Plant Archives Vol. 19 No. 1, 2019 pp. 1208-1212 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF SULFUR AND PHOSPHATE FERTILIZERS APPLICATION ON THE TOTAL PHOSPHORUS AMOUNT IN RHIZOSPHERE OF *ZEA MAYS* L.

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Abstract

A fieldtrial was conducted in the department of soil sciences and water resources, college of agriculture, university of Al-Qadisiyah, during the agricultural season of 2017-2018 according to the design Complete Randomized Design (C.R.D). Four levels of phosphate fertilizer P0, P1, P2, P3 (0, 30, 60 and 90) kg P. h^{1-} and one level of sulfuric fertilizer (agricultural and wettable) 200 kg $S.h^{1-}$ were used. The corn seeds of DKC 6120 cultivar were planted in pots. Total phosphorus in the soil was estimated during plant growth periods (40, 70, and 100) days of the planting date to study the effect of its application levels, sulfuric fertilizer application (agricultural and wettable) fertilizers and their overlap on the amount of availability of total phosphorus into the corn rhizosphere.This experimentcomes up with that the highest amount of the total phosphorus is achieved with the third phosphate level P3 (143 and 158) µg. g^{1-} in the rhizosphere area and out of it for after 40 days of the planting date, respectively. The results also showed that the overlap between wettable sulfur (S) and P3 gave the highest total phosphorus value (138 and 131) µg. g^{1-} for the rhizosphere soil and (146 and 142) µg. g^{1-} for soil outside the rhizosphere for 70 and 100 days of the growing date. The application of sulfuric fertilizer (agricultural and wettable) to the levels of (SaP0 and SP0) reduced the total phosphorus in the soil over time during the periods of 40, 70 and 100 days of cultivation.

Key words: Total Phosphorous, Rhizosphere, *Zea mays*, fertilization, sulfur fertilizer.

Introduction

Zea mays L. is an important cereal crop and ranks the third after wheat and rice in the production of global food grains for human and animal consumption. It is not only a source of food and feed but also a source of a number of sub-products such as glucose, starch, oil, and others. Corn is also one of the most important grain crops in Iraq, which is cultivated in vast areas, Alfalahi, etc (2015). The world-cultivated area is about 24 million hectares with an average yield of 3.94 kg. h^{1-}, Rao, *et al.*, (2014). Phosphorus is one of the 17 essential nutrients for plant growth. It is classified as major nutrients required by crops in relatively large quantities, Thakur and Putatunda (2017). Phosphorus is extracted globally from geological deposits and most of the phosphorus extracted is applied to agricultural soils to meet the urgent need for plant crops. However, the phosphorus recovery of plants is very low, while a large amount of phosphorus that applied to the soil fixed on soil components, which leads to the need to continuously phosphate fertilizers application. Many microorganisms of bacteria and fungi can dissolve organic and inorganic phosphorus in the soil and the environment of the roots through the production of organic acids, Adhya, *et al.* (2015). The phosphorus availability in many soil types is usually about 1 micromole. L^{1-}, but for optimal productivity, the plant requirements for phosphorus are 30 micromoles. L^{1-}. The availability of phosphorus in soils is a major factor limiting the productivity of plants (Simpson *et al.*, 2011). Phosphorus availability to the plant's uptake reduced when used in alkaline and calcareous soils due to the formation of insoluble calcium phosphate minerals. Phosphorus can be stored in the root or transported to the upper parts of the plant, Tripti (2015). The use of sulfur fertilizer increases nutrient availability to plants through the release of nutrients such as phosphorus, copper, iron and others, Panahi *et al.*, (2016). The aim of this experiment is to study the effect of sulfur sorts on the total phosphorus in

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the yellow corn rhizosphere at different growth periods (40, 70, 100) days of planting.

Materials and methods

This study was conducted in the canopy in the Faculty of the Agriculture, University of Al-Qadisiyah on the agricultural season of 2017-2018 using sized 20 kg plastic pots. The soil was dried, tested and passed through a 4 mm diameter sieve. Potassium sulfate fertilizer (K_2O 50%) was applied at the level of 100 Kg $K_2O.h^{1-}$ for all experimental units, while urea fertilizer (N% 46) was applied at 250 Kg $N.h^{1-}$ couple times after 15 days of the planting and the other 30 days of the first application. The experiment was designed according to the Complete Random Design (C.R.D). Twelve experimental treatments were used, including the comparison treatment with 4 replicates. Soil samples were taken before planting. They dried, tested and sifted with a 2 mm sieve. Physical and chemical properties were estimated according to the methods of Jackson (1958), Black (1965) and others (1982). Soil samples were also taken for each experimental unit of the rhizosphere area and outside it during the periods 40, 70 and 100 days of planting to estimate total phosphorus in the soil using the spectrophotometer according to the method presented in Page (1982).

Statistical Analysis System (SAS) (2012) to analyze the data according to the complete random design (CRD) to study the effect of the factor (P) and its levels and the interaction with the factor (Sa) and the factor (S) were used. The differences between the averages were compared with the less difference test (LSD) and at a significant level (0.05).

Table 1: Physical and chemical proprieties of the soil before planting.

	Prosperities		Value	Unit
1.	Soil reaction degree pH 7.6		-	
2.	Electrical conductivity EC (1:1)		3.27	(ds/m)
3.	Cation exchange capacity CEC		22.35	Cmol. Charge. Kg^{1-}soil
4.	Carbonate minerals $CaCO_3$		276	$g.kg^{1-}$
5.	Organic matter O.M		13.6	
6.	Organic Carbon		7.82	
7.	Total phosphorus		95	$mg.kg^{1-}$
8.	Available phosphorus		11.7	
9.	Dissolved phosphorus		30	
10.	Total nitrogen		385	
11.	Available nitrogen	$N\text{-}NH_4^+$	23.5	
12.	in the 2 faces	$N\text{-}NO_3^-$	26.4	
13.	Total potassium		1354	
14.	Available potassium		178	
15.	Available sulfates		325	
16.	Positive dissolved	Ca^{2+}	23	Cmol. Charge. L^{1-}
17.	ions	Mg^{2+}	10	
18.		Na^+	42	
19.		K^+	2	
20.	Negative dissolved	Cl^-	43	
21.	ions	SO_4^{2-}	20	
22.		CO_3^{2-}	Nill	
23.		HCO_3^-	19	
24.	Bulk Density		1.38	Megagram. M^{3-}
25.	Soil separators	Sand	196	$g.kg^{1-}$
26.		Loam	424	
27.		clay	380	
28.	Soil texture	SiCL		

Results and Discussion

The results in table 2 indicate the effect of phosphate fertilizers application at different levels on the total amount of phosphorus in the soil. It is an application made a significant increase in total phosphorus in and out of the rhizosphere soil after 40 days of planting. The highest level of phosphorus fertilizer (P3) made a total phosphorus of (143 and 158) $\mu g.g^{1-}$ in rhizosphere soil and beyond it with an increase in rates by (55.43 and 54.90%) as compared to the control, which had the lowest level of phosphorus (92 and 102) $\mu g.g^{1-}$ in rhizosphere soil and outside it, respectively. Sulfur fertilizer application without interfering with phosphorus levels led to a decrease in the total amount of phosphorus in the soil compared to the control in the soil of the rhizosphere and beyond. This reduction can be attributed to the increase in releasing the dissolved and precipitated phosphorus as a result of the further dissolving the carbonate minerals and thus increasing their absorption.

Table 3 shows the effect of phosphate and sulfuric (agricultural and wettable) fertilizers application and the overlap between the total phosphorus in rhizosphere and soil outside it on the after 70 days of planting. Total phosphorus amount increases significantly as phosphate fertilizer application increases in the soil of the rhizosphere and beyond. The highest phosphate fertilizer level and overlapping with wettable sulfur fertilizer (SP3) made the

Table 2: Total phosphorous concentration (µg.g^{1-}) after 40 days of the planting date.

Treatments		Sampling location	
Fertilization	Treatments	Rhizosphere	Outside of rhizosphere
Phosphorous fertilization	Cont.	92	102
	P1	112	120
	P2	138	150
	P3	143	158
	average	**121.25**	**132.50**
Phosphorous fertilization with agricultural sulfur	SaP0	87	96
	SaP1	110	116
	SaP2	140	148
	SaP3	141	150
	average	**119.50**	**127.50**
Phosphorous fertilization with wettable sulfur	SP0	89	93
	SP1	113	119
	SP2	137	146
	SP3	144	153
	average	**120.75**	**127.75**
LSD 0.05		22.83*	

Cont= Control treatment, P = phosphorus level, Sa = agricultural sulfur, S = wettable sulfur

Table 3: Total phosphorous concentration (µg. g^{1-}) after 70 days of the planting date.

Treatments		Sampling location	
Fertilization	Treatments	Rhizosphere	Outside of rhizosphere
Phosphorous fertilization	Cont.	89	97
	P1	114	117
	P2	135	141
	P3	138	145
	average	**119**	**125**
Phosphorous fertilization with agricultural sulfur	SaP0	88	94
	SaP1	106	110
	SaP2	132	137
	SaP3	135	142
	average	**115.25**	**120.75**
Phosphorous fertilization with wettable sulfur	SP0	86	95
	SP1	109	115
	SP2	134	139
	SP3	138	146
	average	**116.75**	**123.75**
LSD 0.05		19.52*	

Cont= Control treatment, P = phosphorus level, Sa = agricultural sulfur, S = wettable sulfur

Table 4: Total phosphorous concentration (µg. g^{1-}) after 100 days of the planting date.

Treatments		Sampling location	
Fertilization	Treatments	Rhizosphere	Outside of rhizosphere
Phosphorous fertilization	Cont.	90	95
	P1	109	115
	P2	127	136
	P3	129	141
	average	**113.75**	**121.75**
Phosphorous fertilization with agricultural sulfur	SaP0	86	95
	SaP1	106	110
	SaP2	125	131
	SaP3	128	139
	average	**110.25**	**118.25**
Phosphorous fertilization with wettable sulfur	SP0	84	93
	SP1	101	113
	SP2	128	133
	SP3	131	142
	average	**111.00**	**120.25**
LSD 0.05		23.08*	

Cont= Control treatment, P = phosphorus level, Sa = agricultural sulfur, S = wettable sulfur

highest value of total phosphorus (138 and 146) µg. g^{1-} in and outside of the rhizosphere soil at an increased rate of (55.05 and 50.51)% as compared the control that had the lowest total phosphorus level (89 and 97) µg.g^{1-} in the soil of the rhizosphere and outside it, respectively. This amount is close to the amount of total soil phosphorus produced by the application the highest level of phosphate fertilizer (P3), which amounted to (138 and 145) µg.g^{1-} for the soil of in and out the rhizosphere, respectively. Sulfur fertilizer application at the levels of (SaP0 and SP0) decrease the total amount of phosphorus in the soil compared to the control treatment. This reduction is due to the decreased in soil pH because of the application of agricultural and wettable sulfur additional to increase the root excretions in this period. As the increase in the amount of sulfur lead to its interaction with phosphorus and thus sediment it and reduce its amount in one hand, or increase the linking phosphorus with sulfur and sedimentation them on the other hand.

Table 4 shows the effect the application of phosphate and sulfur fertilizers and their overlap in the total phosphorus amount in and out the rhizosphere area after 100 days of planting date. Results indicate a significant interaction between (p-value= 0.05) phosphate and sulfur fertilizers in increasing the total amount of phosphorus in the soil of the rhizosphere area and beyond. The highest level of phosphorus and SP3 had the highest average of phosphorus amount (131 and 142) µg.g^{1-} with an increase of (45.55 and 49.47%) compared with control treatment (90 and 95) µγ.γ1− ιν the soil of the rhizosphere and outside it, respectively. However, P3 and SaP3 levels were low (129, 141), (128 and 139) µg.g^{1-}, respectively for in and out the rhizosphere area. Phosphorus values with P1, SaP1, and SP1 levels were non-significant. The results indicate that there is no significant effect of using sulfuric fertilizer (agricultural and wettable) on the total phosphorus amount in the soil. The SP0 without application of phosphate fertilizer had the less total phosphorus amount (84 and 93) µg. g^{1-}in both the rhizosphere area and out it as compared to the control treatment that gave the amount of phosphorus (90 and 95) µg.g^{1-}, respectively. This reduction in total phosphorus because of the application of the wettable sulfur, which is quickly melting and thus reduces soil pH and increases the amount of dissolved phosphorus that is available to be absorbed by the plant. This led to the reduction of total phosphorus in the soil as a result of its interaction and interference with other ions and its sedimentation, Panhwar *et al.* (2012).

The results in tables (2, 3, and 4) and fig. 1 present that the total phosphate values of phosphate fertilizer treatments without interference with sulfur fertilizer (P1, P2, P3) are increased by increasing phosphorus levels and decreased as plant growth going on. Total phosphorus values of the sulfur fertilization treatments (Sa and S) reduced as crop growth continued. This decrease is clear when comparing to the control at 40 day growth period of cultivation. This element is subjected to fixation and adsorption in soils with different mechanisms and methods, due to the low degree of soil pH at 100 days of planting.

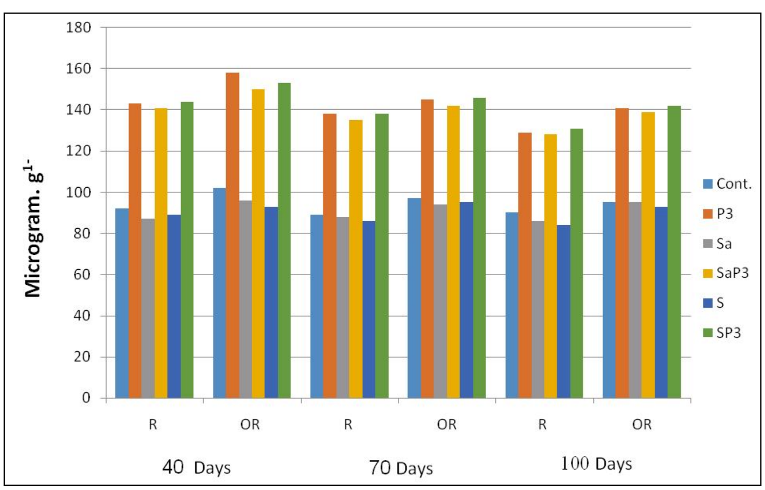

Fig. 1: The effect of phosphate and agricultural sulfur and wettable sulfur fertilizers application on total phosphorous in the rhizosphere and outside its areas.R: rhizosphere, OR : Outside of rhizosphere

This leads to the exposure of phosphorus to the deposition in form of calcium phosphate due to the high affinity between calcium and phosphate, which reduce the amount of phosphorus in the soil. This is consistent with what Sposito (2008) found. Changes occur in phosphate fertilizers that are applied to the soil. These fertilizers are converted from soluble to low solubility by adsorption on the surface of colloids or chemical precipitation, which can be trapped by its interaction with calcium in calcareous soils. This corresponds to Achal *et al.* (2007). It occurs also as a result of increased absorption by the plant, which is evident with the increase in plant growth. This increase in the using sulfur fertilizers reduces the element of phosphorus, but it was sufficient to increase the growth of the plant.

Conclusion

Total, available and dissolved phosphorus increase as the levels of phosphate fertilizer increases, and decrease when sulfur fertilizer apply itself, while the overlap between sulfur and phosphate fertilizers increase total phosphorous levels , but in small quantities compared to levels of phosphate fertilizer. The total phosphorus in the rhizosphere was less than the outside of the rhizosphere in all the treatments, noting the reduction of these values and all the treatments as the growth of the plant progressed.

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