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THE EFFECTS OF SOIL LEAD POLLUTION AND SOME REMEDIATION TREATMENTS ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF COMMON BEAN

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ASBSTRACT

The current study was conducted to investigate the effects of soil pollution with four different levels of lead (0, 100, 200,and 300 ppm) and five different remediation treatments (control , cattle manure (20 m^3 $fed.^{-1}$), super phosphate (45 kg P_2O_5 $fed.^{-1}$), seed inoculation of *Bacillus subtilis* (10 ml of the inoculum/pot having about 10^6 –10^8 cells) and a mixture of the three previous types of the remediation treatments.) as well as their interactions on the vegetative growth characters, green pods yield and Pb and P contents of the roots, stems, leaves, and green pods of common bean (*Phaseolus vulgaris* L.) cv. "Giza 3".Two pot experiments were carried out during the 2005 and 2006 seasons at the Experimental Farm, El-Bostan, Faculty of Agriculture, Damanhour Branch, Alexandria University. A split plot system in a complete randomized blocks design was used with three replications. Vegetative growth characters were significantly inhibited with increasing the Pb concentration in soil. The inhibitory effect of Pb was more pronounced at high Pb concentrations Also, Pb had a deleterious effect on leaf chloroplast pigments. Both chlorophyll a and b were more negatively affected by Pb ions than that of carotenoids. Pollution of soils with Pb significantly, reduced total yield of green beans. Adding remediation treatments to the Pb polluted soils not only led to overcome the deleterious effect of intolerable Pb levels (200 and 300 ppm) on most above mentioned characters, but

also stimulated the growth, increased the yield and protected the photosynthetic pigments and sharply reduced the Pb concentration in both root and top. Both the application of P and the mixed treatment were the best in this respect.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is one of the popular vegetable crops and fundamental protein sources for human consumption in Egypt and other lands all over the world. It is cultivated for its fresh and dried pods. The total area planted with common bean cultivars reached about 44975 feddans with a total annual production of 211446 tons of green beans and 28449 feddans with a total annual production of 30116 ton dry seeds according to the statistics of the Ministry of Agriculture (2004), Egypt.

The increasing consumption, production, and exponential of the earth's raw materials (fossil fuels and minerals), coupled with the growth of the world's population over the past 200 years, have resulted in environmental buildup of waste products, of which heavy metals are of particular concern (Zaghloul and Abou-Seeda, 2005) .

Lead is one of the heavy metals and is considered one of the dangerous environmental pollutants. It emitted from industries, motor vehicles, stationary fuel, road dust composition and traffic roads. Lead is not only a toxic element but also can be accumulated in plant organs and agricultural products (Burzynski, 1987 and Mahmoud and El-Beltagy, 1998), consequently enters human food chain (Wagner, 1993). As a result of consumption of food, lead accumulates in human body and it may cause renal failure, brain and liver damage and it can attack the nervous system and cause failing of sickness (Ramade, 1987). Lead also has a deleterious effect on crop plants. It was found that the high levels of lead have an inhibitory effect on some physiological processes, i.e. photosynthesis (Poskuta *et al.*, 1987), protein synthesis and activity of some enzymes, carbohydrate and sugar content (Stibrova *et al.*, 1986) and chlorophyll contents (Prasad *et al.*, 1989) .These problems created the importance of applying new technologies for minimizing the hazards of these pollutants. Various remediation technologies have been developed to clean up metal contaminated soils. Among those, *in situ* stabilization of heavy metals using binding agents is a promising approach due to its sustainability and cost-effectiveness.

Phosphate amendment has been suggested as a cost-effective remediation option for Pb contaminated soils due to the effectiveness of phosphate-induced Pb immobilization by mixing phosphate minerals with Pb contaminated soils (Cotter-Howells, 1996). The immobilization mechanism is considered to be the dissolution of the lead compounds followed by the precipitation of lead phosphate. Organic matter has the potential to be used as a soil additive as it is known to improve soil fertility by modifying the physical, chemical and biological conditions in soil. Also, the metal binding capacity of organic matter through ion exchange, complexation, and surface adsorption can reduce contaminant availability, toxicity and leachability through the soil. (Jordan *et al.*, 1997).

Other remediation technologies included remove or degrade and detoxify the heavy metal pollutants from water and soil called bioremediation by using bacteria (Mahmoud and El-Beltagy, 1998) as phytoremediants. Mahmoud and El-Beltagy (1998) tested *Bacillus subtilis* bacteria for lead reduction in rocket salad plant grown on polluted soils. They found that the reduction percentage of lead uptake by rocket salad plant was 96.4%. However, studies on the effect of such bioremediants on the growth, physiology and biochemistry as well as yield of plants were rare . Therefore, the objectives of the present study was to investigate the lead – plant relationships by growing common bean plants on different lead soil levels and evaluate the feasibility of two different technologies (chemical remediation, and bioremediation) , as tools for the remediation of lead contaminated soils.

MATERIALS AND METHODS

Two pot experiments were conducted during the two successive summer growing seasons of 2005and 2006 at the Experimental Farm of El-Bostan, Faculty of Agriculture Damanhour Branch, Alexandria University, to determine the effect of lead, cattle manure, *Bacillus subtilis*, super phosphate and the mixed treatment (cattle manure +

Bacillus subtilis + super phosphate) as well as their interaction on the vegetative growth characters, chemical composition and yield and its components of common bean plants (*Phaseolus vulgaris* L.) cv. Giza-3.

The physical and chemical characteristics of the Soil and cattle manure (Tables 1 and 2) were determined according to the methods reported by Page et al. (1982). lead was determined according to the method mentioned by Cottenie *et al.*, (1982). and measured by atomic absorption spectrophotometer (AAS).

Table (1). The main chemical and physical characteristics of the soil used in the experiments.

Seasons	2005	2006
Physical analysis		
Clay (%)	46	46
Silt (%)	41	41
Sand (%)	13	13
Soil texture	Silt clay	Silt clay
Chemical properties		
pH	7.8	7.83
EC(mmohs)	1.2	2.5
Macro- elements (ppm)		
N	110	120
P	32	36
K	426	440
Micro - elements Pb (ppm)	0.49	0.47
Organic matter (%)	3.12	3.23

Table (2). Chemical analysis of cattle manure

Property	Season 2005	Season 2006
PH	7.5	7.3
EC mmohs	2.9	2.7
C %	8.3	9.24
N %	0.83	0.84
P %	0.46	0.49
K %	1.84	1.75
C/N ratio	10	11
Pb (ppm)	1.15	1.03

Experimental Layout

The experimental system split plots was used in a randomized complete blocks design with three replicates. Lead at the concentrations of 0.0,100, 200 and 300 ppm in the form of lead acetate occupied the main plots; whereas, Cattle manure (20 m^3 $fed.^{-1}$), super phosphate (45 kg P_2O_5 $fed.^{-1}$), seed inoculation of *Bacillus subtilis* (10 ml of the inoculum/pot having about $10^6 - 10^8$ cells) and the mixed treatment (cattle manure + *Bacillus subtilis* +super phosphate) as well as the control were assigned at random in the sub-plots. *Bacillus subtilis* was obtained from Microbiological Resources Center, Faculty of Agriculture, Ain Shams University.

Planting

Lead in the form of lead acetate $(CH_3COO)_2\ Pb.3H_2O$ was added and thoroughly mixed with the soil. The soil was brought to field capacity and allowed to air-dry to insure Pb-soil equilibrium prior to planting . Five seedlings of common bean (*Phaseolus vulgaris* L.) cv. Giza-3 were planted in plastic pots (25 cm of inner diameter) having 4 kg soil on summer of 2005 and 2006. Each treatment contained 5 pots. Pots were irrigated with tap water whenever it was needed to keep the moisture in soil at about 70% of the total water holding capacity of the soil during the whole experimental period. Plants were thinned to three plants per pot after about a week.

Experimental Data

At harvest time plats were collected from each treatment to measure the following: Plant height. Number of branches $plant^{-1}$, Plant fresh and dry weight. Number of green pods and Green pods yield per plant (g). Photosynthetic pigments were extracted from fresh leaves using acetone 80% and estimated according to Wettestein (1957), then calculated as mg/g dry weight. Hundred grams from each treatment were dried at 70°C; 0.2 gm from each dried ground organs was acid digested (Chapman and Pratt 1978). Lead concentration (µg/g dry wt.) was estimated by using Atomic Absorption Spectrophotometer according to Cottenie *et al.*, (1982).

Chemical Plant Analysis:

The collected plant samples were washed with tap water to remove the adhered soil particles and then washed several time with distilled water. The plant samples were oven dried at 70 C° for 48 hours and ground in a mill with stainless steel blades .Wet digestion procedure was performed according to Chapman and Pratt (1978).Phosphorus percentage was determined calorimetrically as reported by Jackson, (1967).Potassium percentage was also determined by flame photometer as described by Brown and Lilliand (1946).

Statistical Analysis:

All obtained data were statistically analyzed using SAS software program (1996). Comparisons among the means of different treatments were achieved using the revised least significant difference procedure at $P=0.05$ level as illustrated by Al-Rawy and Khalf-Allah (1980).

RESULTS AND DISCUSSION

Plant height

Data for plant height are given in Table (3). Regarding main effect of Pb concentrations, data showed clearly that a significant decrease in plant height was observed due to lead application. Average plant height was not significantly affected at 100 ppm Pb as compared with control in both seasons. The highest negative effect was found with 300 ppm lead treatment which reduced the plant height by 24.8 and 23.9% as compared with untreated plants in the first and the second seasons respectively. These results are in agreement with those obtained by El-Ghinbihi, (2000) who found that the plant height of common bean was reduced as the concentration of lead increased. Also Kastori *et al.* (1998) found that lead application at $10^{-7} - 10^{-3}$ M reduced plant growth due to retarding cell division and differentiation, thus inhibited their elongation in sunflower plants.

Meanwhile Aiy (1982) reported that higher lead concentrations decreased the height of pepper and Jews mellow plants.

All remediation treatments (Table 3) significantly increased plant height in both seasons. Such an increase in plant height of common bean might be due to reduce uptake of Pb by remediation treatments (Bassuk, 1986) as well as introducing of growth promoting substances such as indole acetic acid and gibberellins produced by microorganism applications (Lazarovite, 2001)

Data presented in Table (3) showed that the interaction between remediation treatments and lead levels did significantly

Table (3). Effect of Pb and some remediation treatments along with their interactions on plant height (cm) of common bean cv. Giza 3 during 2005 and 2006 seasons.

Remed. treatments \ Pb(ppm)	0	100	200	300	Mean
			2005		
Control	32.61 a*	32.00 ab	21.45 ghi	19.60 i	26.42 B
Cattle manure	31.59 abc	33.11 a	25.94 ef	24.17 fgh	28.70 A
B.subtilis	33.10 a	31.87 abc	26.69 ef	24.56 fg	29.05 A
Super phosphate	31.74 abc	32.12 ab	28.89 b-e	27.29 def	30.01 A
Mixed	32.95 a	30.80 a-d	28.27 de	27.60 def	29.90 A
Mean	32.40 A	31.98 A	26.25 B	24.64 C	
			2006		
Control	31.00 ab	30.75 ab	20.52 gh	18.63 h	25.22 B
Cattle manure	30.35 ab	30.83 ab	24.92 ef	23.21 fg	27.32 A
B.subtilis	31.14 ab	30.92 ab	24.85 ef	23.11 fg	27.50 A
Super phosphate	30.02 abc	30.54 ab	27.75 b-e	25.86 def	28.54 A
Mixed	31.22 a	29.13 a-d	26.79 cde	26.24 def	28.35 A
Mean	30.75 A	30.43 A	24.96 B	23.41 C	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05.

affected plant height in both seasons. the results also indicated that application of the mixed treatment or P at (300 ppm Pb) overcame the deleterious effects of Pb and increased the plant height by about 39.2

and 40.8% ; 38.8 and 42.3% in the first and second seasons, respectively.

Plant fresh and dry weight:

Data for plant fresh and dry weights are given in Tables (4 and 5). The plant fresh and dry weights were significantly decreased with increasing the Pb level in soil.

Lead treatments reduced plant fresh weight by 2.99, 8.22 and 15.83% as compared with untreated plants, in the first season and by 2.54, 8.43 and 15.58% in the second season at 100, 200 and 300 ppm Pb, respectively. Meanwhile data for plant dry weight showed clearly that Lead treatments reduced plant dry weight by 10.37and13.01% as compared with untreated plants in the first season and by 10.17 and 12.95% in the second season at 200 ppm, and 300 ppm, respectively. These results are in full agreement with those obtained by Carlson *et al.* (1975) who found that high concentration of lead decreased the fresh and dry weight of maize plants; El- Ghinbihi, (2000) who found that the fresh and dry weight of roots and stems of common bean decreased significantly with increasing lead levels. Attia and Moftah (2002), who found that the fresh and dry weight of roots and shoot of borage decreased significantly with increasing lead levels; and Moftah (2000) who reported that the fresh and dry weight of roots and shoots of tomato and eggplants were decreased significantly with increasing lead levels.

Adding remediation treatments (Cattle manure, *Bacillus subtilis,* Super phosphate and the mixed treatment) to the lead polluted soils varied significantly in their effect on both seasons. The mixed treatment was the most pronounced treatment that increased plant fresh and dry weight by 8.22 and 15.35%, 7.72 and 9.41% in the first and second seasons, respectively. Such positive effects might be due to the increase in nitrogen content in the soil as a result of N fixation and phosphorus from phosphate dissolving bacteria and applied phosphate as well as growth promoting substances such as iodole acetic acid and gibberellins produced by the applied microorganisms used. These results are in line with Ali and Selim (1996)

The interaction between Pb levels and all remediation treatments did not significantly affect plant fresh and dry weights compared to control in both seasons (Tables 4 and 5).

Number of branches:

The results recorded in Tables (4 and 5) indicated that the average number of stems per plant was significantly affected by lead levels in both seasons .The estimated reductions in number of branches per plant were 6.48, 9.84 and 14.36% of the control in the first season; and 8.1, 9.4 and 14.96% in the second season at 100, 200, and 300 ppm Pb, respectively. These results are ina general harmony with those reported by Attia and Moftah (2002) on borage who found that number of branches decreased with increasing lead level in soil. All remediation treatments significantly increased number of branches per plant compared to control and P and mixed treatments were more effective than bacteria and cattle manure treatments in both seasons.

Significant effects for the interactions between remediation treatments and Pb levels on average number of branches per plant were noticed in both seasons (Tables 4 and 5). At the highest lead application level (300 ppm), the mixed and P treatments exhibited higher numbers of branches per plant in both seasons.

Yield and its component:

Yield of green pods plant^{-1}and average number of green pods plant^{-1} were negatively affected by Pb treatments (Table 6). The depressions were more sever at the rates of 200 and 300ppm Pb. The reductions of green pod yield /plant were recorded by 53.19 and 56.4% in the first season and 51.64 and 56.9% in the second season, respectively. Meanwhile the average number of pods per plant were reduced by 44.9 and 49% in the first season and 46.47 and 49.86% in the second season at 200 and 300ppm respectively. These results are in agreement with those obtained by El-Ghinbihi (2000) on common bean who found that number of pods per plant decreased significantly with increasing Pb levels in the soil.

Table (4). Effect of Pb and some remediation treatments along with their interactions on vegetative growth characters of common bean cv. Giza3 during 2005 season.

Pb(ppm) / Remed. treaatments	0	100	200	300	Mean
Plant Fresh weight g/plant					
Control	70.43 a*	70.75 a	62.02 a	58.00 a	65.30 B
Cattle manure	72.85 a	67.94 a	64.00 a	59.49 a	66.07 B
B.subtilis	69.69 a	69.50 a	64.87 a	62.25 a	66.58 B
Super phosphate	75.28 a	72.20 a	71.55 a	61.53 a	70.14 A
Mixed	75.10 a	72.037 a	71.01 a	64.54 a	70.67 A
Mean	72.67 A	70.49 Ab	66.69 B	61.16 C	
Plant Dry weight g/plant					
Control	15.00 a	15.70 a	12.04 a	12.40 a	13.785 C
Cattle manure	15.59 a	15.41 a	13.31 a	12.72 a	14.26 B
B.subtilis	14.4 a	15.94 a	13.39 a	13.05 a	14.20 B
Super phosphate	16.23 a	15.31 a	14.55 a	13.96 a	15.01 A
Mixed	15.74 a	16.15 a	14.86 a	14.79 a	15.39 A
Mean	15.39 A	15.50 A	13.62 B	13.38 B	
Number of branches per plant					
Control	5.20 d	4.55 i	4.44 j	4.22 l	4.60 C
Cattle man[ure	5.20 d	5.11 e	4.88 h	4.33 k	4.88 B
B.subtilis	5.33 c	4.99 f	4.99 f	4.55 i	4.97 B
Super phosphate	5.44 b	5.11 e	4.88 h	4.99 f	5.11 A
Mixed	5.66 a	5.33 c	4.99 f	4.89 g	5.21 A
Mean	5.37 A	5.019 B	4.84 B	4.60 C	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05.

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Table (5). Effect of Pb and some remediation treatments along with their interactions on vegetative growth characters of common bean cv. Giza3 during 2006 season

Remed. treatments \ Pb(ppm)	0	100	200	300	Mean
		Plant Fresh weight g/plant			
Control	67.62 a*	69.34 a	60.53 a	56.26 a	63.44 B
Cattle manure	71.40 a	64.54 a	62.72 a	58.30 a	64.24 B
B.subtilis	66.90 a	68.81 a	61.63 a	59.76 a	64.27 B
Super phosphate	72.65 a	70.04 a	68.02 a	59.50 a	67.55 A
Mixed	72.60 a	69.52 a	68.66 a	62.60 a	68.34 A
Mean	70.23 A	68.45 Ab	64.31 Bc	59.29 C	
		Plant Dry weight g/plant			
Control	14.14 a	15.52 a	12.53 a	12.22 a	13.60 C
Cattle manure	15.28 a	14.64 a	13.05 a	12.47 a	13.86 B
B.subtilis	15.71 a	15.58 a	14.53 a	13.64 a	14.85 A
Super phosphate	15.66 a	14.95 a	14.46 a	13.50 a	14.64 A
Mixed	15.23 a	15.59 a	14.37 a	14.35 a	14.88 A
Mean	15.20 A	15.25 A	13.79 B	13.23 B	
		Number of branches per plant			
Control	5.11 abc	4.33 def	4.33 def	4.11 f	4.47 C
Cattle manure	5.11 abc	4.77 bcd	4.88 bc	4.22 ef	4.74 B
B.subtilis	5.11 abc	4.88 bc	4.66 cde	4.22 ef	4.72 B
Super phosphate	5.22 ab	4.77 bcd	4.88 bc	4.77 bcd	4.91 A
Mixed	5.44 a	5.11 abc	4.77 bcd	4.78 bcd	5.02 A
Mean	5.20 A	4.77 B	4.71 Bc	4.42 C	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05.

Yield of green pods and average number of green pods plant^{-1} reflected significant differences among the four studied remediation treatments. High increments on yield and average number of green pods plant^{-1} were produced by the mixed and phosphate treatments in both seasons, whereas organic manure application gave the lowest yield as shown in Table (6).

Significant effects for the interaction between Pb levels and all remediation treatments on yield of green pods plant^{-1} and average number of green pods plant^{-1}were noticed in both seasons (Table 6). At 300ppmPb level it was found that adding mixed or P or Bacillus tended to show more effects on yield and average number of green pods plant^{-1}than organic manure in both seasons.

The increase of common bean yield and its components by adding the mixed treatment (bacteria, phosphate and cattle manure) led to marked increases on yield and its components which might be due to its role in removing the toxic effect of lead and production of phytohormones such as auxins and cytokinins, which can enhance plant growth; and to solubilization of minerals such as phosphorus that counteracted the adverse effects of heavy metals on metabolic mechanisms (Kloepper *et al.*, 1989).

Photosynthetic pigments:

Data for photosynthetic pigments in leaves of common bean presented in Tables (7 and 8), showed clearly that the lead concentration level of 200 ppm significantly reduced chlorophyll a, chlorophyll b and carotenoids by 20.34, 34.24 and 5% in the first season and by 33.9, 20.24 and 5.2%, in the second season respectively compared to the control treatment. Meanwhile, 300 ppm decreased significantly chlorophyll a, chlorophyll b and carotenoids by 48.37%, 50.97% and 7.2% in first season and by 51.87, 48.16 and 7%, in the second season respectively. Photosynthetic pigments have often been shown as one of the main sites of the toxic Pb and other heavy metal actions in many plant species such as cucumber, safflower, tomato and eggplant and common bean (Fodor *et al* , 1998 ; Sayed , 1999 ; Moftah , 2000 and El- Ghinbihi, 2000). Thus, the decreases in chlorophylls and carotenoids content appeared to be one of the first visible bio-markers of Pb toxicity. The possible mechanism of toxicity on chlorophyll pigments were attributed to inhibiting the biosynthesis

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of the amino levulinic acid (ALA) a precursor of chlorophyll (Thomas and singh, 1996) and / or an enhancement of chlorophyll degradation occurs in Pb-treated plants due to increased chlorophyllase activity (Abdel-Basset *et al.*, 1995). In a recent study Ahmed and Tajmir-Riahi (1993) reported that Pb damaged the photosynthetic apparatus due to its affinity for protein N- and S- ligands through interfering the sulfhydryl site on the enzyme. Also, lead decreased the carotenoids that prevent chl photodestruction or/and due to inhibition of Fe uptake and transport to plant leaves that might result in reducing chl synthesis and cause chlorosis (Fodor *et al.*, 1998). Pb inhibits chlorophyll synthesis by causing impaired uptake of essential elements such as Mg and Fe by plants (Burzynski, 1987).

All remediation treatments as shown in Tables (7 and 8) seemed to overcome the harmful effect of Pb and improved the photosynthetic pigment concentration in leaves. There were significant increases on chl a, b and carotenoids due to all used remediation treatments compared to control. The best results in this concern were obtained from mixed-, followed by super phosphate-treatments.

Table (6). Effect of Pb and some remediation treatments along with their interactions on yield and its component of common bean cv. Giza3 during 2005 and 2006 seasons.

Remed. treatments \ Pb(ppm)	0	100	200	300	Mean
2005					
Number of green pods per plant					
Control	14.22 a*	13.55 ab	5.22 e	4.33 e	9.33 C
Cattle manure	13.44 ab	13.78 ab	8.33 cd	7.22 d	10.69 B
B.subtilis	14.00 a	12.33 b	7.89 cd	8.00 cd	10.55 B
Super phosphate	14.22 a	14.33 a	9.00 c	8.11 cd	11.41 A
Mixed	14.42 a	13.86 ab	8.32 cd	8.18 cd	11.2 A
Mean	14.06 A	13.57 B	7.75 C	7.17 C	
Yield of green pods per plant (g)					
Control	65.21 a	58.56 bc	20.36 f	14.42 f	39.64 D
Cattle manure	60.60 abc	61.15 abc	29.18 e	28.92 e	45.63 C
B.subtilis	65.20 a	57.51 c	31.38 de	31.84 de	47.06 B
Super phosphate	63.90 abc	62.83 abc	37.68 d	33.11 de	49.38 A
Mixed	66.46 ab	65.72 abc	37.63 d	32.81 de	50.65 A
Mean	64.2 A	61.16 A	30.05 B	28.02 B	
2006					
Number of green pods per plant					
Control	14.55 ab	14.11 ab	5.22 e	4.33 e	9.55 C
Cattle manure	14.22 ab	14.00 ab	7.44 d	7.00 d	10.67 B
B.subtilis	14.22 ab	12.89 b	8.33 cd	8.22 cd	10.9 B
Super phosphate	14.55 ab	15.00 a	8.44 cd	8.33 cd	11.57 A
Mixed	14.66 ab	14.00 ab	9.22 c	8.33 cd	11.55 A
Mean	14.44 A	14.00B	7.73 C	7.24 D	
Yield of green pods per plant (g)					
Control	67.83 ab	62.87 b	20.86 g	14.97 h	41.63 D
Cattle manure	67.56 ab	63.37 ab	30.69 ef	28.27 f	47.4 C
B.subtilis	66.87 ab	62.58 b	34.89 c-e	34.05 cde	49.6 B
Super phosphate	67.40 ab	68.15 ab	39.41 c	35.15 cde	52.53 A
Mixed	68.84 a	67.50 ab	37.87 cd	33.48 def	51.92 A
Mean	67.70 A	64.90 A	32.74 B	29.18 B	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05.

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Table (7). Effect of Pb and some remediation treatments along with their interaction on the concentration of photosynthetic pigments of common bean leaves cv. Giza3 during 2005 growing season

Pb(ppm) / Remed. Treatments	0	100	200	300	Mean
Concentration of chlorophyll a (mg/g drywt) in leaves					
Control	59 a*	51.27 ab	25.92 ef	17.04 h	38.3 D
Cattle manure	58.8 a	51.23 ab	50.54 d	25.43 fg	46.49 BC
B.subtilis	59.02 a	51.05 a-d	50.60 cd	25.25 g	46.48 C
Super phosphate	59 a	58.86 a	50.5 d	33.9 e	50.56 A
Mixed	59.03 a	51.16 abc	50.68 bcd	33.96 e	48.7 AB
Mean	58.97 A	52.714 A	45.65 B	27.12 C	
Concentration of chlorophyll b(mg/g drywt) in leaves					
Control	30.90 a	30.90 a	10.97 c	10.57 c	20.84 D
Cattle manure	30.01 a	30.72 a	20.73 b	10.91 c	23.09 C
B.subtilis	30.94 a	30.67 a	20.81 b	20.16 b	25.64 B
Super phosphate	31.15 a	30.89 a	20.82 b	20.29 b	25.79 A
Mixed	30.89 a	30.88 a	20.74 b	20.44 b	25.74 A
Mean	30.78 A	30.81 A	18.81 B	16.474 C	
Concentration of carotenoids (mg/g drywt) in leaves					
Control	13.00 a	12.23 def	12.20 def	11.76 g	12.3 C
Cattle manure	13.00 a	12.57 bc	12.20 def	11.97 fg	12.43 Bc
B.subtilis	12.92 a	12.94 a	12.37 cd	12.01 efg	12.56 Ab
Super phosphate	12.91 a	12.94 a	12.29 cde	12.07 ef	12.55 Ab
Mixed	12.85 ab	13.01 a	12.38 cd	12.24 def	12.62 A
Mean	12.94 A	12.74 B	12.29 C	12.01 D	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05

Table (8). Effect of Pb and some remediation treatments along with their interaction on the concentration of photosynthetic pigments of common bean leaves cv. Giza3 during 2006 growing season.

Remed. Treatments \ Pb(ppm)	0	100	200	300	Mean
Concentration of chlorophyll a (mg/g dwt) in leaves					
Control	60.92 a*	60.82 a	30.70 ef	20.16 h	43.15 D
Cattle manure	60.84 a	60.52 a-d	50.97 cd	30.17 fg	50.63 BC
B.subtilis	60.87 a	60.65 ab	50.82 d	25.86 gh	49.55 C
Super phosphate	60.88 a	60.77 a	50.94 cd	40.16 e	53.94 AB
Mixed	60.93 a	60.56 abc	60.02 bcd	40.23 e	55.43 A
Mean	60.89 A	60.66 A	50.49 B	31.31 C	
Concentration of chlorophyll b(mg/g dwt) in leaves					
Control	30.72 ab	30.79 ab	10.89 e	10.39 f	20.7 D
Cattle manure	30.91 a	30.47 b	20.66 c	10.94 e	23.25 C
B.subtilis	30.73 ab	30.49 b	20.63 c	20.02 d	25.46 B
Super phosphate	30.96 a	30.93 a	20.75 c	20.17 d	25.70 A
Mixed	30.71 ab	30.83 ab	20.63 c	20.33 c	25.62 A
Mean	30.80 A	30.70 A	18.71 B	16.37 C	
Concentration of carotenoids (mg/g dwt) in leaves					
Control	12.90 a	12.18 cde	12.00 def	11.69 g	12.19 C
Cattle manure	12.93 a	12.42 b	12.14 cde	11.92 fg	12.35 B
B.subtilis	12.78 a	12.90 a	12.20 bcd	11.91 fg	12.45 AB
Super phosphate	12.79 a	12.83 a	12.23 bc	11.98 ef	12.46 AB
Mixed	12.74 a	12.89 a	12.27 bc	12.18 cde	12.52 A
Mean	12.83 A	12.64 B	12.17 C	11.94 D	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D.test at P=0.05

Mixed treatment increased chlorophyll a and b and carotenoids by 27.15, 23.5 and 2.6 %; 28.46, 23.77 and 2.7 % compared to control in first and the second seasons ,respectively. Meanwhile, P treatment increased chlorophyll a and b and carotenoids by 32.0, 23.75 and 2.0% and by 25.0, 24.15 and 2.2 in the first and the second seasons respectively. The promoting effect of mixed and P treatments on photosynthetic pigments under the lead polluted soils may be due to its effect on reducing the concentration of lead ions and/or due to providing the plants with ATP and NADPH and other compounds that play a vital role in biosynthesis of chlorophylls and other pigments (Marschner, 1995).

Data presented in Tables (7 and 8) illustrated that the interactions of Pb levels and all remediation treatments had significant effects on concentration of the photosynthetic pigments. Concentrations of chlorophyll a and b and carotenoids were higher in the combinations of Pb treatments and all of remediation treatment compared to control. The mixed and phosphate treatments resulted in significant increments in chlorophyll a and b and carotenoids at the high concentrations of Pb.

Lead content

Data presented in Tables (9 and 10) indicated that Pb content in roots, stems, leaves and green pods of common bean increased significantly in plants exposed to 300ppm of lead compared to the Pb-200 or 100ppm treatments. At the highest level of Pb application, Pb accumulations were 281.33, 206.53, 140.26 and 5.05 µg/g dry weight in roots, shoots ,leaves and green pods, respectively, in the first season whereas the accumulations were 279.87, 206, 137.13 and 4.96 µg/g in roots, shoots, leaves and green pods were detected in the second season, respectively . Generally, the roots portion of the plants showed higher levels of lead than the above ground portions. The contents of Pb in roots were about 1.5, 2 and 56 times higher than those in stems, leaves and green pods, respectively, in both seasons. The precise cause of the these large differences in Pb concentration between roots and shoots has not been established, but several workers have suggested that the accumulation of Pb in the roots occurs because the endodermis functions as a barrier to the radial transport of Pb in the root, thereby restricting its movement to the shoots (Hardiman *et al.*, 1984). Other mechanisms of Pb-exclusion

Table (9). Effect of Pb and some remediation treatments along with their interaction on the concentration of lead in roots, stems, leaves, green pods and seeds of common bean cv. Giza3 during 2005 growing season.

Pb(ppm) / Reemd. treatments	0	100	200	300	Mean
Concentration of lead (µg/g dry wt) in roots					
Control	32.3 k*	169.7 fg	378.3 b	425.7 a	146.08 A
Cattle manure	28 kl	97.3 i	233.33 d	318.6 c	119.8 B
B.subtilis	23.33 klm	90 ij	177.4 f	236.3 d	118.17 B
Super phosphate	18.7 m	84.7 j	165 gh	214.4 e	102.8 C
Mixed	13.7 m	83 j	153.6 h	211.8 e	94.7 D
Mean	23.2 D	104.9 C	221.5 B	281.3 A	
Concentration of lead (µg/g dry wt) in stems					
Control	17.07 j	113.3 h	215.7 bc	241 a	251.5 A
Cattle manure	12.6 j	72 i	173.6 ef	221 b	169.33 B
B.subtilis	14 j	69.3 i	175.4 e	214 c	131.75 C
Super phosphate	12.67 j	70.4 i	139.3 g	189 d	120.67 D
Mixed	8.0 k	67.6 i	135.43 g	167.7 f	115.5 D
Mean	12.88 D	78.53 C	167.87 B	206.53 A	
Concentration of lead (µg/g dry wt) in leaves					
Control	8.7 j	83.3 g	135 c	179.6 a	101.7 A
Cattle manure	9.3 j	62.4 h	130 cd	157.7 b	89.8 B
B.subtilis	9.6 j	62.3 h	107.3 e	125.3 d	76.17 C
Super phosphate	7.0 j	64.6 h	93 f	119.6 d	71.08 D
Mixed	5.0 j	56 i	87.6 fg	119 d	66.9 E
Mean	7.9 D	65.7 C	110.6 B	140.26 A	
Concentration of lead (µg/g dry wt) in green pods					
Control	0.257 j	4.86 c	6.4 b	7.13 a	4.74 A
Cattle manure	0.253 j	2.3 h	3.5 f	4.97 c	2.83 B
B.subtilis	0.26 j	2.1 h	3.23 f	4.7 cd	2.67 C
Super phosphate	0.246 j	2.03 h	2.733 g	4.4 d	2.41 D
Mixed	0.25 j	2.07 h	2.63 g	4.07 e	2.25 D
Mean	0.253 D	2.680 C	3.7 B	5.053 A	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05

Table (10). Effect of Pb and some remediation treatments along with their interaction on the concentration of lead in roots, stems, leaves, green pods and seeds of common bean cv. Giza3 during 2006 growing season.

Remed. treatments \ Pb	0	100	200	300	Mean
Concentration of lead (µg/g dwt) in roots					
Control	33.67 m*	163.70 h	378.00 b	420.33 a	248.92 A
Cattle manure	29.70 m	95.00 j	231.30 d	323.40 c	169.83 B
B.subtilis	24.43 n	88.00 k	177.40 g	235.66 d	131.36 BC
Super phosphate	19.54 o	81.00 l	164.00 h	203.00 f	116.95 CD
Mixed	13.47 p	79.30 l	152.00 i	217.00 e	115.45 D
Mean	24.16 D	101.40 C	220.53 B	279.86 A	
Concentration of lead (µg/g dwt) in stems					
Control	17.77 l	117.00 h	209.67 c	242.67 a	146.77 A
Cattle manure	12.60 m	67.30 i	173.66 e	213.34 b	116.73 B
B.subtilis	13.30 m	67.00 i	153.70 f	213.00 b	111.75 C
Super phosphate	12.67 m	60.60 k	138.60 g	185.00 d	99.25 D
Mixed	7.66 n	64.00 j	138.67 g	176.00 e	96.58 D
Mean	12.81 D	75.20 C	162.87 B	206 .00 A	
Concentration of lead (µg/g dwt) in leaves					
Control	8.40 k	88.67 h	129.67 c	180.34 a	101.77 A
Cattle manure	9.77 k	52.00 i	123.34 d	149.33 b	83.61 B
B.subtilis	9.60 k	51.00 i	112.33 f	124 .00 d	74.23 C
Super phosphate	6.83 kl	45.67 j	92.66 g	112.33 f	64.37 D
Mixed	4.67 l	47. 70 j	86.00 h	119.67 e	64.50 D
Mean	7.85 D	57 C	108.8 B	137.13 A	
Concentration of lead (µg/g dwt) in green pods					
Control	0.26 h	4.53 d	6.30 b	7.10 a	4.63 A
Cattle manure	0.25 h	1.43 g	3.27 e	4.87 c	2.53 B
B.subtilis	0.26 h	1.40 g	3.27 e	4.23 d	2.37 BC
Super phosphate	0.24 h	1.60 g	2.60 f	4.30 d	2.23 C
Mixed	0.24 h	1.67 g	2.50 f	4.30 d	2.13 C
Mean	0.25 D	2.13 C	3.59 B	4.96 A	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05

are also important in preventing the movement of Pb to the shoots. For example, it is possible that Pb might be immobilized by the negatively charged pectin within the cell wall, precipitated as insoluble Pb salts in the cell walls or intercellular spaces or having crossed the plasma membrane, be sequestered in the vacuoles of rhizodermal and cortical cells (Lasat *et al.*, 1998). These results are in a general harmony with those reported by Moftah (2000) on tomato and eggplant, El–Ghinbihi (2000) on common bean, and Attia and Moftah (2002) on borago plant.

All remediation treatments (cattle manure, *Bacillus subtilis*, super phosphate, and the mixed treatment significantly decreased Pb accumulation in common bean plants in both seasons (Tables 9 and 10). There were significant differences among their ability to decrease Pb accumulation in plants in both seasons. The mixed treatment reduced Pb contents in plant organs by 54, 35.5, 34.1 and 52% and by 53.6, 34.2, 36.6 and 54% compared to control treatment in roots, stems, leaves and green pods in the first and second seasons, respectively. These results are in a general agreement with those reported by Bassuk (1982) who showed that Pb concentration of lettuce leaves were decreased when soil was treated with cattle manure + phosphor. Bautier *et al.* (2001) found that natural formation of pyromorphite is enhanced by an acidic pH and a high organic carbon. The potential utility of humus rich soil along with hydroxyapatite in minimizing the environmental risks of heavy metals from contaminated site through immobilization was highlighted by Misra and Pandey (2005). The findings suggested that amending the non-humus soil with humus soil and hydroxyapatite could immobilize toxic metals more effectively and also reduce their bioavailability. Regarding the effect of using P as a chemical agents for lead remediation, it was found that adding P to the contaminated soils reduced Pb in roots, stems, leaves and, green pods by 52, 29.9, 30 % and 49.2; 53, 32.4, 36.7 and, 51.9 % compared to control in the first season and second seasons ,respectively .Similar results were reported by Bassuk (1986) who found that the addition of phosphor reduced Pb uptake by lettuce plants . Boisson *et al.* (1999) also found that addition of hydroxyaptite to soil significantly reduced Pb in the leaves of corn and common bean. Xie *et al.* (2005) illustrated that the addition of single super phosphate significantly decreased the percentage of water – soluble and exchangeable soil Pb and reduced the uptake of Pb by cabbage. Adding phosphate to a Pb–contaminated soil, soluble Pb – phases will precipitate to more stable Pb-phosphates such as pyromorphite which reduces both the availability and mobility of Pb (Hettiarachchi and Pierzynski, 2004).

The effects of the interaction between application rates of Pb and all remediation treatments on lead concentration of plant root, shoot, leaves and green pods were found significant in both seasons. The application of remediation treatments significantly decreased Pb concentration of common bean roots, shoots ,leaves, green pods and dry seeds but with different magnitudes (Tables 9 and 10). The order of effectiveness of remediation treatments on decreasing Pb concentration in different plant tissues was as follows: the mixed > super phosphate > *Bacillus subtilis* > cattle manure. At the highest lead application level (300ppm), data showed that the reduction in Pb concentration due to the mixed treatment application were 50.25, 30.4, 33.74 and 42.92% in the first season and 48.37, 27.47, 33.64 and 39.44% in the second season in roots, stems, leaves and green pods of common bean, respectively, compared to control. Also, it was found that adding P to the lead contaminated soils at the same above mentioned lead rate reduced Pb content by 49.64, 21.29, 33.41 and 38.29 % in the first season and by 51.7, 23.76, 37.71 and 39.44 %in the second season in roots, stems, leaves, green pods of common bean respectively compared to control (Tables 9 and 10).

Phosphorus content

Data presented in Tables (11 and 12) indicated that phosphate contents in plant tissues decreased significantly with increasing Pb in the soil. At the highest lead level (300 ppm) phosphorus contents were decreased by 65.98%, 70.22%, 49%, and 53.44% in roots, stems, leaves and green pods, respectively, in the first season , and by 65.27, 69.95, 58.73 and 59.68%, in the second season compared to control treatment. These results are in full agreement with those obtained by Attia and Moftah (2002) who found that phosphorous concentration in leaves of borage plants linearly decreased with increasing Pb levels in the soil. The obtained results are also in accordance with those obtained by Aly (1982) who found that P concentration of pepper and

Jews mallow leaves was decreased when plants were treated with lead. A reduction in P concentration was reported in coconut leaves treated with lead by Biddappa *et al.* (1987). El-Ghinbihi (2000) found that P concentration of common bean roots, leaves and seeds decreased when plants were treated with lead compared to untreated plants. On the other hand, Paivoke (2002) reported that Phosphorus content in pea leaves was found to be negatively correlated with soil Pb. The inhibitory effect of heavy metal pollution on P content of plant tissues may be due to the action of pollutants on the uptake and translocation of the P element within plant roots (Larcher, 1980).

All remediation treatments (cattle manure, *Bacillus subtilis*, super phosphate, and the the mixed treatment increased significantly P concentration in common bean plants in both seasons (Tables 11 and 12). The best results in increasing P uptake were obtained from the mixed treatment and super phosphate-treatments. Application of the mixed treatment increased P (%)in roots , stems , leaves and green pods of common bean by 36.9%, 21.2%, 81.2% and 45.3% in first season and by 25.68%, 20.29%, 57.6%, and 28.7% respectively compared to control in the second season.

Meanwhile the percentages of P increments in roots, stems, leaves, green pods and seeds due to super phosphate treatment compared to control, were 34.16%, 14.47%, 67.3% and 43.12% in the first season and 23.95%, 14.6%, 47.4% and 25% in the second season respectively. This increasing of phosphorous concentration might be due to reduction of Pb uptake by remediation treatments.

Table (11): Effect of Pb and some remediation treatments along with their interaction on the percentage of P in roots, stems, leaves, green pods and seeds of common bean cv. Giza3 during 2005 growing season.

Pb(ppm) / Remed. treatments	0	100	200	300	Mean
Concentration of P(%)in roots					
Control	0.467 bc*	0.427 cde	0.387 e	0.263 h	0.57 C
Cattle manure	0.45 bcd	0.467 bc	0.39 e	0.33 f	0.672 B
B.subtilis	0.47 bc	0.49 b	0.397 de	0.33 f	0.68 B
Super phosphate	0.50 A	0.467 bc	0.407 de	0.39 e	0.769 A
Mixed	0.547 A	0.49 b	0.433 cde	0.4 de	0.785 A
Mean	0.807 A	0.750 B	0.697 C	0.533 D	
Concentration of P(%)in stems					
Control	0.797 bc	0.587 h	0.57 h	0.34 j	0.386 D
Cattle manure	0.777 cd	0.713 de	0.66 fg	0.537 h	0.41 CD
B.subtilis	0.777 cd	0.75 cd	0.71 def	0.48 i	0.4225 BC
Super phosphate	0.85 a	0.853 a	0.73 d	0.64 g	0.442 AB
Mixed	0.83 ab	0.85 a	0.79 bc	0.66 ef	0.467 A
Mean	0.488 A	0.468 A	0.403 B	0.343 C	
Concentration of P(%)in leaves					
Control	0.427 e	0.35 gh	0.27 i	0.17 k	0.306 E
Cattle manure	0.497 c	0.44 d	0.377 fg	0.257 j	0.349 D
B.subtilis	0.43 de	0.42 ef	0.347 gh	0.19 k	0.39 C
Super phosphate	0.68 A	0.577 b	0.477 cd	0.313 hi	0.512 B
Mixed	0.72 A	0.58 b	0.49 c	0.42 fg	0.554 A
Mean	0.551 A	0.475 B	0.393 C	0.270 D	
Concentration of P(%)in green pods					
Control	0.43 abc	0.32 efg	0.17 i	0.15 i	0.267 C
Cattle manure	0.44 ab	0.34 de	0.277 fgh	0.26 gh	0.329 B
B.subtilis	0.39 cd	0.397 bc	0.31 efg	0.267 gh	0.342 B
Super phosphate	0.48 a	0.463 a	0.33 ef	0.247 h	0.382 A
Mixed	0.483 a	0.45 ab	0.35 d	0.267 gh	0.39 A
Mean	0.4453 A	0.393 B	0.289 C	0.238 D	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05

Table (12). Effect of Pb and some remediation treatments along with their interaction on the percentage of P in roots, stems, leaves, green pods and seeds of common bean cv. Giza3 during 2006 growing season.

Pb(ppm) / Remed. treatments	0	100	200	300	Mean
Concentration of P(%)in roots					
Control	0.49 bc*	0.437 c	0.397 cd	0.27 e	0.58 C
Cattle manure	0.46 bc	0.477 bc	0.403 cd	0.353 de	0.65 B
B.subtilis	0.477 bc	0.493 bc	0.403 cd	0.317 de	0.657 B
Super phosphate	0.52 ab	0.477 bc	0.427 c	0.403 cd	0.716 A
Mixed	0.56 a	0.503 abc	0.443 c	0.41 cd	0.726 A
Mean	0.779 A	0.71 AB	0.665 B	0.51 C	
Concentration of P(%)in stems					
Control	0.77 ab	0.62 c	0.573 d	0.34 e	0.398 B
Cattle manure	0.69 bc	0.7133 b	0.69 bc	0.503 d	0.423 B
B.subtilis	0.77 ab	0.74 b	0.61 c	0.503 d	0.423 B
Super phosphate	0.85 a	0.7366 b	0.7 b	0.573 d	0.457 A
Mixed	0.85 a	0.727 b	0.75 ab	0.62 c	0.479 A
Mean	0.501 A	0.477 A	0.415 B	0.35 C	
Concentration of P(%)in leaves					
Control	0.443 a	0.337 cd	0.293 de	0.18 f	0.30 D
Cattle manure	0.437 a	0.42 a	0.343 cd	0.273 e	0.350 C
B.subtilis	0.46 a	0.417 ab	0.37 b	0.203 f	0.340 C
Super phosphate	0.457 a	0.423 a	0.353 bc	0.33 cd	0.443 B
Mixed	0.4433 a	0.43 a	0.39 b	0.347 cd	0.474 A
Mean	0.4813 A	0.383 B	0.381 B	0.283 C	
Concentration of P(%)in green pods					
Control	0.46 b	0.3 e	0.263 e	0.18 f	0.313 C
Cattle manure	0.437 c	0.33 de	0.363 d	0.267 e	0.368 B
B.subtilis	0.45 b	0.357 d	0.347 d	0.213 f	0.36 B
Super phosphate	0.55 a	0.4433 bc	0.453 b	0.33 de	0.392 AB
Mixed	0.517 ab	0.48 b	0.477 b	0.423 c	0.403 A
Mean	0.448 A	0.405 B	0.3507 C	0.267 D	

*Values having a common alphabetical letter (s), do not significantly differ, using the revised L.S.D. test at P=0.05

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The interaction effects between Pb levels and all remediation treatments on phosphorous concentration in both seasons are illustrated in Tables (11 and 12). The results showed that there were significant differences among the effects of Pb levels and all remediation treatments on phosphorous concentration in both experimental seasons. The favoring effects of remediation treatments on phosphorous concentration varied according to the used lead level. The combined treatments, which included application of mixed and super phosphate treatments with 200 or 300 ppm Pb, could be considered, more effective than other treatment combinations in increasing P bioavailability in the Pb contaminated soil in both seasons.

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الملخص العربي

دراسة تأثير تلوث الأراضي بالرصاص وبعض معاملات معالجة التلوث على النمو والمحصول والتركيب الكيماوي للفاصوليا

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اقترحت هذه الدراسة بهدف دراسة تأثير بعض معاملات معالجة تلوث الأراضى بالرصاص حيث استخدمت اربع مستويات مختلفة من الرصاص وهى 0 ،100،200،300 جزء في المليو ن وخمس معاملات معالجة وهي الكنترول ، وبكتيريا باسيلس ساتلس (10 مل تحتوى على 10^6 -10^8 خلية/ اصيص) ، وروث الماشية(20م3/فدان) و سماد سوبر فوسفات الكالسيوم(45كجم فو$_2$ ا$_5$/ فدان) والخليط من هذه المعالجات المختلفة والتداخلات بينهما على صفات النمو الخضرى ومحصول القرون الخضراء ومحتوى نباتات الفاصوليا صنف جيزة 3 من عنصرى الرصاص و الفوسفور .
اجريت تجربتين باستخدام الأصص خلال موسمي 2005 ، 2006 فى مزرعة كلية الزراعة بدمنهور فى منطقة البستان بمحافظة البحيرة ، جمهورية مصر العربية. تم تنفيذ التجارب باستخدام القطع المنشقه فى تصميم القطاعات العشوائية الكاملة فى ثلاث مكررات. اظهرت النتائج ان تلوث التربة بالرصاص ادى الى انخفاض معنوى فى صفات النمو الخضرى مقارنة بالتربة غير الملوثة في كل من موسمي النمو. وقد ارتبطت اقل القيم المسجلة لهذة الصفات وذلك عند تلوثها بالرصاص بأعلى مستوى (300 جزء فى المليون) في كل من موسمي النمو.و قد وجد ايضا ان التلوث بالرصاص ادى الى انخفاض معنوى فى محتوى الاوراق من كلوروفيل ا وب ومن الكاروتين مقارنة بالكنترول وكان الانخفاض في الكلوروفيل ا كثر وضوحا من الكاروتين.كما ادى التلوث بالرصاص أيضا إلى انخفاض معنوي في محصول النبات من القرون الخضراء .
وقد أظهرت الدراسة كذلك أن إضافة معاملات المعالجة قد أدى إلى التغلب على التاثير السلبى للرصاص على صفات النمو والمحصول وادى الى خفض محتوى نباتات الفاصوليا من الرصاص .
واوضحت النتائج ان افضل معاملات معالجة تلوث الاراضى بالرصاص كان باستخدام سوبر فوسفات الكالسوم أو معاملة الخليط من المعالجات المختلفة.