The Effect of Phosphorus Fertilizers on Faba Bean Plant Growth in Soils were Polluted by Heavy Metals

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Abstract: The biological experiment was conducted from 25/11/2015 to 11/5/2016 in the experimental farm of the Agriculture College, University of Salahaddin at the Grdarasha field 3.5 km, south of Arbil governorate, 36˚ 07 N, 44˚ 01E, 0411359, 03997002 UTM. 411m above the sea level, during growing season 2015-2016 in order to determine the effect of triple super phosphate in different levels of phosphorus (0, 20, 40,60 and 80 mg kg^{-1}) on heavy metals concentration in plant and uptakes of faba bean plant (*Vicia faba*). Soil samples were collected under the polluted location in the landfills which were located between Bnaslawa district and Daratoo county, using factorial complete randomize design with three replicates. The increase of applied P caused a significant increase ($p \leq 0.05$) of the dry matter weight of plant and caused a significant decrease of heavy metal concentration. A negative correlation coefficient between P and Fe, Zn and Pb concentrations in pods of field bean were (- 0.93, - 0.97 and - 0.92) respectively.

Keywords: Phosphorus, Heavy Metals, Faba Bean

1. Introduction

Faba bean is one of the legume family plants that collect a high amount of heavy metals like (Fe, Pb and Zn). Many health problems of human beings such as kidney, brain can be caused by heavy metals through nutrition. Some soil chemical and physical properties; Hydrogen potential, electrical conductivity, moisture and temperature in addition to the concentration of heavy metal in soil layers, as well as genetic and managing activities can affect the heavy metals level in plants (Grant et al., 1999). Heavy metals considered as a source of pollutants in chemical fertilizers such as phosphorus fertilizer, with repeating fertilizing processes the heavy metal quantity increase in plant (Tylor, 1997; Grant et al., 2002; Grant & Sheppared, 2008).

The aim of this research paper is to present the effect of phosphorus fertilizer on heavy metals (Fe, Pb and Zn) concentration of field bean across a range of soils and environments. Increasing of phosphorus fertilizers to the earth surface layer caused reducing heavy metals availability (Miretzky & Fernandez-Cirelli, 2010).

There are two sources of heavy metals presence in the soil, natural source and human activities products. Municipal solid waste and liquid wastes which products through human activities in agriculture and industrial sectors, these products considered as well as particulate source of environmental pollution (Adriano, 2001).

2. Materials and Methods

Soils were collected from landfills which were located between Bnaslawa district and Daratoo County. The soils were taken from the soil surface (0 -30) cm depth (Table 1). The pot experiment included the following steps. Packing the pots each pot (22cm height, 22cm top diameter and 16cm bottom diameter) packed with same weight (6 kg) of dry soil after passing through (4) mm sieve. On 25/11/ 2015, three (3) seeds of faba bean *(Vicia faba)* were planted in each pot, then reduced to (2) seeds per pot after two weeks of germination.

Table 1: Physico-chemical characteristics of the selected soils

pH	EC	M	O.M	T.CaCO$_3$	Fe	Pb	Zn	Particle Size Distribution mg g^{-1}			
	dSm^{-1}	%	mg g^{-1}		µg kg^{-1}			Sand	Silt	Clay	Textural Name
7.6	2.23	2.9	33	23.8	541.36	108	140	219	447	334	Clay Loam

EC: Electrical conductivity**, M:** Moisture, **O.M**: Organic Matter

The pot experiment included five levels of phosphorus (0, 20, 40, 60 and 80 mg P / kg soil) using (Triple Super Phosphate % 46 P) which equivalent to (0.00, 43.47, 86.95, 130.43 and 173.91 mg TSP kg $^{-1}$ soil) using factorial CRD with three replicates, a fixed amount of nitrogen (30 mg N kg^{-1} soil) which equal to 90 kg N ha^{-1} was added for all pots. Irrigation was depending on rain-falls and supplemental irrigation depending on weighing method whenever needed. The plants were harvested on 10/5/2015. The pods 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, 1974).

0.3g of powdered dried samples (pods) 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 atomic absorption spectrophotometer (AAS) was used to figure heavy metal concentration according to (Allen, 1974). The statistical analysis was carried out using Statistical Analysis System (SAS Version 9.1). The comparison among groups was done by depending Duncan test ($p < 0.05$) was considered as a result of the statistical significant (SAS, 2005).

3. Results and Discussion

3.1 Phosphorus and Faba Bean Growth Parameter (Dry matter weight)

Growth parameters pod dry matter (Table 2) was influenced by soil P fertilization rate. Soil P application had significant influence on dry matter production of field bean. This increase is attributed to sufficient P supply which 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; Fageria, 2009). Furthermore the increase weight of dry matter might be because of the role of P in chlorophyll formations, physiological processes and nutrient balance in plants. The results agree with those reported by (Hassan et al., 1975; Russel, 2001; Stewart et al., 2003).

Table 2: Relationship between different Levels of Phosphorus and Heavy Metals Concentration (µg g^{-1}) and up take (µg pot^{-1}) of field bean Pods

Phosphorus concentration µg g^{-1}	Fe	Pb	Zn	Dry matter weight (g)	Fe	Pb	Zn
	Conc. µg g^{-1}				Up take µg pot^{-1}		
0	400 a	3.90 a	70 a	15.67	6267	61.11	1096.9
20	386 a	2.86 a	67 a	18.71	7222	53.51	1257.0
40	245 b	2.41 b	68 a	15.42	3778	37.16	1048.6
60	189 c	1.39 b	56 b	18.90	3572	26.27	1058.4
80	190 c	1.17 c	48 b	24.20	4598	28.31	1161.6
Normal ranges (Alloway,1990)	50-300	5-10	20-60				

3.2 Phosphorus and heavy metals uptake and its Interactions

The P treatment used in this study affected growth of bean plants (Table 2) whenever growth accumulation of dry matter or grain yield is altered the concentration and uptake of plant nutrients is affected (Mengle & Kirkby, 2001). In general the results declared that application of the higher concentration of phosphorus caused a decrease in the heavy metals concentration in the wheat plant parts, these results agree with Haldar and Mandal (1981) Which reported that the addition of P caused a decrease in concentration of Fe and with (Al-Athami, 1981) which clarified that the addition of P [KH_2PO_4] and [CaH_2PO_4] to soil causes a significant decrease in iron availability. This decrease may be due to the competition effect of phosphorus anions with the heavy metals, subsequently phosphorus intervenes with uptake and with their inner transport. A good P administration is known to diminish the impacts of Pb harmfulness. This impedance is because of the capacity of phosphorus to frame insoluble Pb in plant tissues, and in soils. The data of Pb substance of plants is recorded as to both date of gathering and area of the Examples. The immense variety of Pb substance of plants is impacted by a few natural elements, for example, the nearness of geochemical inconsistencies, contamination, regular variety, and genotype capacity to gather Pb (Kabata & Pendias, 2001).

3.3 Phosphorus supply generally decreased, Fe, Pb and Zn concentrations in pods of bean plant

As shown Table (2) and Figure (1) the application of phosphorus caused a significant decrease ($P \leq 0.05$) of heavy metal concentration in pods of bean plant. Phosphorus supply decrease Fe concentrations were 3.50, 38.75, 52.75 and 52.50 % lower in $P_{, 20,40,60,80}$ treatments as compared to $P_{0.0}$ treatments. There 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.

Iron-phosphate connections ordinarily happen in both plant digestion and soil media. The partiality amongst Fe and Phosphorus particles is known to be incredible, and consequently, the precipitation of $FePO_4.2H_2O$ can undoubtedly happen under ideal conditions (Kabata & Pendias, 2001).

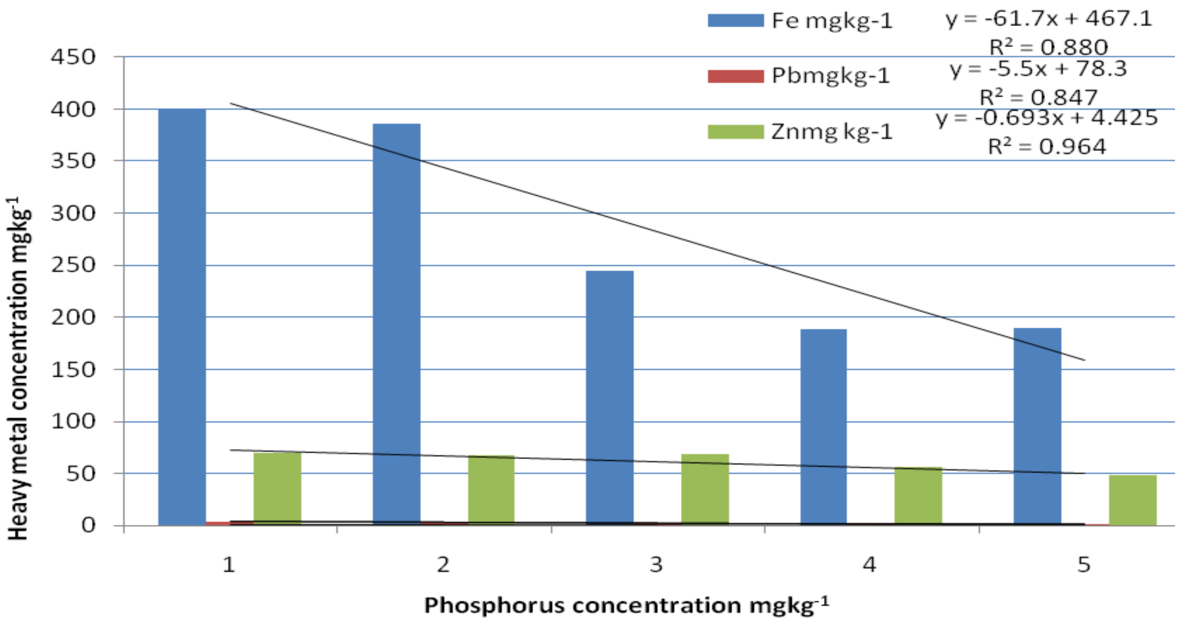

Figure 1: Relationship between Phosphorus concentration and heavy metals concentration in faba bean in mg kg^{-1}

The highest value of Fe in pod (400 mg kg^{-1}) was recorded from treatment ($P_{0.0}$) while the lowest value (189 mg kg^{-1}) was obtained from treatment (P_{60}) this may be due to in adequate amount of available P in the studied soils, therefore the application of phosphorus to a certain level caused decrease in Iron uptake, this result agrees with those recorded by (Abu-Thahi & Al-Yonis, 1988), or may be due to the application of high amount of phosphorus may cause nutrient imbalance then decrease in iron concentration (Edmeades, 2003).

The statistical analysis indicated to significant coefficient of determination ($R^2 = 0.88$) between Fe concentration and levels of P application at some studied soils. The application of P significantly reduced the concentration of Pb in pods of bean plants. Pods Pb concentration percent decreases were 26.66, 38.20, 64.35 and 64.70 % in the $P_{20, 40, 60, 80}$ treatments as compared to $P_{0.0}$ treatments respectively (Table 2). Lead accumulated and only small fraction of this Pb was transported to the bean plant. Similar results were found by (Kabata & Pendias, 2001**).**

The highest and lowest values of Pb in pods (3.90 to 1.17 mg kg^{-1}) were recorded from control treatments ($P_{0.0}$) and treatment (P_{80}). In spite of the fact Pb binges naturally in all plant parts, Pb not been display to any essential functions in their metabolism 2- 6 ppb of Pb should be sufficient for plants (Tylor, 1997). In the different ecosystem the stability of Pb shows that the input of this metal greatly exceeds its output (Kabata & Pendias, 2001).

The concentration of Zn in pod was higher at 0.0 level of P applied to soil and the magnitude of reduction in Cd concentration with the application of P to soil in pod of bean plants 4.28, 2.85, 20.0 and 31.42 % (in pods) in the $P_{20,40,60,80}$ treatments as compared to$P_{0.0}$ treatments. The phosphate may be limit solubility as well. Therefore, movability and bioavailability of Zn is low in neutral to alkaline soils (Yap et al., 2010).

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