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EFFECT OF DIFFERENT LEVELS OF PHOSPHORUS FERTILIZER ON11 HEAVY METALS CONCENTRATION IN DIFFERENT PARTS OF WHEAT PLANT

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ABSTRACT

A biological experiment was conducted at 20/1/2011 to 2/6/2011 in pots in the experimental farm of college of Agriculture, 3.5 km south of Arbil governorate, 36˚ 07N, 44˚01E, 0411359, 03997002 UTM. 411m above the sea level, during growing season 2011-2012 in order to determine the effect of different levels of phosphorus (0,10,20,30,and 40 mgkg^{-1} on heavy metals concentrations and uptake for different parts roots, shoots and grains of wheat plant *Triticum durum* L. cv.Summit. Soil samples were collected under the polluted location in the landfills were located between Bnaslawa district and Daratoo county, triple super phosphate fertilizer applied to soils to know the effect of phosphorus absorption and distribution of heavy metals in the different parts of wheat plant by using factorial Complete Randomize Design (CRD) with four replicates. The present investigation started at 24/1/2011 and plants were harvested at 2/6/2011. The increase of applied P caused a significant increase ($p \leq 0.05$) of the dry matter weight of different parts of plant (roots, shoots and grains) and a significant decrease of heavy metal concentration. A negative correlation coefficient between P and Fe, Ni, Cd and Pb concentrations in roots were (0.98, 0.94, 0.95 and 0.99 and in shoots part 0.69, 0.93, 0.89, and 0.99 and in grains part 0.89, 0.90, 0.97, and 0.96) respectively.

Key words: Phosphorus, heavy metals, uptake.

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INTRODUCTION

The application of different P amendments causes heavy metals in soils to shift from forms with high availability to the most strongly bound metals fractions (Miretzky and Fernandez-Cirelli, 2010). Heavy metals that can accumulate to high levels in specific crops. Heavy metals have been linked to negative health effects, so it is desirable to reduce the heavy metal concentrations of crops entering the human diet. Heavy metals concentration in crops is influenced by a wide range of factors, including crop genetics, soil characteristics such as texture, pH and salinity, weather, crop sequence, crop management practices and soil heavy metal concentration(Grant *et al.* 1999).Heavy metals are present at varying concentrations as a contaminant in phosphate (P) fertilizers (Taylor 1997;Grant *et al.* 2002; Grant and Sheppard 2008) and repeated applications of P fertilizers may decrease heavy metals content of soils, potentially increasing trace metals content of crops across a range of soils and environments. Heavy metal reaches the soil environment through pedogenic, related to the origin and nature of the parent material, and anthropogenic processes. Anthropogenic activities primarily associated with industrial processes, manufacturing and the disposal of domestic and industrial waste materials are the

Cited from PhD thesis of first researcher.

major source of lead contamination of soils (Adriano, 2001). The normal ranges of heavy metals (Fe, Ni, Cd, and Pb in soil were 500-5000, 5-500, 0.01-2 and 2-300 $mgkg^{-1}$) and in plant were (1.1-160, 0.1-5, 0.05-0.2 and 5-10 $mgkg^{-1}$) respectively according to (Kabata-Pendias and Pendias, 2001). This study was conducted to determine the long-term influence of Phosphorus applied (triple super phosphate) on heavy metals (Fe, Ni, Cd and Pb) concentration of different parts of durum wheat (roots, shoots and grains).

MATERIALS AND METHODS

Soils were collected from landfills located between Bnaslawa district and Daratoo County; the GPS reading of the studied locations were recorded. The soils were taken from the soil surface (0-30) cm depth Table (1).

Table (1). Some selected chemical and physical properties of the studied soils.

pH	EC	M*	O.M	T.$CaCO_3$	Fe	Ni	Cd	Pb	Particle Size Distribution gkg^{-1}			
	dSm^{-1}	%	$g.kg^{-1}$		$mg.kg^{-1}$				Sand	Silt	Clay	Textural Name
7.3	2.3	2.9	2.6	24.68	681.36	29.74	0.715	158	288.0	393.4	318.6	Clay Loam

* (M %) Moisture percentage, (O.M) Organic matter.

The biological experiment included packing the pots each pot (22cm height, 22cm top diameter and 16cm bottom diameter) packed with same weight (6kg) of dry soil after passing through (4) mm sieve. On 24/1/2011.Thirteen seeds of wheat *Tritium durum* L. cv. Summit were planted in each pot at (5) cm depth, then thinned to (8) seedling / pot after two weeks of germination. The pot experiment included five levels of phosphorus (0, 10, 20, 30 and 40 mg P kg soil) using (Triple Super Phosphate % 46 P) which equivalent to (0.00, 21.73, 43.47, 67.39 and 86.95 mg TSP kg^{-1} soil) by applying factorial CRD with four replicates, a fixed amount of nitrogen (22.5 mg N kg^{-1} soil) equivalent to 90 kg N ha^{-1} was added to all the pots. The supplemental irrigation was done by depending on weighing method whenever needed. The plants were harvested on 2/6/2011. Plant roots, shoots and grains were separated , then root of plants were washed with distilled water to clean the soils from the samples and then oven dried at 65 ºC for 48 hours. After weighting and grinding with stainless steel mill, the samples were stored for further analysis (Mekeague, 1978).The phosphorus was determined by using ammonium molybdate with $SnCl_2$ according to Allen *et al*., (1974). 0.3g of powdered dried samples (roots, shoots and grains) digested separately by mixed acid digestion (5 ml of HNO_3, 1ml of 60% $HClO_4$ and 1ml of H_2SO_4), they were swirled gently and digested slowly by gradual temperature increase, after appearance of white fumes, the colorless digested samples were diluted and filtered through filter paper (No.42) and completed to 50 ml; the blank was carried out in the same way but without sample, the heavy metal concentrations of Fe, Ni, Cd and Pb were determined by using Atomic Absorption Spectrophotometer (AAS) Alpha-4-according to (Hseu *et al.*, 2002), after preparation of appropriate calibration standards. All the samples were digested and analyzed in replicate. The statistical analysis was carried out using Statistical Analysis System (SAS Version 9.1).Data analysis were made using one-way analysis of variance (ANOVA).The comparison among groups was done using LSD test ($p \leq 0.05$) was considered as statistical significant (Anonymous, 2005).

RESULTS AND DISCUSSION

1 - Phosphorus and Wheat growth parameters:-Growth parameters (root dry weight and shoot dry matter) and grain yield Tables (2, 3 and 4). Were influenced by soil P fertilization rate .Soil P application had a significant increase on both root and shoot dry matter production and on yield of wheat plants. This increase is attributed to sufficient P supply where an essential nutrient for plant growth due to its role in plant biological processes such as the formation and division of living cells in the transfer of genetic materials, energy storage and transfer like ADP and ATP, photosynthesis respiration, protein and nucleic acid synthesis, and ion transport across cell membranes (Havlin *et al*., 2007 and Fageria, 2009). Further more, the increase in dry matter weight may due to the role of p in chlorophyll formations, physiological processes and nutrient balance in plants .These results agree with those reported by (Hassan *et al*.1975; Russel, 2001; and Stewart *et al*. 2003).

2- Phosphorus and heavy metals uptake and Interaction: the P treatment used in this study affected growth of wheat plants Tables (2, 3 and 4) whenever growth accumulation of dry matter or grain yield is altered the concentration and the uptake of plant nutrients is affected (Mengel and Kirkby, 2001).As expected, P supply increased P concentration and content in roots, shoots, and grains of wheat plants. Root - P concentrations were 11.89, 4.60, 5.40 and 1.89 % higher (Table 2), shoot-P concentrations were 8.85, 6.25, 2.86 and 0.00 % higher (Table 3), and grain–P concentration were 22.59, 3.76, 1.25 and 0.41 % higher (Table 4) in the $P_{40,\ 30,\ 20,\ 10}$ treatments respectively compared to $P_{0.0}$ treatments with P contents in roots, shoots and grains. The same patterns were found when the contents increased with increasing the amount of P applied Tables (2, 3 and 4). The concentration and content of P in roots, shoots and grains of wheat plants seemed to reflect total supply of phosphorus more than any other factor. Similar results were stated by (Zhu *et al*., 2002) who found that with high P availability in soil solution barley plant biomass increased and concentrations of P were high.

Table (2): Effect of different levels of phosphorus on heavy metals concentration ($mg.kg^{-1}$) in root parts and the heavy metals uptake ($\mu g.\ pot^{-1}$) by Wheat plant.

Part of plant	mg P kg^{-1} soil	Fe	Ni	Cd	Pb	P	Dry Matter Weight	Fe	Ni	Cd	Pb	P
		Conc. (mg.kg^{-1})				%	g.pot^{-1}	Uptake (µg. pot $^{-1}$)				
Root	0	75.00	0.180	0.020	3.31	0.326	5.96	447.00	1.073	0.119	19.727	1.943
	10	74.70	0.179	0.016	2.94	0.353	6.40	478.08	1.145	0.102	18.816	2.259
	20	74.00	0.168	0.007	2.23	0.350	7.10	525.40	1.193	0.049	15.833	2.485
	30	69.83	0.162	0.006	1.47	0.363	7.30	509.76	1.182	0.044	10.73	2.650
	40	66.62	0.159	0.003	0.82	0.370	7.32	487.66	1.163	0.022	6.002	2.708
	$LSD_{.05}$	*10.18*	*0.005*	*0.0239*	*0.305*	*0.010*	*1.005*	*78.79*	*0.172*	*0.0154*	*3.404*	0.335

3- Phosphorus supply generally decreased, Fe, Ni, Cd and Pb concentrations and contents in roots, shoots and grain of wheat plant. Phosphorus supply significantly decreased Fe concentration. Root Fe concentrations were 0.4, 1.33, 6.89 and 11.17%

lower Table (2), shoot Fe only 30, 40 mg P kg^{-1} caused decrease of Fe concentration, while the application of 10 and 20 mg P kg^{-1} caused increase in Fe concentration, this may be due to higher concentration of Fe in root increase application of 10 and 20 mg P kg^{-1} were 0.72 and 3.72% lower Table (3), and grain Fe concentrations were 0.98, 5.90, 5.95 and 6.62 % lower Table (4) in the $P_{10,20,30,40}$ treatments as compared to $P_{0.0}$ treatments. Our results showed that P interfered with Fe uptake and translocation (clearly when P concentration supply was high). The possible mechanism for this antagonism could be the reaction between P and Fe in soil and Fe precipitation as insoluble iron phosphate occurred. Iron – phosphate interactions commonly occur in both plant metabolism and soil media. The affinity between Fe and phosphorus ions is known to be great, and therefore the precipitation of $FePO_4.2H_2O$ can easily occur under favorable conditions (Kabata-Pendias and Pendias, 2001).

The application of P reduced the Ni concentration in roots, shoots and grains of wheat plants Tables (2, 3and 4). The concentrations of these heavy metals were higher at 0.0 level of P and decreased gradually with increasing the amount of P applied to the soil. Root Ni concentrations were 0.56, 6.67,10.00 and 11.67% lower, shoot Ni concentration were 11.53,19.23,19.23 and 30.77 % lower and grain Ni concentrations were 0.0, 0.28, 0.56 and 50.56% lower in the $P_{10,\ 20,\ 30,40}$ treatments compared to $P_{0.0}$ treatments. This may be due to the soil treatments such as addition of lime, phosphorus, organic matter, is known to decrease Ni availability to plants (Chaney *et al.*, 1984). The concentration of Cd in root, shoot and grain was higher at zero (0) level of P applied to soil and the magnitude of reduction in Cd concentration with the application of P to soil in roots, shoots and grains of wheat plants were 20.0, 65.0, 70.0 and 85.0% (in roots) 80.0, 84.0, 89.0 and 90.0 % (in shoots) and 75.0, 50.0, 75.0 and 75.0% (in grains) in the $P_{10,20,30,40}$ treatments as compared to $P_{0.0}$ treatments. The phosphate may be limited solubility as well. Therefore, mobility and bioavailability of Cd in neutral to alkaline soils is low (McBride, 1994).

Table (3): Effect of different levels of phosphorus on heavy metals concentration ($mg.kg^{-1}$) in shoot parts and the heavy metals uptake (µg. pot^{-1}) by Wheat plant.

Part of plant	mg P kg^{-1}soil	Fe	Ni	Cd	Pb	P	Dry Matter Weight	Fe	Ni	Cd	Pb	P
		Conc. ($mgkg^{-1}$)					$g.pot^{-1}$	Uptake (µg. pot^{-1})				
Shoot	0	31.70	0.130	0.010	0.183	0.350	15.60	494.52	2.028	0.156	2.85	5.46
	10	39.45	0.115	0.002	0.148	0.360	16.04	632.77	1.845	0.032	2.37	5.77
	20	41.00	0.105	0.0016	0.152	0.373	16.50	676.50	1.732	0.027	2.50	6.15
	30	31.47	0.105	0.0011	0.116	0.389	16.98	534.36	1.782	0.019	1.97	6.60
	40	30.52	0.090	0.0010	0.115	0.384	18.00	549.36	1.620	0.018	2.07	6.91
	$LSD_{.05}$	*3.046*	*0.011*	*0.102*	*0.022*	*0.007*	*1.708*	*78.33*	*0.231*	*0.138*	*0.433*	0.691

Table (4): Effect of different levels of phosphorus on heavy metals concentration (mg.kg^{-1}) in grain and the heavy metals uptake (µg.pot $^{-1}$) by Wheat plant.

Part of plant	mg P kg^{-1} soil	Fe	Ni	Cd	Pb	P	Dry Matter Weight	Fe	Ni	Cd	Pb	P
		Conc. (mgkg^{-1})					g.pot^{-1}	Uptake (µg. pot $^{-1}$)				
Grain	0	42.00	0.356	0.004	2.74	0.37	2.15	90.30	0.765	0.0086	5.891	0.79
	10	41.59	0.383	0.001	2.55	0.46	2.29	95.24	0.877	0.0023	5.839	1.03
	20	39.52	0.355	0.002	1.12	0.47	2.51	99.19	0.891	0.0050	2.811	1.15
	30	39.50	0.354	0.001	0.94	0.47	2.91	115.00	1.030	0.0043	2.735	1.36
	40	39.22	0.176	0.001	0.55	0.47	3.00	117.66	0.528	0.0029	1.650	1.41
	LSD.05	*4.239*	*0.038*	*0.011*	*0.36*	*0.055*	*0.852*	*34.72*	*0.296*	*0.024*	*1.53*	0.435

The application of P significantly reduced the concentration of Pb in the roots, shoots and grains of wheat plant. The Pb percent concentrations in the root decrease were 11.18, 32.63, 55.59 and 75.23% in the $P_{10, 20, 30, 40}$ treatments as compared to P_0 treatments respectively (Table 2).

For shoot Pb concentration the magnitude of reduction with an increase of P supply were 19.13, 16.93, 36.61 and 37.16% in the $P_{10, 20, 30, 40}$ treatments as compared to P_0 treatment (Table 3).

Grain Pb concentration percent decreases were 6.93, 59.12, 65.69 and 79.92% in the $P_{10,20, 30,40}$ treatments as compared to P_0 treatments respectively (Table 4).Lead accumulated mainly in the root, and only small fraction of this Pb was transported to the shoots of wheat plant .Similar results were found by (Kabata - Pendias and Pendias, 1995)

تأثير مستويات مختلفة من السماد الفوسفاتي على تركيز العنا صر الثقيلة في الأجزاء المختلفة لنبات الحنطة

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الخلاصة

اجريت التجربة البايولوجية في 2011/1/20 الى 2011/6/2 في السنادين في حقل التابعة لكلية الزراعة الذي تقع 3.5 كم جنوب محافظه اربيل، 36° 07 N, 44° 01E, 0411359, 03997002 UTM وارتفاعه عن مستوى سطح البحر 411 م ومن خلال موسم النمو(2011-2012) وذلك لتحديد تاثير السماد (سوبر فوسفات الثلاثي) وبمستويات مختلفه من الفسفور P (0 ,40,30,20,10) غم كغم$^{-1}$) على العناصر الثقيلة لمختلف أجزاء النبات كالجذور والسيقان والبذور، جمعت نماذج التربة تحت المناطق الملوثة لموقع رمي الفضلات الواقعة بين قضاء بنصلاوه و ناحية داره تووالتابعة لمحافظة أربيل، و بإستخدام التصميم العشوائي الكامل وبأربع مكررات، ولوحظ بأن زيادة إضافة الفسفور أدى الى زيادة معنوية ($p \leq 0.05$)

للماده الجافة للأجزاء المختلفة للنبات (الجذور، السيقان والبذور) وأدى أيضا الى إنخفاض معنوي لتراكيز العناصر الثقيلة، ومعامل الأرتباط السلبية بين تركيزالفسفورالمضاف وتركيز العناصر الثقيلة كالحديد ،النيكل،الكادميوم والرصاص في الجذور(0.98، 0.94، 0.95 و0.99) وفي السيقان (0.69 ،0.93، 0.89 و 0.99) وفي البذور(0.89 ،0.90، 0.97 و 0.96) على التوالي.
كلمات داله :الفسفور، العناصر الثقيلة،الكمية الممتصة.

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