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RESEARCH PAPER

Alleviating of Lead toxicity using salicylic acid foliar spray in common bean *(Phaseolus vulgaris L.)* plant

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ABSTRACT

This study was carried out in a greenhouse at the college of science university of salahaddin,erbil, Iraq. Salicylic acid (SA) and Lead (pb) with (0, 50, 100, 200 and 400 ppm) and pb (0, 5 and 10 ppm) are used in a (type of the experiment must be recorded) experiment. Consisting of 10 treatment combinations with 4 replicates. Treatments were compared according to Duncan's multiple range tests at 0.05 level. Some vegetative growth, yield and chemical components were measured. The results notices that SA significantly decreased the harmful effects of Pb on the vegetative growth characteristics such as height of plant number of leaves, number of branches, weight dry of shoot system, also on yield parameters such as number of seeds per pod, dry weight of 100 seeds and on chemical contents such as chlorophyll a and total chlorophyll contents, total protein content of leaves and total sodium.

KEY WORDS: Lead; Toxicity; Salicylic acid; Chlorophyll; Common bean
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1. INTRODUCTION

The common bean(*Phaseolus vulgaris* L.) is a herbaceous annual plant, belongs to leguminous family trained autonomously in old Mesoamerica and now become over wall both for green beans and as dry bean. Among the significant nourishment vegetables the common Bean is the third most significant around the world, after soybean (*Glycine max* L.), and peanut (*Arachis hypogaea* L.) (Zeka, 2007).

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The common bean green pods, seeds are the principle source of protein (20–25%) and complex carbohydrates (50–60%) (Martiniz *et al.*, 2011), Vitamins, dietary fiber, mineral nutrients such as phosphorus, zinc, iron and calcium (Carvalho *et al.*, 2012). Bean plants have ability to absorb pollutants from contaminated environments by their roots with other nutrients (Mwstefa and Ahmed, 2019).

Salicylic acid (SA) is the plant hormone, which has fundamental role in the control of most physiological processes in plants. SA has found to assume the significant role in plant growth, and when it combined with other factors is great concern in reactions considerable lot of environmental stresses. Moreover, it play arole in seed germination, plant growth, flowering, fruit yield, glycolysis, ion uptake and stomatal number, transpiration, transport and rate of photosynthetic process, …etc (Sadeghipour and Aghaei, 2012 A, B). It is proved that have primary reactions to a biotic stresses and some reactions of abiotic stress, such as herbicides, heavy metals, salinity, low temperature (Mohsenzadeh *et al.,* 2011), and osmotic stress. Among those stresses, harmful heavy metal stress is a rising and most stress that is effective for major products (Bhardwaj *et al.,* 2009). (Rashid, 2018) reported that salicylic acid corrosive fundamentally increases yield components such as pods weight, pod yield, total yield, seed number per pod, dry weight of hundred seeds, and total seed yield.

Lead (Pb), is one of the heavy metals which is unnecessary discharged into the common habitat from a number of anthropogenic processes (Ekmekçi *et al.,* 2009). When it is discharged, it has harmful effect on plants and animals because of its accumulation in the soil (Kaur *et al.,* 2010). Accumulation of Pb near urban and industrial areas cause a significant increase of Pb in the surface ground layer which effects the cultivated of soil (Hussain *et al*., 2006). Sullying of soils with Pb not just influences the number and movement of microorganism but also declines soil fertility, yet additionally directly influence the difference in physiological indices and brings about the reduction of yields (Majer *et al.,* 2002). Pb absorbed by the plants principally through root, leaves and trichomes. Toxicity of Pb cause more problems as decrease in growth, yield, senescence of young leaves, reducing in the absorption of essential elements such as iron and decrease in the rate of photosynthesis. Contamination of Pb in the plant is known to have adverse effects on germination of seed, photosynthesis, seedling growth, respiration, nitrate assimilation and differnt processes (Singh *et al.*, 2003).

Foliar application of SA at doses of 0.1 or 0.2 mM decreased the impact of Pb^{+2} on seedling development of two rice (*Oryza sativa* L.) cultivars, SA improve the fresh and dry mass of shoots and roots in the two cultivars under stresses of Pb (Mishra and Choudhuri, 1997). Interaction effect of SA and Pb increased significantly the height of plant, leaves number, leaf area, fresh and dry weight in contrasted to those treated with Pb in eggplants (Tavakoli *et al.,* 2011)

The principle target of this study was to investigate the ability of SA as foliar spray to decrease the harmful effect of Pb toxicity in the soil.

2. MATERIALS AND METHODS

This experiment was conducted in the greenhouse of the College of Science, Salahaddin University-Erbil, during the growing season March 7 2012 to July 5 2012, in order to evaluate the combination impact of lead (Pb) and Salicylic acid (SA) on growth and development of common bean. The study involved 40 plastic pots each pot with 24 and 21 cm diameter and depth respectively. Each contained 7kg dry sandy loam soil of Askikalak area, the soil sieved through 2mm pore size sieves, and 3 seed were sown in each pot. This test comprised of 10 treatment combinations with 4 replicates of foliar spray with different Salicylic acid (SA) concentrations at doses (0, 50, 100, 200, 400ppm) and soil water system of Pb ($PbNO_3$) in two doses (0, 5, 10 ppm), and involved 10 treatments with four replications. The following characteristics were taken: height of plant (cm), leaves number.$plant^{-1}$, branches number .$plant^{-1}$, shoot dry weight (g), water content of shoot system, leaf area (cm^2), stem diameter, yield components such a pods number, seeds number, dry weight of hundred seeds. In addition chemical contents were estimated as photosynthetic pigments, proline, phenol and mineral nutrients of leaves.

Water content of the system of shoot assessed as follows: fresh weight dried in an oven 110°C for an hours and then at 70°C for 24 hours, in an oven. Dry weight of shoot system obtained thirty minutes after cooling at room temperature (He *et al*, 2005). The following formula was used for the estimation of water content

Water content =F.wt.-D.wt.

F.wt. =fresh weight

D.wt. =dry weight

Chlorophyll content in leaves (mg.g^{-1}) evaluated by taking 0.5g of crisp leaves left in 10 ml of absolute ethanol for 24 hrs. In dull condition, this procedure repeated three times to finish extraction of chlorophyll the last volume arrived 30 ml were spectrophotometrically evaluates on two wavelength 649and 665 nm as follows (Wintermans and Demote, 1967):

µg chlorophyll a/ml solution = (13.70) (A665nm)-(5.76) (A 649nm)

µg chlorophyll b/ml solution = (25.80) (A649nm)-(7.60) (A 665nm)

Total chlorophyll =chlorophyll a + chlorophyll b

A=absorbance

m =nanometer

Proline content of leaves

Proline was estimated by the method as depicted by (Bates et *al.*, 1973 and Hassan, 2011)**.**

3. RESULTS AND DISCUSSION

3.1. Vegetative growth characteristics

Table (2) shows that SA decreased the adverse impact of Pb on plant height at various development stages which increased significantly ($p \leq 0.05$) by Pb_5SA_{200}, Pb_5SA_{400}, $Pb_{10}SA_{400}$ as compared with controls Pb_5SA_{50} and $Pb_{10}SA_{200}$ after 15 days from application. And at Pb_5SA_{400} as compared with Pb_5SA_0 after 30 days from application, and at Pb_5SA_{200}, Pb_5SA_{400} as compared with control $Pb_5SA_{0,}$ $Pb_{10}SA_{100,}$ $Pb_{10}SA_{200}$, $Pb_{10}SA_{400}$ as compared with controls $Pb_5SA_{0,}$ $Pb_{10}SA_{400}$ after 45days from application. After 60 days from application at Pb_5SA_{100}, Pb_5SA_{200}, Pb_5SA_{400}, $Pb_{10}SA_{50,}$ $Pb_{10}SA_{100,}$ $Pb_{10}SA_{200}$, $Pb_{10}SA_{400}$ as compared with Pb_5SA_0, $Pb_{10}SA_0$. However, there were significant differences between treatments. The increases in plant height with the increase of concentrations of SA in the present investigation are in agreement partially with those reported by (Sadeghipour and Aghaei, 2012A). SA treatments showed synergetic effect with endogenous phytohormones auxins, gibberellins and cytokinines, which are cause cell elongation leading to increase of plant height (Mady, 2009).

Table (3) shows that SA decreased the adverse effect of Pb on leaves number at different growth stages, number of leaves increased significantly by the treatment Pb_5SA_{100}, Pb_5SA_{400}, $Pb_{10}SA_{200}$ as compared with control after 15 days from application and at Pb_5SA_0, Pb_5SA_{400}, $Pb_{10}SA_{200}$, $Pb_{10}SA_{400}$ as compared with controls $Pb_5SA_{0,}$ $Pb_{10}SA_0$ after 30 days from application. And at Pb_5SA_{200}, Pb_5SA_{400} as compared with controls $Pb_5SA_{0,}$ $Pb_{10}SA_0$ after 45 days from application and after 60 days from application at Pb_5SA_{200}, Pb_5SA_{200}, Pb_5SA_{400}, $Pb_{10}SA_{400}$ as compared with Pb_5SA_0, $Pb_{10}SA_0$ and there were significant differences between treatments.). These results partially conquered with those got from basil and marjoram plants (Gharib, 2007), common bean plants (Hegazi and El-Shairy, 2007) and pea plants (El-shairy and Hegazi, 2009). SA at 400ppm was the more effect treatments in increasing leaf numbers.

Table (4) indicated thta SA alleviated the effect of Pb stress on the number of branches at different growth stages, which increased significantly by Pb_5SA_{400}, $Pb_{10}SA_{400}$ as compared with controls Pb_5SA_0 $Pb_{10}SA_0$ after 15, 30, 45 days from application and at Pb_5SA_{200}, $Pb_{10}SA_{400}$ as compared with controls Pb_5SA_0, $Pb_{10}SA_0$ after 60days from application and observed clear significant differences between treatments. these results agreed partially with those obtained by Devi *et al.*, (2011) and Ali and Mahmoud, (2013), who pointed out that SA treatments increased the number of branches. The increase in the number of branches could be due to the suppression of apical dominance, thereby diverting the polar transport of auxins towards the basal nodes leading to increased branching (Naz, 2006).

Table 1: Some physical and chemical properties of the soil used in the experiments

Properties	value
Sand	70.10 %
Silt	24.22 %
Clay	5.68 %
Soil texture	Sandy loam
Soil moisture	3.1 %
Organic matter	0.91 %
PH	7.24
$CaCO_3$ (Trimetric method)	25.7%
Electrical conductivity (ds m^{-1} at 25°C)	0.58
Total nitrogen % (kjeldahl method)	0.4%
Total phosphorus ppm(Olsen method)	118 ppm
Total potassium ppm (flame photometer)	45 ppm
Total calcium ppm (atomic absorption method)	240 ppm
Total lead ppm (atomic absorption method)	9.5 ppm

Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 5% level

Table 2: Interaction effects of SA and Pb on plant height at different stages of growth

Interaction treatments		Plant height (cm) after (days) from application			
Pb $mg.Kg^{-1}$	**SA ppm**	**15 days**	**30days**	**45days**	**60days**
5	0	12.62 ^{b}	15.40 ^{b}	18.32 ^{c}	20.62 ^{e}
	50	13.22 ^{b}	15.58 ^{ab}	19.20 ^{bc}	21.90 ^{de}
	100	14.30 ^{ab}	16.14 ^{ab}	20.17 ^{bc}	22.64 ^{cd}
	200	15.17 ^{a}	17.35 ^{ab}	22.52 ^{a}	25.23 ^{ab}
	400	15.57 ^{a}	17.92 ^{a}	21.25 ^{ab}	24.70 ^{ab}
	0	12.65 ^{b}	15.30 ^{b}	18.70 ^{c}	21.50 ^{cd}

	50	14.02 ab	15.72 ab	20.85 abc	23.97 b
10	100	13.70 ab	16.25 ab	21.14 ab	24.03 bc
	200	13.20 b	17.35 ab	22.45 a	25.87 a
	400	15.62 a	16.87 ab	22.15 a	24.92 bc

*Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 5% level

Table 3: Interaction effects of SA and Pb on number of leaves at different stages of growth

Interaction treatments		Number of leaves after (days) from application			
Pb mg.Kg^{-1}	**SA ppm**	**15 days**	**30days**	**45days**	**60days**
5	0	9.00 b	11.75 c	13.75 c	16.00 b
	50	9.75 ab	12.00 bc	15.25 bc	17.50 ab
	100	11.00 a	12.75 abc	15.00 bc	18.50 a
	200	10.50 ab	13.50 ab	16.25 a	18.25 a
	400	11.25 a	14.00 a	16.00 a	19.50 a
10	0	9.25 b	11.50 c	13.75 c	15.75 b
	50	10.50 ab	12.00 bc	15.25 bc	17.50 ab
	100	9.75 ab	12.75 abc	14.25 bc	17.50 ab
	200	11.00 a	14.00 a	15.75 bc	17.00 ab
	400	10.50 ab	14.75 a	17.00 a	19.25 a

* Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 5% level

Table 4: Interaction effects of SA and Pb on number of branches at different stages of growth

Interaction treatments		Number of branches after (days) from application			
Pb mg.Kg^{-1}	**SA ppm**	**15 days**	**30days**	**45days**	**60days**
5	0	3.25 b	5.00 b	6.00 c	7.50 c
	50	3.25 b	5.25 ab	6.25 bc	8.00 c
	100	3.50 b	5.25 ab	6.25 bc	8.25 c
	200	3.75 ab	5.75 b	6.75 bc	8.75 ab
	400	4.50 a	6.00 a	7.50 a	9.00 abc

	0	3.50 ^{b}	5.25 ^{ab}	6.50 ^{c}	8.25 ^{c}
	50	3.75 ^{ab}	5.50 ^{ab}	6.75 ^{bc}	8.50 ^{bc}
	100	4.00 ^{ab}	5.75 ^{ab}	6.75 ^{bc}	8.25 ^{c}
10	200	3.75 ^{ab}	6.00 ^{ab}	7.25 ^{bc}	9.00 ^{abc}
	400	4.75 ^{a}	6.75 ^{a}	8.00 ^{a}	9.75 ^{a}

* Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 5% level

3.2 Yield characteristics

Table (5) shows the combination impact of SA and Pb on yield components. It is observed that there are no significant differences between treatments.

Table 5: Interaction effects of SA and Pb on yield characteristics

Interaction treatments		Yield characteristics		
Pb mg.Kg^{-1}	**SA ppm**	**Number of pods .plant^{-1}**	**Number of seeds .pod^{-1}**	**Dry weight of 100 seeds**
5	0	14.25 ^{a}	4.75 ^{b}	25.63 ^{b}
	50	15.75 ^{a}	5.25 ^{ab}	26.90 ^{ab}
	100	19.25 ^{a}	5.75 ^{ab}	28.25 ^{ab}
	200	18.50 ^{a}	5.50 ^{ab}	29.08 ^{ab}
	400	20.25 ^{a}	6.00 ^{ab}	26.80 ^{ab}
10	0	12.25 ^{a}	5.25 ^{ab}	26.63 ^{ab}
	50	17.50 ^{a}	5.50 ^{ab}	27.25 ^{ab}
	100	15.75 ^{a}	5.80 ^{ab}	28.25 ^{ab}
	200	14.25 ^{a}	5.25 ^{ab}	29.08 ^{ab}
	400	17.75 ^{a}	6.25 ^{a}	31.50 ^{a}

* Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 5% level

3.3. Chemical characteristics in leaves

Table (6) indicated that SA diminished the negative impact of Pb on chlorophyll contents of fresh leaves, which significantly ($p \leq 0.01$) increased chlorophyll a by Pb_5SA_{100}, as compared with $Pb_5SA_{0,}$ and significantly increased by $Pb_{10}SA_{50,}$ $Pb_{10}SA_{400}$ as contrasted with $Pb_{10}SA_0$, and there significant differences between 100ppm and 400ppm in total chlorophyll components of leaves. These results somewhat agreed with those conquered by Turkyilmaz *et al.* (2005), who recommended that foliar spray with SA increased chlorophyll a, b, and some photosynthetic pigments in bean in field conditions. The incitement impact of SA on chlorophyll concentration was affirmed by Azooz *et al.* (2011) on broad bean, Fahd and Bano (2012) on maize plants. Table (7) SA treatments decreased the adverse impact of Pb on total protein content of leaves, which increased significantly ($p \leq 0.01$) y $Pb_{10}SA_{100}$, $Pb_{10}SA_{400}$ as compared with $Pb_{10}SA_{0.}$, SA treatments decreased significantly ($p \leq 0.01$) the content of proline under Pb stress by $Pb_{10}SA_{400}$ as compared with $Pb_{10}SA_0$.Data in Table (8) indicated that SA decreased the negative effect of Pb on nitrogen content of leaves. It was observed that there were significant differences between 50ppm with 100 and 400ppm. It is observed that there were significant differences between $Pb_{10}SA_{50}$ with $Pb_{10}SA_{100}$ $Pb_{10}SA_{200}$ and $Pb_{10}SA_{400}$ in potassium content of leaves. The combination impact of SA and Pb on potassium content in leaves, that there were significant differences between Pb_5SA_{50} with Pb_5SA_{400}.There were no significant differences between treatments in total zinc, iron, and lead content of leaves. SA treatments increased the contents of K, while decreased Na contents in mung bean plant (Khan *et al.*, 2010). SA caused critical increases in the uptake of elements in tomato plant (Amin *et al.,* 2007). These increases in some mineral content might be associated with the increase in photosynthetic pigments which thusly influence the rate of organic compound assimilation (Abou El-Yazeid, 2011).

Table 6: Interaction effects of SA and Pb on chlorophyll content of leaves (mg.g^{-1}fresh weight)

Interaction treatments		Photosynthetic pigments (mg.g^{-1}fresh weight)		
Pb mg.Kg^{-1}	**SA ppm**	**Chlorophyll a**	**Chlorophyll b**	**Total chlorophyll**
5	0	0.78 ab	0.16 a	0.95 abc
	50	0.69 ab	0.27 a	0.97 abc
	100	0.32 c	0.26 a	0.58 bc
	200	0.88 a	0.43 a	1.32 ab
	400	0.67 ab	0.68 a	1.35 a
10	0	0.45 bc	0.10 a	0.56 c
	50	0.89 a	0.43 a	1.32 bc
	100	0.56 abc	0.41 a	0.98 abc
	200	0.57 abc	0.19 a	0.76 abc
	400	0.83 a	0.39 a	1.22 abc

* Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 1% level

Table 7: Interaction effects of SA and Pb on some biochemical contents of leaves and seeds

Interaction treatments		Biochemical contents			
Pb mg.Kg^{-1}	**SA ppm**	**Protein (%)**	**Carbohydrate (%)**	**Proline (µg.g^{-1})**	**Total phenol (µg.g^{-1})**
5	0	26.49 abc	48.17 a	31.46 ab	26.99 ab
	50	27.95 ab	49.96 a	26.97 ab	23.96 ab
	100	20.17 c	53.26 a	25.95 ab	23.55 ab
	200	25.28 abc	51.93 a	31.97 ab	20.16 ab
	400	29.41 a	48.92 a	25.69 ab	16.93 ab
10	0	20.42 c	47.52 a	37.43 a	28.98 a
	50	22.85 abc	52.62 a	29.79 ab	23.33 ab
	100	21.15 ab	46.10 a	26.15 ab	15.81 ab
	200	25.03 abc	45.35 a	28.57 ab	18.81 ab
	400	22.12 ab	48.47 a	18.76 b	24.46 ab

* Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 1% level

Table 8: Interaction effects of SA and Pb on some mineral nutrient contents of leaves

Interaction treatments		Mineral nutrient contents							
		Mg.g^{-1}							µg.g-1
Pb mg.Kg^{-1}	**SA ppm**	**Nitrogen**	**phosphorus**	**Potassium**	**Sodium**	**Manganese**	**Zinc**	**Iron**	**Lead**
5	0	43.94 ^{ab}	2.10 ^{a}	11.65 ^{b}	2.72 ^{ab}	25.10 ^{a}	35.50 ^{a}	339.55 ^{a}	103.17 ^{b}
	50	44.72 ^{a}	2.65 ^{a}	12.97 ^{ab}	2.25 ^{b}	16.53 ^{ab}	40.24 ^{a}	341.62 ^{a}	174.60 ^{ab}
	100	32.66 ^{b}	2.81 ^{a}	13.19 ^{ab}	2.99 ^{ab}	19.90 ^{ab}	35.61 ^{a}	353.18 ^{a}	124.60 ^{ab}
	200	39.35 ^{ab}	2.41 ^{a}	13.76 ^{ab}	3.08 ^{ab}	16.12 ^{ab}	34.76 ^{a}	489.50 ^{a}	120.96 ^{ab}
	400	32.27 ^{b}	3.09 ^{a}	13.86 ^{ab}	3.25 ^{a}	16.72 ^{ab}	40.06 ^{a}	373.41 ^{a}	141.38 ^{ab}
10	0	36.55 ^{ab}	3.25 ^{a}	14.01 ^{ab}	2.66 ^{ab}	14.89 ^{b}	43.52 ^{a}	454.43 ^{a}	184.83 ^{ab}
	50	34.22 ^{ab}	3.44 ^{a}	14.60 ^{b}	3.21 ^{a}	15.92 ^{ab}	36.22 ^{a}	358.90 ^{a}	132.90 ^{ab}
	100	40.44 ^{ab}	3.55 ^{a}	14.63 ^{a}	2.58 ^{ab}	18.38 ^{ab}	42.43 ^{a}	315.20 ^{a}	254.01 ^{a}
	200	33.83 ^{ab}	3.77 ^{a}	14.72 ^{a}	2.83 ^{ab}	21.26 ^{ab}	35.13 ^{a}	395.56 ^{a}	155.53 ^{ab}
	400	40.83 ^{ab}	4.03 ^{a}	15.52 ^{a}	2.77 ^{ab}	18.91 ^{ab}	27.83 ^{a}	441.13 ^{a}	153.17 ^{ab}

* Means within colums followed with the same letters are not significantly different from each others according to Duncan multiple range test at 1% level

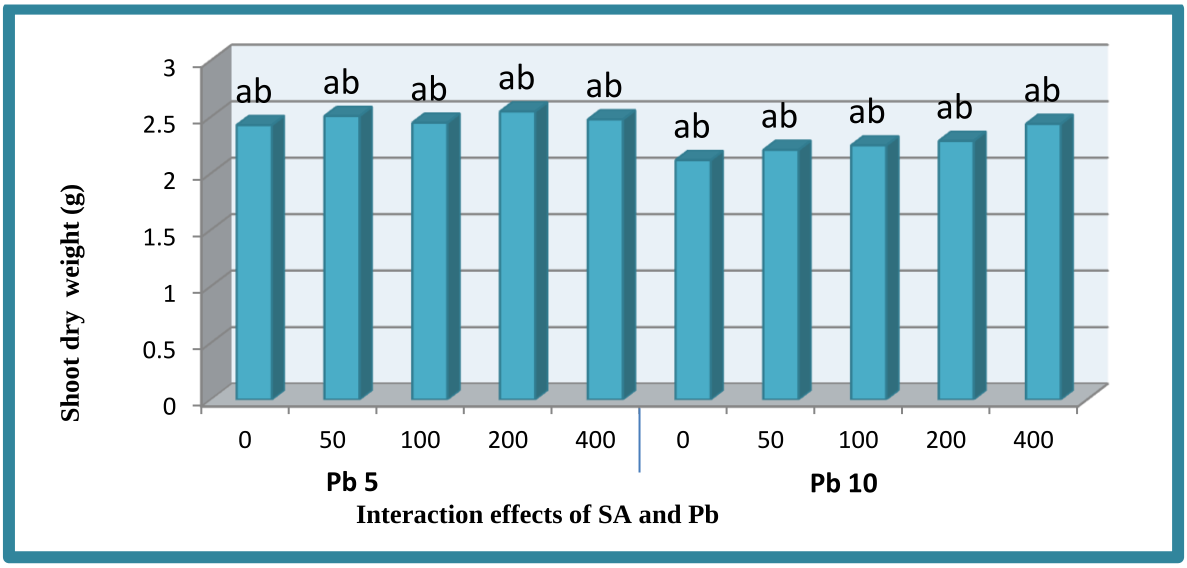

Figure 1: Interaction effects of SA and Pb on dry weight of shoot system.

***Columns followed with the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.**

* Figure Number 1 should be redrawn because the column heights do not represent the reality according to the letters on them

4. CONCLUSIONS

In conclusion the adverse effects of Pb toxicity alleviated by foliar application of SA in common bean plants on vegetative growth such plant height, number of leaves, number of branches, as well as on yield characteristics like number of seeds per pods and dry weight of 100 seeds, further more on and chemical components such as photosynthetic pigments also chemical contents protein, proline, total phenol, mineral nutrients nitrogen, potassium, sodium, and manganese

REFERENCES

A.O.A.C., (2010). Determination of total nitrogen in waste water by steam distillation. Published by Association Official Agriculture Chemists, Washington, D.C., USA.

A. Abou El-Yazeid. (2011). Effect of Foliar Application of Salicylic Acid and Chelated Zinc on Growth and Productivity of sweet pepper (*Capsicum annuum* L.) Under Autumn Planting. Res. J. of Agric. and Biol. Sci., 7(6): 423-433.

S.E. Allen. (1974). Chemical Analysis of Ecological Materials. Black well Scientific Publication Osney Mead, Oxford, 565 p.

E.A.Ali and M. Mahmoud. (2013). Effect of Foliar spray of Salicylic Acid and Zinc concentrations on seed Yield and yield components of Mungbean in Sandy soil. Asian J. of crop Sci., 5(1):33-40.

M.M. Azooz; A.M. Youssef and P. Ahmad. (2011). Evaluation of salicylic acid (SA) application on growth, osmotic solutes and antioxidant enzyme activities on broad bean seedlings grown under diluted seawater. Int. J. Plant Physiol. & Bioch., 3(14): 253-264.

P. Bhardwaj; A.K. Chaturvedil and P. Prasadi. (2009). Effect of Enhanced Lead and Cadmium in soil on Physiological and Biochemical attributes of *Phaseolus vulgaris* L. Natural & Sci., 7(8):63-75.

L.S. Bates; R.P. Waldren and D. Teare. (1973). Rapid determination of free proline for water-stress studies. Plant and Soil, 39:205-207.

L.M. J.Carvallo; M.M. Correa ; E. J. Pereira ; M. R. Nutti ; J.L.V. Carvalho ; E. M. G. Riebeiro and S. C. Freitas. (2012). Iron and Zinc retention in common beans (*Phaseolus vulgaris* L.) after home cooking. Food & Nut. Res., 56:1656-1661.

P.M.Dey. (1990). Methods in plant biochemistry. Vol-II. Carbohydrates. (Publ.) Acad. Press London.

K.N. Devi; A.K. Vyas and M.S. Singh. (2011). Effect of bioregulators on growth, yield and chemical constituents of Soybean (*Glycine max* L.). J. of Agric. & Sci., 3(4).151-159.

Y. Ekmekçi; D. Tanyolac and B. Ayhan. (2009). A crop tolerating oxidative stress induced by excess lead: maize. Acta Physiol. Plant, 31: 319-330.

A.M. El-shraiy and A.M. Hegazi. (2009). Effect of Acetylsalicylic acid ,Indol-3-Bytric Acid and Gibberellic Acid on plant Growth and Yield of Pea (*Pisum sativum* L.). Aus. J. of Basic and Applied Sci., 3(4):3514-3523.

S. Fahad and A. Bano. (2012). Effect of salicylic acid on physiological characterization of maize grown in saline area. Pak. J. Bot., 44(4):1433-1438.

F.A.E. Garib (2007). Effect of salicylic acid on the growth ,metabolic activities and oil content of basil and marjoram . Int. J. of Agric. & Biol., 9(2): 294-301.

T. M. Hassan. (2011). Role of Salicylic acid on Alleviating Cadmium Toxicity in Pea *Pisum sativum* L. Plants. M.Sc. Thesis. College of Education-Scientific Department. University of Salahaddin-Iraq.

Y. He; Y. Liu; W. Cao; M. Huai; B. Xu and B. Huang. (2005). Effect of salicylic acid on heat tolerance associated with antioxidant metabolism in Kentucky bluegrass. Am. Crop Sci. Soci., 45:988-995.

A.M. Hegazi and A.M. EL-Shraiy. (2007). Impact of salicylic acid and paclobutrazol exogenous application on the growth, yield and nodule formation of common bean. Aus. J. Basic & Applied Sci., 1(4):834-840.

M. Hussain; M.S.A. Ahmad and A. Kausar. (2006). Effect of Lead and Chromium on growth ,photosynthetic pigments and yield components in Mash bean (*Vigna mungo* L.) Hepper. Bot., 38(5):1389-1396.

L. Kaur; K. Gadgil and S. Sharma. (2010). Effect of pH and lead concentration on phytoremoval of lead from lead contaminated water by *Lemna minor*. American-Eurasian. J. Agric. & Environ. Sci., 7(5): 542–550.

A.N.Khan; S. Syeed; A. Masood; R. Nazar and N. Iqbal. (2010). Application of salicylic acid increases contents of nutrients and antioxidative metabolism in mungbean and alleviates adverse effects of salinity stress. Int. J. of Plant Biol., 1(1): 1-8.

M.A. Mady. (2009). Effect of foliar application with salicylic acid and vitamine E on growth and productivity of tomato (*Lycopersicon esculentum*, Mill.). Plant J. Agric. Sci. Mansoura Univ., 34(6): 6735-6746.

B.J. Majer; D. Tscherko and A. Paschke. (2002). Effects of heavy metal contamination of soils on micronucleus induction in Tradescantia and on microbial enzyme activities: a comparative investigation. Mutation Res. /Genetic Toxicology and Environmental Mutagenesis, 515(1-2):111-124.

M.O. Martiniz; L.A.B. Perez; K.W. Hitney; P.O. Diaz and S. Semik. (2011). Starch characteristics of bean (*Phaseolus vulgaris*) grown in different localities. Carbohydrate Polymers, 85(1):54-64.

A. Mishra and M. A. Choudhuri. (1997). Ameliorating effects of salicylic acid on lead and mercury – induced inhibition of germination and early seedling growth of two rice cultivars. Seed Sci. Technol., 25: 263-270.

S. Mohsenzadeh; M. Shahrtash and H. Mohabatkar. (2011). Interactive effect of salicylic acid on some physiological response of cadmium-stressed maize seedlings. Iranian J. of Sci. & Tech., 6, 57-60.

T. Naz (2006). Infleunce of Salicylic acid and mepiquat chloride on physiology of disease resistance in groundnut (*Arachis hypogaea* L.). M. Sc. Thesis, department of crop physiology, College of Agriculture, Dharwad University of Agricultural Science. Dharwad. India.

J. Rayn; G. Estefon and A. Rashid. (2001). Soil and plant analysis Labrotory Manual, 2nd edition. National Agriculture Research Center (NARC). Islamabad, Pakistan.

O. Sadeghipour and P. Aghaei. (2012, A). Impact of exogenous salicylic acid on some traits of common bean (*Phaseolus vulgaris* L.) under water stress conditions. Int. J. of Agric. & Crop Sci., 4(11):685-690.

O. Sadeghipour, and P. Aghaei. (2012, B). Response of Common bean (*Phaseolus vulgaris* L.) to exogenous application of salicylic acid (SA) under water stress conditions. Advances in Environ. Biol., 6(3):1160-1168.

G.N. Sharma; S.K. Dubey; N.Sati and J. Sanadya. (2011). Phytochemical Screening and Estimation of Total Phenolic Content in *Aegle marmelos* Seeds. Int. J. of Pharm. and Clinical Res., 3(2): 27-29.

Singh, R.P.; R.D. Tripathi, S. Dabas ; S.M.H. Rizvi; M.B. Ali; S. K. Shina; D. K. Gupta; S. Mishra and U.N. Rai. (2003). Effect of lead on growth and nitrate assimilation of *Vigna radiata* (L) Wilczik seedling in a salt affected environment. Chemosphere. 52(7):1245-1250.

M. Tavakoli; A.Chehregani; H. L. Yazdi and A. Pakdel. (2011). Study on the effect of different concentrations of Pb and salicylic acid on some growth factors in eggplants (*Solanium melongena* L.). Iranian J. of Plant Biol., 3(7): Abstract.

B. Türkyılmaz; L.Y. Aktaş and A. Güven. (2005). Salicylic acid induced some biochemical and physiological changes in *Phaseolus vulgaris* L. Science and Engineering J. of Firat Univ., 17(2): 319-326.

J.F. Wintermans and A. Demote. (1967). Spectrophotometry characterstics of chlorophyll (a) and (b) and their phynophytins in ethanol. Bioch. Biophysiology Acta., 109:448-453.

D. Zeka. (2007). Inventory of phenotype diversity of landraces of common beans (*Phaseolus vulgaris* L.) in Kosova for a national gene bank.M.Sc.Thesis. Int. Master Programme at the Swedish Biodiversity Centre, pp41.