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A STUDY ON THE TOXIC EFFECT OF LEAD (PB) ON BARLEY' S GROWTH VIA MULTIFACTOR EXPERIMENT

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ABSTRACT

Negative and injurious effects of heavy metals especially lead (Pb) have increased recently on plant , animal , and human-kind . Consequently, this research was undertaken to investigate the effect of different levels of (Pb) : (50 – 100 – 150 – 200 mg/kg soil) on barley growth in sandy plantations. Moreover, correlative effects among Pb (50 mg/kg soil) and nutritive elements, *viz.* (N-P-K-Ca –S –Fe – Cu – Zn – Mg) which were used at (50– 100 – 150 and /or 200 mg/kg soil of each mineral element with the fixed level of Pb) were reported.

Correlative effects of these elements and Pb have been investigated *via* multifactor experiments. These elements were added at specific ratios as 1:1 and 1:5 of lead according to specific table related to it .

It was found that adding (Pb) increased the negative effects on barely upto injourious peaks at 200 mg Pb / kg soil. However , adding some other elements like (S and N) decreased the harmful impacts of lead , whereas adding (Ca, Cu and Zn) increased it .

Multifactor experiments showed positive effects of some fertilizer element groups ; *e.g.* two – elements : (S, N), (S, P) , (Mg, S) , three – elements : (S , K , N) , four elements : (Mg , S , K , N) , (Fe, S, K, N), five - elements: (Mg, Fe, S, P, N). Other fertilizer-element groups have negative effects on barely seedling and growth ,

such as : two elements : (Cu, Zn), three elements : (Zn, Fe, K), four elements: (Zn, Mg, K, P) and five elements : (Cu, Fe, Ca, K, P).

Of special interest is the effect of adding fertilizers that contain N,K and/or S to reduce the effect of lead in soils contaminated with it which improve plant growth under these cases.

Key words: *barley, growth, heavy metals, lead , multifactor experiment, toxic effect.*

1. INTRODUCTION

Universe is subject to a precise and balanced system. But mankind interfered conflicted style with ecological laws, which cause this balance to be fissured. These crises awaked wide spread communities to study the problems that endanger eco-systems.

One of the most troubled environmental problems for humankind is the various toxic materials, and the most important of them are the heavy metals that contaminate Biosphere (Al Oudat,1988). Of these minerals, lead (Pb), is the most important pollutant that causes great damage for plant, people, and animals. It is known that lead pollution sources are so various. The most excretion into environment comes from public-transport vehicles, where lead is added to gasoline to increase its octane number. One car exhausts upto 1 g of lead compounds per day in microparticles form (Al Hayak,1991) which is able to be transferred far away by wind, besides of its accumulation in body tissues without disposition up to toxic levels which causes serious damages of living organisms and may cause death (Waldren,1989).

Plants are important commercial basis for human being, and essential episode in ecological equlibrium. So, researches are directed widely to investigate pollutant effects on plants. Investigations made by (HOLL, 1985) proved that subsides tree's leaves contain toxic minerals concentrations up to 50 mg/kg of dry weight.

Chemical forms of heavy metals , and specially lead, have a major role in its absorption. Plant growth can be affected by lead salts respecively by acetates < nitrates < citrates (Foy,1983).

Cation form of heavy metals is more toxic than anions(Davis,1985). So, searching and investigating dual relations between nutritive mineral resources of plants with heavy metals may give some conclusions about absorption, toxicity, and to control its harms (Biddappa, 1987 and Terry 1983).

Imbalances in bio-operations in plants by lead contamination appear in reduced growth and development. Nature and roles of system are affected by decreasing nutritive passage and reception from soil. This negative effect turned to the nature and roles of vegetative system.(Lane and Martin 1990).

Increasings of Pb concentrations in vegetal tissues affect the composition and roles of cellular ingredients, which reflected negatively on the whole vegetal organs's actions.(Agrawal and Patel 1981).

Photosynthesis and respiration are the most sensitive operations influenced by lead harms. Photosynthesis and materials interchanges, for special the active transportation, are reduced (Bazzaz and Rolf 1987)

Respiration, formation of new tissues , transudation, and water absorption are influenced and growth can be ceased in the plants (Foy,1993)

The present investigation was carried out to study the effect of various concentrations of "toxic" lead on barely plants, in addition to study mutual effect of various mineral concentrations with lead. Also, we tried to set a method to increase plant resistance to toxic effect of lead by multifactor experiment that stands on the study of the mutual and corporate effect of various minerals with Pb.

2.MATERIALS AND METHODS

Black barely of common strains (Baladi variety) was planted in pots of sandy farms of 5kg sand/ pot, washed twice with distilled water to get rid of mineral traces attached to sand grains , then we performed three experiments:

The first experiment was carried out to study the various effects of Pb concentrations on barely. Fifty – 100 – 150 and 200 mg Pb / kg soil were used .

The second experiment was to test the effects of different concentrations of mineral elements on Pb, and used N ,Ca , K , P, Cu , Zn , S , Fe , Mg at 50 – 100 – 150 – 200 mg/ kg soil of each ,respectively; with fixed level (50 mg/kg soil) .

The third experiment was the multifactor experiment which was carried out to study the corporate effect of nutritive elements with each other, and with Pb. These elements were added as shown in Table (1).

Table (1): Mineral feed element distribution according to multi-factors experiment for studying their effect on barely plant growth under Pb treated soil .

Experiment no.	N	P	K	Ca	S	Fe	Mg	Zn	Cu
1	-	-	-	-	-	-	-	-	-
2	+	-	-	-	-	+	+	-	-
3	-	+	-	-	-	+	+	+	+
4	+	+	-	-	-	-	-	+	+
5	-	-	+	-	-	+	-	+	-
6	+	-	+	-	-	+	-	+	-
7	-	+	+	-	-	-	+	-	+
8	+	+	+	-	-	+	-	-	+
9	-	-	-	+	-	+	+	+	+
10	+	-	-	+	-	-	-	+	+
11	-	+	-	+	-	-	-	-	-
12	+	+	-	+	-	+	+	-	-
13	-	-	+	+	-	-	+	-	+
14	+	-	+	+	-	+	-	-	+
15	-	+	+	+	-	+	-	+	+
16	+	+	+	+	-	-	+	+	-
17	-	-	-	-	+	-	-	-	+
18	+	-	-	-	+	+	+	-	-
19	-	+	-	-	+	-	+	+	-
20	+	+	-	-	+	+	-	+	-
21	-	-	+	-	+	+	-	+	+
22	+	-	+	-	+	-	+	+	+
23	-	+	+	-	+	-	+	-	-
24	+	+	+	-	+	+	-	-	-
25	-	-	-	+	+	-	+	+	-
26	+	-	-	+	+	+	-	+	-
27	-	+	-	+	+	-	-	-	+
28	+	+	-	+	+	+	+	-	+
29	-	-	+	+	+	+	+	-	-
30	+	-	+	+	+	-	-	-	-
31	-	+	+	+	+	-	-	+	+
32	+	+	+	+	+	+	+	+	+
33 with Pb	0	0	0	0	0	0	0	0	0
34 without Pb	0	0	0	0	0	0	0	0	0

Where: (-) Means added quantity of related element equals to 50 mg / kg soil.

(+) Means added quantity of related element equals to 200 mg / kg soil.

Results were analysed according to Maximov and Alisenco (1980) in style 2^{4-9} that include (32) experiments with two controls ; the first control with Pb at 50 mg / kg soil, the second without Pb additives or other elements. Results were recorded weekly for five weeks. Lead was added in the form of lead nitrates , N : Ammonium nitrates, Ca : Calcium chloride, K : Potassium chloride, P: Sodium phosphates, Cu : Copper chloride, Zn : Zinc chloride, S : Ammonium sulfate , Fe : Ferric chloride, and Mg : Magnesium chloride.

3.RESULTS

3.1 . Effect of various Pb concentrations on seedling height of treated barely

Table (2) shows the differences in seedling heights of barely under four different concentrations of Pb. In the absence of Pb , seedlings of barely showed normal and vigorous growth. Height decreased slightly at 50 mg Pb / kg soil, but decrement in height of seedlings increased as Pb concentrations increased upto 200 mg Pb / kg soil .

Seedlings of the control (Pb free soil) were 2.5 folds taller than those grown in soil containing 200 mg Pb /kg soil at T_1. Deleterious effects of higher concentrations were more obvious at later growth periods and at higher Pb concentrations. Differences were statistically significant.

3.2. Effect of different mineral nutritive elements concentrations on Pb

Table (3) shows that adding some elements like (N) has increased seedling growth and reduced the harm effect of Pb, since mean length of barely was 112 % and 158 % comparing with controls (without Pb) and / or with 50 mg Pb / kg soil , respectively. Adding (S) increased seedting length 118 % and 166 % comparing with controls (without Pb) and with 50 mg Pb / kg soil, respectively.

Zn, Cu , and ca decreased mean length to 76 , 78 and 81 %, respectively comparing to Pb free control.

Table (2): Mean seedling height, (mm).

Period (week)	Mean (mm) ± SE for Pb concentration(mg/kg) of				
	0	50	100	150	200
T1	57 ± 4	52 ± 3	44 ± 4	37 ± 5	22 ± 4
T2	92 ± 4	88 ± 6	72 ± 6	68 ± 6	48 ± 3
T3	143 ± 6	129 ± 11	105 ± 8	84 ± 10	62 ± 8
T4	194 ± 8	166 ± 4	139 ± 7	113 ± 11	79 ± 9
T5	283 ± 13	201 ± 17	171 ± 8	132 ± 9	88 ± 8

Table (3): Seedling height, mm at different concentrations of added nutrition elements at T5.

Element concentrations	X= 0 Pb = 0	X= 50 Pb = 50	X= 100 Pb = 50	X= 150 Pb = 50	X= 200 Pb = 50
N	283 ± 13	211 ± 11	233 ± 8	280 ± 11	319 ± 10
P	283 ± 13	208 ± 7	218 ± 7	232 ± 10	271 ± 8
K	283 ± 13	214 ± 10	247 ± 9	288 ± 11	231 ± 7
Ca	283 ± 13	204 ± 8	213 ± 9	221 ± 12	288 ± 10
S	283 ± 13	223 ± 6	248 ± 8	289 ± 11	334± 11
Fe	283 ± 13	210 ± 6	221 ± 8	233 ± 10	265 ± 9
Cu	283 ± 13	206 ± 7	211 ± 8	215 ± 9	221± 8
Zn	283 ± 13	201 ± 13	207 ± 11	211 ± 10	216± 11
Mg	283 ± 13	209 ± 10	216 ± 12	230 ± 10	278 ± 12

3.3.Testing cross-effect of mineral nutritive elements with Pb on barely growth

Mean lengths of barely in multifactors experiment are shown in Table (4) .

Table (4): Mean plant length (mm).

Experiment No.	T1	T2	T3	T4	T5
1.	55	92	138	179	210
2.	48	121	186	259	361
3.	46	117	179	251	358
4.	42	131	198	289	394
5.	63	103	130	166	193
6.	41	86	133	168	210
7.	40	113	188	269	349
8.	43	108	172	243	318
9.	42	122	280	281	353
10.	44	117	199	268	328
11.	49	133	214	296	387
12.	33	104	176	288	306
13.	48	140	226	307	392
14.	41	83	141	199	241
15.	50	128	212	297	379
16.	43	120	208	284	359
17.	49	129	223	323	410
18.	41	120	217	318	408
19.	40	118	199	278	336
20.	48	131	222	314	398
21.	58	129	218	301	381
22.	51	143	236	329	422
23.	53	133	218	299	377
24.	43	121	210	301	384
25.	44	127	228	311	391
26.	41	1260	209	297	387
27.	50	135	222	311	401
28.	51	142	229	321	311
29.	43	128	218	310	393
30.	41	133	218	320	418
31.	50	118	179	246	323
32.	43	120	209	297	385
33.With Pb	52	88	129	166	201
34.Without Pb	57	92	194	194	283

Analyzing these data showed positive effects of various groups of elements which are :
Two – elements : (S, N), (S, P) , (Mg, S)
Three – elements : (S , K , N)
Four elements : (Mg , S , K , N) , (Fe , S , K , N) ,
Five - elements : (Mg , Fe , S , P , N)
By contrast, other groups have negative influences on barely's growth . These groups are as follours:
Two – elements : (Cu , Zn), three – elements : (Zn , Fe , Ca) , four elements : (Zn , Mg , Ca, P) and Five - elements : (Zn , Cu , Fe , Ca , P)

Table (5): Mean length of barely (mm) after adding nutritive elements in multi-factors experiment at T5.

Element	-	+
N	350	360
P	343	362
Ca	364	341
K	352	359
S	318	371
Fe	352	359
Mg	344	361
Zn	361	350
Cu	363	343

Data in Table (5) define mean lengths of barely by adding each element (-) (+) . using N,P,K,Mg, S at 5 folds to Pb which had enhanced total growth. Note,however, that Zn,Cu, Ca at the same folds and levels did not give any positive results.

4.DISCUSSION

Our data are unique in revealing the deleterious effects of pb and the methods to modify or reduce the harmful effects via single addition or group additions of nutritions. The main conclusions can be sunsmarized as follows: Increasing of Pb concentrations in the soil caused negative effects on barely growth. Integrated studies should be carried out on the toxic effects of heavy metals (especially Pb) on plants especially that which are included in food chains, then the pollutant concentrations should be determinned.

Deleterious effects of higher concentrations of Pb were more obvious at later growth periods

Addition of mineral elements in the soil can help in reducing the toxic effects of Pb, some elements (N,K,S) gave positive results , when others like (Fe, Zn, Cu) may add to the negative effects on barely.

Combined effects of some elements helped in reducing toxic effects of Pb such as : (N,S,K) , (K,N), (N,Ca) , (S,P,N) and (N,K,S,Mg). But, some elements such as : (Cu,Zn,Fe) have inversive action, and may increase the toxic effect of pb on seedling growth .

When soil is contaminated with Pb, adding of fertilizers that contain potassium, nitrogen, and sulfur will help in reducing lead toxic effect and plant growth improvement.

Planting of field crops should be taken at distances away from roads not less then 200 m, in order to stop transferring Pb from the plants and, then to human being, while road sides can be planted with trees that can help in reducing pollutants concentrations in air.

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دراسات على سمية الرصاص (Pb) على نمو نباتات الشعير ضمن تجربة العوامل المتعددة

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ملخص

ازدادت في الآونة الأخيرة الآثار السلبية والخطيرة للمعادن الثقيلة وخاصة الرصاص على النباتات والحيوانات والإنسان ، وقد جاء هذا البحث لدراسة أثر أربعة تركيزات من الرصاص (٥٠ - ١٠٠ - ١٥٠ - ٢٠٠ ملغ / كغ تربة) على نمو نباتات الشعير المنماة على مزارع رملية ، ثم تمت دراسة الأثر المتبادل بين الرصاص (بمعدل ٥٠ ملغ / كغ تربة) وكل من العناصر التالية :
(N ، P ، K ، Ca ، S ، Fe ، Cu ، Zn ، Mg) والمضافة كل على حدة وفق التراكيز التالية (٥٠ - ١٠٠ - ١٥٠ - ٢٠٠ ملغ / كغ تربة) كما تمت دراسة التأثير المشترك لهذه العناصر مع الرصاص في تجربة العوامل المتعددة والتي تعتمد على إضافة هذه العناصر وفق نسب محددة تعادل ١ : ١ و ١ : ٥ بالمقارنة مع الرصاص وذلك وفق جدول خاص بها .

أظهرت النتائج أنه بزيادة تراكيز الرصاص يزداد التأثير السلبي على نمو النباتات ويصل إلى ذروته عندما تصل تركيز الرصاص إلى ٢٠٠ ملغ / كغ تربة ، كما أن الأثر السلبي للرصاص يزداد مع مرور الزمن .

إن إضافة بعض العناصر السمادية مثل (N ، S) إلى التربة قد ساهم في الحد من الأثر الضار للرصاص ، بينما أدت إضافة بعض العناصر السمادية الأخرى مثل (Ca, Cu , Zn) إلى زيادة التأثير السلبي . وفي تجربة العوامل المتعددة بينت النتائج وجود تأثير إيجابي لمجموعات مختلفة من العناصر السمادية ، فمثلا : - ثنائية (S و N) (S و P) (Mg و S) - ثلاثية (N و K و S) - رباعية (N و K و S و Mg) (N و K و S و Fe) (N و S و Fe و Mg) - خماسية (N و S و P و Fe و Mg) ، بينما أثرت مجموعات سماديةأخرى سلباً على نمو النباتات مثل : - ثنائية (Cu و Zn) - ثلاثية (Zn, Fe , K) - رباعية (Zn , Mg , K , P) - خماسية (Cu , Fe , Ca , K , P) .

وقد أظهرت النتائج أهمية اضافة الكبريت او البوتاسيوم او النتروجين بصورة فردية او في مجاميع لتخفيف الأثر السام للرصاص وتحسين نمو النباتات في وجود آثار من الرصاص.
