	44.0	11.0	4.20	0.68	51.7	12.0	5.34	0.83
Cd 200	30.2	7.0	1.88	0.28	37.7	9.0	2.52	0.30
+ y	41.7	11.0	4.00	0.50	45.2	11.3	4.2	0.50
+ g	40.8	9.0	3.82	0.43	43.3	11.0	3.9	0.45
+ e	41.6	9.0	3.01	0.41	40.4	11.0	3.7	0.43
Control	43.0	11.3	4.37	0.49	48.3	12.3	4.26	0.55
LSD 5%	6.1	2.9	1.4	0.29	3.7	2.2	1.0	0.19

Y = yeast 6 g/L , g = garlic 30 g/L and e = eucalyptus 5%

The reduction in plant height and dry matter caused by Pb and Cd may be attributed to the deleterious effect of those metals on the activity of enzymes that involve in the regulation of growth and physiological behaviour (Salisbury and Ross, 1978). In addition, Vassilev *et al.* (1997) reported that heavy metals may cause toxicity to some plants as photosynthetic pigments and photosynthesis are affected causing inhibition in the growth and development of many species.

The natural extracts seemed to overcome the harmful effects of Pb and Cd pollution and improved plant vegetative growth. It is clear that, tomato plants treated with lead and cadmium, then sprayed with garlic, yeast or eucalyptus extracts showed better growth behaviour than those unsprayed. The best results in this concern were obtained from yeast extract followed by garlic then eucalyptus. In this respect, some natural extracts have been applied to some economic plants as new trends for enhancing the plant growth, increasing the final yield and improving its quality as well as diminishing the amount of applied fertilizers. Of those studies are Fathy and Farid (1996), Atawia and El-Desouky (1997), Fathy *et al.* (2000) and Mahmoud (2001). Yeast treatments were suggested to participate in a beneficial role during vegetative and reproductive growth through improving the conc.of auxins and cytokinins as well as flower formation and setting in some plants (Barnett *et al.*, 1990). Also, it was reported about its stimulatory effects on cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation (Karaig and Haber, 1980 and Wanas *et al.*, 1998). Hanafy *et al.* (1994) reported that, garlic antagonized lead toxicity. The role of garlic in overcoming the harmful effects of some heavy metals was explained as, garlic contains chelating compounds capable of enhancing the elimination of lead.

Concerning the effect of eucalyptus extract, it was reported that the extracts contains volatile oils and some growth regulator like substances that may induce some kinds of tolerance to treated plants against heavy metal toxicity. In addition, it has been reported that oil of such plants may influence the synthesis of some compounds inside cells of treated plants such as lipids and aromatic compounds that may play an important role in plant growth and physiological behaviour (Salisbury and Ross, 1978). In this regard, Selim *et al.* (2002) found that, chloroformic extract of eucalyptus plants contained saponins, sterols, tannins, alkaloids and flavonoids.

2. Water relation:

Data of water relations presented in Table (2) show clearly that all levels of lead and cadmium decreased TWC, RWC and increased LWD as compared with untreated plants. These results are in agreement with those obtained by Obata *et al.* (1997) who found that, the efflux of H^+ form, and influx of K^+ to, radicals of rice were inhibited by 10 µm Cd. It is concluded that Cd may affect the permeability of plasma membrane of plant roots. Obata and Umebayashi (1997) reported that, water absorption in *Phaseolus vulgaris* was reduced by Cd. The pronounced negative effect was observed under high levels of lead and Cd treatments. According to Burzynski (1987) the inhibitory effect on water relations may be attributed to the effect of heavy metals on transpiration and water content as a consequence of the harmful effect on transpiration system and stomatal structure.

The natural extracts seemed to overcome or reduce the harmful effects of Pb and Cd pollution and improve plant water relations. All the natural extracts improved TWC, RWC and decreased LWD in lead and Cd treated tomato plants compared with control. In this regard, Angle *et al.* (1992) reported that yeast extract significantly reduced Cd toxicity and alleviated

Table (2): Effect of yeast, garlic and eucalyptus extracts on total water content (TWC), relative water content (RWC) as well as leaf water deficient (LWD) of polluted tomato plants during 2001 and 2002 seasons.

Pb & Cd (mg/L)	2001			2002		
	TWC%	RWC%	LWD%	TWC%	RWC%	LWD%
	Pb polluted plants					
Pb 250	65.9	68.0	31.9	69.7	70.4	29.6
+ y	88.7	80.9	19.1	93.4	82.6	17.4
+ g	86.8	75.2	24.8	90.4	81.6	18.4
+ e	80.5	74.4	25.6	88.4	80.4	19.6
Pb 500	55.4	60.7	39.3	58.9	66.4	33.6
+ y	73.3	71.6	28.4	77.4	75.4	24.6
+ g	72.3	70.5	29.5	76.3	74.4	25.6
+ e	70.3	70.9	29.1	75.8	73.5	26.5
Control	81.6	72.1	27.9	85.9	78.4	21.6
LSD 5%	3.18	4.62	2.58	1.89	2.01	3.20
	Cd polluted plants					
Cd 100	70.0	71.5	28.5	70.9	72.4	27.6
+ y	89.6	81.2	18.8	92.3	85.4	14.6
+ g	85.1	80.4	19.6	88.4	83.4	16.6
+ e	83.4	78.7	21.3	89.7	82.4	17.6
Cd 200	55.9	65.3	34.7	60.3	68.6	31.3
+ y	70.4	75.5	24.5	80.6	78.2	21.8
+ g	69.5	74.7	25.3	79.4	75.3	24.7
+ e	66.6	74.5	25.5	77.2	72.4	27.6
Control	81.6	72.1	27.9	85.9	78.4	21.6
LSD 5%	3.0	3.3	1.0	0.56	1.8	1.28

the harmful effect of heavy metals on many plant species. Selim *et al.* (2002) reported that eucalyptus extracts increased the water content and transpiration rate of *Zea uays* L.

3. Chemical analysis:

Data concerning the effect of Pb and Cd as well as yeast, garlic and eucalyptus extracts on photosynthetic pigments, total carbohydrates and soluble sugars are presented in Table (3).

3.1. Photosynthetic pigments:

Statistical analysis show a highly significant decrease in total chl. (a + b) and carotenoids by increasing heavy metals concentration. The use of high lead and cadmium concentration reduced chl. a + b by 60 and 32.5% while

Table (3): Effect of yeast, garlic and eucalyptus extracts on photosynthetic pigments, total carbohydrate as well as solubles sugars determined as (mg / g d.wt.) of polluted tomato plants during 2001 and 2002 seasons.

Pb & Cd (mg/L)	2001				2002			
	Chl. a + b	Caroten-oids	Total carbo-hydrates	Total soluble sugars	Chl. a + b	Caroten-oids	Total carbo-hydrates	Total soluble sugars
	Pb-polluted plants							
Pb 250	2.9	1.4	133.1	2.6	3.2	1.58	115.5	3.4
+ y	4.4	2.9	278.1	4.7	4.6	2.9	240.4	5.7
+ g	4.3	2.7	251.8	4.6	4.6	2.8	224.4	5.6
+ e	4.4	2.2	208.5	4.5	4.6	2.6	212.9	5.4
Pb 500	1.6	1.0	98.0	1.2	2.5	1.01	70.5	2.4
+ y	4.2	2.6	182.2	4.2	4.5	2.4	182.0	4.9
+ g	3.9	2.3	161.9	4.0	4.2	2.3	160.5	4.7
+ e	3.2	1.5	177.5	3.6	3.9	1.9	117.5	4.6
Control	4.0	2.1	151.6	3.6	4.4	2.0	177.0	3.6
LSD 5%	0.3	0.33	12.4	0.81	0.32	0.27	13.6	1.2
	Cb-polluted plants							
Cd 100	3.2	1.7	100.4	1.7	2.9	1.3	140.8	2.6
+ y	4.9	3.0	174.1	3.7	4.8	2.4	250.5	5.5
+ g	4.8	2.9	160.3	3.4	4.7	2.3	230.6	4.7
+ e	4.5	2.9	158.6	3.4	4.3	2.3	220.6	4.4
Cd 200	2.7	1.5	83.9	1.3	2.5	1.1	80.5	2.4
+ y	4.4	2.4	140.8	3.0	4.0	2.1	188.7	3.9
+ g	4.0	2.1	135.5	2.8	3.9	2.0	187.1	3.9
+ e	4.3	2.1	130.2	2.8	3.9	2.0	172.8	3.8
Control	4.0	2.1	151.6	3.6	4.4	2.0	177.0	3.6
LSD 5%	0.3	0.3	7.2	0.59	0.32	0.36	10.8	0.6

carotenoids were decreased by 52.4 and 28.6% for lead and cadmium, respectively, compared with control plants. Skorzynska and Basznski (1993) reported that a significant reduction (73%) in the leaf chlorophyll content was observed with increasing cadmium concentration. Gil *et al.* (1995) working on tomato, reported that, leaf total chl. and carotenoids concentration decreased with increasing Cd concentration. In this regard, Lagriffoul *et al.* (1998) reported that Pb can alter chl. biosynthesis by inhibiting protochlorophyllide reductase through interfering the sulfhydryl site on the enzyme. The decrease in carotenoid concentration, occurred by Pb application, may also lead to decreasing chl. a and chl. b because carotenoids prevent chl. photodestruction. The inhibition of Pb on Fe uptake and transport to plant leaves may result also in reducing chl. synthesis and cause chlorosis (Fodor *et al.*, 1998).

Yeast, garlic and eucalyptus extracts were able to decrease the harmful effect of Pb and Cd and to improve the photosynthetic pigment concentrations in leaves. The best results in this concern were obtained from yeast followed by garlic then eucalyptus extract. These results are generally in accordance with those obtained by El-Desouky *et al.* (1998) on squash and Wanas (2002) on faba bean, who reported that yeast enhanced the formation of chlorophyll, and delayed its degradation and senescence of bean plants. Such promotional effects upon the formation of chlorophyll might be due to the active role of such agents in the pathway of synthesis of α-aminolevulinic acid (Stroev, 1989) the precursor of chlorophyll bio synthesis (Hess, 1981). Both garlic and yeast extracts caused an increase in the concentration of photosynthetic pigments.

3.2. Total carbohydrates and soluble sugars:

It is obvious that increasing lead and cadmium levels significantly reduced total carbohydrates and soluble sugars (Table 3). It is clear that, under 500 mg/L of lead and 200 mg/L of cadmium the reduction in total carbohydrates reached 35.4 and 44.7% soluble sugars 66.7 and 63.8% for lead and Cd, respectively, compared to their controls. The pronounced negative effect was observed under the highest concentrations of lead and cadmium treatments. This negative effect of Pb and Cd on carbohydrate levels of treated plants may be attributed to their deleterious effects on the photosynthesis process and water relation parameters inside plant tissues (Poskuta *et al.*, 1988 and Burzynski, 1987). The present study showed that the concentration of chl. were reduced. Thus, direct damage to the photosynthesis process, may occur leading to decreasing carbohydrate formation within plant tissues.

Yeast, garlic and eucalyptus extracts tended to alleviate the toxic effect of heavy metals on the total carbohydrates and soluble sugars. These extracts increased significantly the total carbohydrate and soluble sugars in Pb and Cd treated tomato plants compared with Pb and Cd treatments alone. In this respect, Barnett *et al.* (1990) reported that, yeast extract, enhanced carbohydrate accumulation in plant tissues. Also, its stimulatory effects on protein and nucleic acid synthesis and chlorophyll formation was reported by Fathy and Faried (1996), El-Desouky *et al.* (1998) and Wanas *et al.* (1998).

4. Yield:

Data presented in Table (4) show clearly that yield in tomato plants was significantly affected by heavy metals. All lead and cadmium levels significantly decreased number of flowers / plant, number of fruits / plant and fruit yield / plant. The highest reduction in weight and number of fruits

Table (4): Effect of yeast, garlic and eucalyptus extracts on the yield and yield components of polluted tomato plants during 2001 and 2002 seasons.

Pb & Cd (mg/L)	2001			2002		
	No. of flowers / p	No. of fruits / p	Fruit yield (g / p)	No. of flowers / p	No. of fruits / p	Fruit yield (g / p)
	Pb-polluted plants					
Pb 250	35.4	15.2	295.4	30.3	12.3	325.6
+ y	55.4	30.0	537.0	45.9	25.6	460.9
+ g	60.8	35.8	570.4	53.4	28.3	480.7
+ e	50.9	25.9	500.5	43.2	23.4	450.8
Pb 500	20.9	10.8	200.5	15.9	9.8	280.2
+ y	33.6	15.6	300.7	30.2	13.9	330.7
+ g	35.8	18.6	350.3	35.4	15.2	360.9
+ e	34.9	14.3	320.3	32.8	12.8	320.2
Control	45.9	22.8	456.7	40.6	18.6	406.3
LSD 5%	4.1	4.8	49.0	4.9	5.6	25.6
	Cd-polluted plants					
Cd 100	36.7	16.7	300.2	33.2	13.0	340.8
+ y	45.9	25.3	540.3	34.9	20.0	423.6
+ g	55.6	28.6	560.8	38.4	23.0	460.6
+ e	53.9	27.4	500.0	33.1	20.0	450.8
Cd 200	22.5	11.5	251.2	23.9	10.0	274.0
+ y	34.4	16.8	310.8	30.4	16.0	340.7
+ g	38.4	19.4	360.9	32.6	18.0	370.6
+ e	30.8	14.3	350.2	29.9	17.0	350.9
Control	40.6	22.8	456.7	40.6	18.6	406.3
LSD 5%	5.2	4.7	35.4	4.71	6.11	28.9

was obtained at 500 and 200 mg/L of lead and Cd, respectively as compared with control. Data in the second season followed almost the same trend of those reported at the 1st one. These results are in agreement with those obtained by Xian (1989) who found that high levels of lead and cadmium significantly decreased the yield of kidney beans. Moreover, McCrea (1984) reported that road dust, as a source of lead, reduced plant yield.

Data recorded in the same table indicate that, garlic, yeast and eucalyptus extracts significantly increased the number of flowers, the number of fruits and the total fruit yield as compared with Pb and Cd treatment without extract spray. These extracts seem to alleviate the negative effects of Pb and Cd and make a progressive improvement on the yield. In this respect, the best results were obtained from garlic followed by yeast then eucalyptus extract. It is clear that the effect of the interaction between Pb, Cd and other treatments on the fruit number and weight / plant was significant in both seasons. This increase in yield by natural extract treatments may be attributed, directly, to the enhancing effect of fruit setting and the increment in the number of flowers and weight / plant. The positive effect of these extracts on plant growth may contribute also to the increase in plant productivity. The stimulating, effects of natural extracts on yield of plants was also reported by Helmy (1992), El-Desouky *et al.* (1998) and Wanas (2002).

5. Fruit chemical constituents:

As vitamin C, titratable acidity, and total soluble solids are very important nutritive components in tomato fruits. It was necessary to follow up these components as well as the concentration of heavy metals in tomato fruits.

Data presented in Table (5) show clearly that T.S.S. and vitamin C in tomato fruits were significantly affected by heavy metals pollution. All lead and cadmium levels used significantly decreased T.S.S. and vitamin C in plant fruits. In this concern, the highest reduction in T.S.S. and vitamin C was obtained under 500 and 200 mg/L lead and cadmium as compared with control plants. These results indicated that the pronounced negative effect of heavy metals was obtained under lead and cadmium treatments. Data in the second season followed almost the same trend. These results are in agreement with those obtained by Nagoor and Vyas (1998), who reported that higher cadmium concentrations decreased the protein content.

Concerning the effect of heavy metals with addition of natural extracts, data recorded in Table (5) indicated that, garlic, yeast and eucalyptus improved the fruit quality and decreased the deleterious effects of heavy metals. All extracts caused an increase in the T.S.S. and vitamin C as compared with heavy metal treated plants without extract spray. The best results were obtained from yeast followed by garlic then eucalyptus extracts.

It has been found that the natural extracts had the potential to protect the enzymes involved in the metabolism against oxidative damages that might occur from environmental pollution. These results are in agreement with those obtained by Abdel-Aziz (1997), who found that, spraying tomato plants by yeast at 1 kg / 200 L water, increased T.S.S., ascorbic acid and titratable acidity in fruit juice of tomato. Meanwhile, the enhancing effect of yeast might be due to the promotion effects as a result of its containing a source of cytokinins (Shoog and Miller, 1957) and enhancing the synthesis of protein and RNA (Natio *et al.*, 1981). Increasing the concentration of garlic, yeast and eucalyptus induced a significant reduction in the toxicity of these heavy metals.

Table (5): Effect of yeast, garlic and eucalyptus extracts on the concentrations of Pb and Cd (µg / g d.wt.), total soluble substances (%), vitamin C as well as titratable acidity determined as (mg / 100 gm fresh. wt) of polluted tomato fruits during 2001 and 2002 seasons.

Pb & Cd (mg/L)	2001				2002			
	Pb & Cd	T.S.S. %	Vitamin C.	Titratable acidity	Pb & Cd	T.S.S. %	Vitamin C.	Titratable acidity
	Pb-polluted plants							
Pb 250	0.05	3.6	25.6	0.48	0.047	4.2	25.6	0.50
+ y	0.03	6.0	38.2	0.72	0.280	5.9	40.1	0.92
+ g	0.02	5.6	36.7	0.64	0.022	5.4	38.3	0.80
+ e	0.028	5.1	36.5	0.64	0.270	5.6	38.4	0.84
Pb 500	0.060	3.1	21.3	0.39	0.082	3.3	20.4	0.41
+ y	0.045	4.9	31.4	0.59	0.049	4.8	30.4	0.80
+ g	0.040	4.4	28.2	0.59	0.042	4.5	28.3	0.77
+ e	0.042	4.3	27.3	0.60	0.044	4.4	26.2	0.80
Control	0.016	4.1	30.7	0.57	0.015	5.0	34.9	0.74
LSD 5%	0.013	0.9	0.21	0.01	0.001	0.8	1.8	0.60
	Cd-polluted plants							
Cd 100	0.039	3.7	28.4	0.41	0.039	4.6	27.8	0.54
+ y	0.028	6.4	37.0	0.61	0.030	6.3	39.6	0.80
+ g	0.022	6.0	36.7	0.60	0.020	5.6	38.4	0.79
+ e	0.025	5.5	36.3	0.54	0.028	5.2	38.6	0.74
Cd 200	0.070	3.1	22.8	0.38	0.064	4.0	22.2	0.42
+ y	0.047	4.3	28.0	0.57	0.040	4.8	28.3	0.68
+ g	0.040	4.2	26.5	0.54	0.035	4.6	26.5	0.65
+ e	0.044	4.0	25.2	0.54	0.038	4.5	25.5	0.62
Control	0.016	4.1	30.7	0.57	0.015	5.0	34.9	0.74
LSD 5%	0.008	0.6	3.2	0.004	0.001	1.2	2.7	0.11

It is evident that the titratable acidity in fruit juice was significantly affected by treated plants with Pb and Cd with different levels. This effect might be due to the effects of Pb and Cd on the carboxylic groups of cell compounds that may increase acidity in cell sap. Under 500 and 200 mg/L the increase in acidity of fruits reached 31.6 and 33.3% for lead and cadmium respectively compared with control plants.

The natural extracts seemed to overcome the harmful effects of Pb and Cd pollution and enhanced fruit quality. Any of the natural extracts used in this study was found to decrease the acidity in lead and Cd treated tomato plants and induce a significant reduction in the toxicity of all tested heavy metals compared with control.

Fruit-lead and cadmium concentration:

The effect of external lead and cadmium treatments on the level of both elements in tomato fruits is presented in Table (5). Both Pb and Cd within fruits were increased by treating plants with lead and Cd as compared with control plants. High lead and Cd concentration was more effective in accumulating high amounts of lead and Cd in the fruits than low concentration. These results are in accordance with those obtained by Simon *et al.* (1999), who found that internal cadmium concentration increased by treating plants with Cd.

With regard to the effect of natural extracts, in the presence of Pb and Cd, on the internal Pb and Cd concentration in tomato fruits, it is clear that, natural extracts seemed to decrease Pb and Cd levels in the tomato fruits. The most reduction was recorded at garlic followed by eucalyptus then yeast extract treatments. The application of garlic, eucalyptus and yeast extracts increased the ability of the plants to prevent the translocation of excess Pb and Cd to fruit and / or the ability to detoxify the metal after it has been absorbed. In this regard, Hanafy *et al.* (1994) reported that, garlic contains chelating compounds capable of enhancing elimination of lead.

In conclusion, the present study indicates that the toxicity and harmful effects of heavy metals, could be reduced or eliminated to a significant extents with the use of some natural extracts that do not cause any harm for the plants or cause a carcinogenic effects.

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معادلة التأثيرات الضارة للكادميوم والرصاص على نباتات الطماطم بإستخدام مستخلصات الخميرة والثوم والكافور

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الملخص العربى :

أجريت التجارب فى الأصص بكلية الزراعة جامعة المنوفية خلال الموسمين الزراعيين ٢٠٠١ ، ٢٠٠٢ لدراسة تأثير تركيزات مختلفة من الرصاص (صفر ، ٢٥٠ ، ٥٠٠ مليجرام / لتر) والكادميوم (صفر ، ١٠٠ ، ٢٠٠ مليجرام / لتر) على صفات النمو الخضرى والصفات الكيماوية ، وكذلك المحصول ومكوناته على الطماطم بإستعمال الصنف فلورادید ، كما تم الرش بمستخلصات الخميرة والثوم والكافور لتقليل التأثيرات الضارة للكادميوم والرصاص على الصفات سابقة الذكر ، حيث يُمكن تلخيص أهم النتائج فيما يلى :

- أدت زيادة تركيزات كلٍ من الرصاص والكادميوم إلى نقص معنوى فى النمو الخضرى المتمثل فى طول النبات وعدد الأوراق والوزن الجاف لكل من الجذور والمجموع الخضرى لنبات الطماطم ، وقد أدى إستخدام التركيز العالى من الرصاص ٥٠٠ مليجرام / لتر والكادميوم ٢٠٠ مليجرام / لتر إلى حدوث أعلى نقص معنوى فى هذه الصفات .
- أثرت المعاملة بالرصاص والكادميوم على العلاقات المائية لنبات الطماطم ، كما أدت إلى نقص كل من محتوى الماء الكلى والنسبى وزيادة نقص الماء فى أوراق النبات .
- قلت نسبة صبغات البناء الضوئى كلوروفيل a + b وأيضاً الكاروتين وكذلك الكربوهيدرات الكلية والسكريات الذائبة بإستخدام كلٍ من الرصاص والكادميوم .
- أدت معاملة النبات بالرصاص والكادميوم إلى حدوث نقص فى صفات الجودة لثمار الطماطم المتمثلة فى T.S.S. وفيتامين C مقارنةً بالنباتات الغير معاملة .
- أدت زيادة تركيز كلٍ من الرصاص والكادميوم إلى نقص معنوى فى عدد الأزهار ، عدد الثمار ، وزن الثمار لكل نبات مقارنةً بالكنترول .

- أدت المعاملة بالرصاص والكادميوم إلى زيادة تركيز الرصاص والكادميوم فى الثمرة .
- فـــى كل الحالات سابقة الذكر أدى الرش بمستخلص الخميرة والثوم والكافور إلى الإقلال من التأثـــيرات الضارة الناتجة من الملوثات (الكادميوم ، الرصاص) حيث أدى إلى تحسّن واضح فـــى نمـــو النـــباتات ربمـــا نتيجة لإحتواء بعضها على الهرمونات والفيتامينات ومواد النمو والـــزيوت الطيارة اللازمة لنمو النبات وحمايته من أخطار التلوث ، وكان مستخلص الخميرة أحسن المستخلصات فى تقليل الأثر الضار لهذه الملوثات تلاه الثوم فالكافور .
- أدت المعاملـــة بهـــذه المستخلصـــات إلى تقليل تركيز كلٍ من الرصاص والكادميوم فى ثمار الطماطم وكان مستخلص الثوم أحسن المستخلصات فى هذا الصدد تلاه الكافور ثم الخميرة .