QJAS Al-Qadisiyah Journal For Agriculture Sciences
ISSN: 2618-1479 Volume 9, No.2 ,(2019), PP 233-239
http://qu.edu.iq/jouagr/index.php/QJAS/index
DOI: https://doi.org/10.33794/qjas.Vol9.Iss2.94

The Effect of Sulfur and Phosphate Fertilizers Application on the Dissolved Phosphorus Amount in Rhizosphere of Zea Maize L.

Raid SH. Jarallah[1], Nihad A. Abbas[1]*
[1] *(College of Agriculture / University of Al-Qadisiyah , Iraq)*
Email: raid.jarallah@qu.edu.iq
Email: nohad92@yahoo.com

Received : 7/7/2019
Final Revision : 25/8/2019

Abstract: **The experiment has been carried out in the department of soil sciences and water resources, college of agriculture, university of Al-Qadisiyah, during the agricultural season 2017-2018 by using the design Complete Randomized Design (C.R.D). The experiment in pots has used four levels of phosphate fertilizer P0, P1, P2, P3 (0, 30, 60 and 90) kg P. h^{1-} respectively and one level of sulfuric fertilizer (agricultural and wettable) Sa and S (200) kg S.h^{1-}. Maize seeds of DKC 6120 variety have been in plastic pots grown. Dissolved phosphorus in the soil is estimated during plant growth periods (40, 70, and 100) days of planting to study the effect of its application levels, sulfuric fertilizer application (agricultural and wettable) fertilizers and their overlap on the amount of dissolved phosphorus into the corn rhizosphere. Results show that the highest amount of dissolved phosphorus in and out of the rhizosphere soil obtained with application of the phosphate level P3 (90) kg P. h^{1-} which were (0.69, 0.58, 0.55) µg. g^{1-} and (0.75, 0.63, 0.59) µg. g^{1-} for the soils of the rhizosphere and beyond respectively during the periods (40, 70 and 100) days of planting.**

Keywords: Dissolved Phosphorous, Rhizosphere, Zea Maize, Fertilization, Sulfur Fertilizer.

***The research is part of MSc for 2st author**

I. INTRODUCTION

Chemical and biologic changes due to root activity in the rhizosphere play a vital role in enhancing the vital availability of soil phosphorus (1). Plants absorb phosphorus in the form of $H_2PO_4^-$ and HPO_4^{2-} because the concentrations of these ions in the soil are in the micromolar range. It requires high-quality active transport systems in order to absorb phosphorus metal since facing a high chemical gradient across the plasma membrane cortical cells (2,3).

Roots have the critical area of interactions between plants, soil, and microorganisms. Plant roots can greatly modify the root environment through its various physiological activities, especially the release of organic compounds such as gum, organic acids, phosphates, and some distinctive signaling materials, which are the key engines of different root processes (2). Although the total phosphorus content in the soil does no more than the other requirements of the plant, decrease its movement in the soil and reduces its availability to plants. Therefore, dissolved phosphorus solution should be substituted in the soil rhizosphere solution 20 to 50 times a day by the transmission of phosphorus from the soil out of the rhizosphere to the rhizosphere to meet plant needs (5). Therefore, the phosphorus dynamics in the rhizosphere are mainly controlled by the function and growth of plant roots and are highly related to the physical and chemical properties of soil (6).

Dissolved phosphorus in soil water is an appropriate indicator of bioavailability since it is the medium that plants get their mineral nutrient requirements of (7). The dissolved phosphorus in the soil solution is no more than 0.01% of the total phosphorus in soil. It has a great importance in plant nutrition since it is first metal that moves to meet plant needs (8). Plants absorb phosphorus from the soil solution in the form of ($H_2PO_4^{1-}$ and HPO_4^{2-}) by roots (9). Chemical fertilizers improve their fertility, increase crop production, maintain a level of phosphorus in soil and increase the effectiveness of plant roots to obtain the phosphorus element by the roots. This is done by integrating morphological and physiological adaptation strategies. Phosphorus plays a vital role in the stability of crop production (4).

It is subjected to stabilization or adsorption in soils with different mechanisms and methods. Transforms to phosphate fertilizers occurs into the soil. These fertilizers are converted from soluble forms to low solubility forms by adsorption on the surface of colloids or by chemical deposition process through its interaction with aluminum in acid soils and calcium in soils (10). It can be said that the application of phosphorus, which is not absorbed by the plant, is exposed to the adsorption and sedimentation processes, all of which are called soil retention. This sedimentation depends mainly on the degree of soil interaction degree (pH). Sediment occurs in calcareous soils in the form of calcium phosphate because of the high affinity between calcium and phosphate (11). The objective of the study is to find out the effect of sulfur and phosphate fertilization on the amount of dissolved phosphorus in the rhizosphere of the corn plant during different growth periods (40, 70, 100) days of planting.

II. Materials and Methods

This pots study which usen pots has been conducted in the canopy of the College of Agriculture/ University of Al-Qadisiyah. The soil has been dried, tested and sifted through a 4 mm diameter sieve. 20 kg of dry soil has been placed in each pot and prepared for planting. The study has been designed according to the Complete Randomized Design (C.R.D). Twelve experimental treatments have been used, including the control with four replications. The treatments are randomly distributed to the 48 experimental units. Seeds of maize (Zea mays L.) of US DKC 6120 cultivar have been planted on Jul 15, 2017, at a rate of 5 seeds per pot then rugged out to a single seedling after 15 days of the planting date. Fertilizers are applied before planting, which are potassium sulfate (K_2O 50%) at a level of 100 kg K_2O. h^{1-} for all experimental units, while nitrogen fertilizer (N 46%) has been plural applied at 250 kg N. h^{1-} couple times, one after 15 days of planting and the second after 30 days of the first application. *Sesamia cailica* insect is controlled by applying with a 10% active diazinon pesticide on the apical meristem after 20 days of germination.

The process of weeding is done manually whenever necessary to eliminate the growth of bushes. Soil samples are taken before planting then dried and sifted with a 2 mm diameter sieve. Some physical and chemical properties have been estimated according to the methods that are listed in (12,13,14) Table (1). Dissolved phosphorus in and out of the rhizosphere soil is estimated during plant growth periods after 40, 70 and 100 days of planting y distillation with distilled water as reported in (14) . Data have been statistically analyzed by using the Statistical Analysis System (15) according to the complete random design (C.R.D) to study the effect of the factor (P) and its levels and the interaction with the factor (Sa) and the factor (S). The differences between the means are compared with the less difference test (LSD) and at a significant level of (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	$ds.m^{1-}$
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		0.30	
10.	Total Nitrogen		385	
11.	Available Nitrogen in the 2 Faces	$N-NH_4^+$	23.5	
12.		$N-NO_3^-$	26.4	
13.	Total Potassium		1354	
14.	Available Potassium		178	
15.	Available Sulfates		325	
16.	Positive Dissolved Ions	Ca^{2+}	23	Cmol. Charge. L^{1-}
17.		Mg^{2+}	10	
18.		Na^+	42	
19.		K^+	2	
20.	Negative	Cl^-	43	

21.	Dissolved 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		

III. Results and Discussion

The effect of phosphate and sulfuric (agricultural and wettable) fertilizers application and their overlap on the amount of dissolved phosphorus in and out of the rhizosphere soil after 40 days of planting is presented in Table (2). Phosphate and sulfur fertilizers treatments lead to an increase in the dissolved phosphorus in and out the rhizosphere area. All levels of phosphorus have made a significant increase in dissolved phosphorous availability as compared with the control treatment (Cont.) except the level 3 (P3, SaP3, SP3) for phosphorus fertilization and sulfur interference, which has significant values at the significant level of 0.05. This is due to the application of phosphate fertilizers.

All levels of sulfuric fertilizer application are higher than the control treatment outside the rhizosphere. This is due to the application of sulfur fertilizer, which increases the availability of dissolved phosphorus by reducing the reaction rate and increasing the availability of dissolved phosphorus in the soil solution. It is done by substituting the hydrogen ion instead of phosphorus that is found on the surfaces of the soil miners (16,17). Values of interference with sulfur are less than the values of fertilization with phosphorus itself. This may due to the overlap and the negative effect of increasing the presence of sulfur on the amounts of phosphorus. It can be observed that the highest amount of dissolved phosphorus in and out of the rhizosphere soil done by the (90) Kg P. h^{1-} application treatment. This treatment has been made 0.69 µg. g^{1-} in the soil of the rhizosphere and 0.75 µg. g^{1-} outside of the rhizosphere increasing the rates by (76.92 and 63.04) % as compared with the control treatment that had the lowest amount of dissolved phosphorus (0.39, 0.46) µg. g^{1-} in the soil of the rhizosphere and outside, respectively.

Dissolved phosphorus content in the soil of the rhizosphere has decreased in all treatments as compared with the outside soil of the rhizosphere. This is due to the absorption of soluble phosphorus in the area that is very close to the roots of the plant in larger quantities as compared with the beyond area in addition to increases the overall biological activity, which has the consistency with (4). Dissolved phosphorus values increase as phosphate fertilizer level increase, while this increased level slows down and become in smaller quantities when interfering with sulfur fertilizer in the soil. Dissolved phosphorus produced by the application of phosphate fertilizer itself is more than the dissolved phosphorus produced by the application it with sulfur fertilizer and by the overlap with phosphate fertilizer, Table (2). This is due to the application of sulfur (agricultural and wettable) fertilizer, which reduces the degree of soil reaction (pH) and increase the availability of dissolved nutrients, including the element of phosphorus and increases its absorption by the roots of the plant, which has led to drop in its level in the soil. In the outside area the rhizosphere, the amount of dissolved phosphorus increases with the application of sulfur fertilizer with phosphorus. This is because this region is far from the roots, which means less phosphorus absorption of adding to that phosphorus element is a slow-moving element in its nature.

Table (2): Dissolved Phosphorous Concentration (µg. g1-) after 40 Days of the Planting Date.

Treatments		Sampling Location	
Fertilization	Treatments	Rhizosphere	Outside of Rhizosphere
Phosphorous Fertilization	Cont.	0.39	0.46
	P1	0.50	0.51
	P2	0.62	0.67
	P3	0.69	0.75
	Average	**0.55**	**0.60**
Phosphorous Fertilization	SaP0	0.42	0.45
	SaP1	0.49	0.52

with Agricultural Sulfur	SaP2	0.59	0.65
	SaP3	0.67	0.77
	Average	**0.54**	**0.60**
Phosphorous Fertilization with Wettable Sulfur	SP0	0.40	0.44
	SP1	0.48	0.53
	SP2	0.58	0.66
	SP3	0.68	0.76
	Average	**0.53**	**0.60**
LSD (0.05)		0.239*	

Cont= Control Treatment, P = Phosphorus Level, Sa = Agricultural Sulfur, S = Wettable Sulfur

Of the above results, applied treatments of the third level of phosphate fertilizer and the overlap with sulfur in the area outside the rhizosphere have made higher amounts of dissolved phosphorus as compared with the rest of the treatments. The increase in phosphorus availability because of sulfur fertilizer application to the soil where sulfur is subjected to the process of chemical and biological sulfur oxidation and thus the formation of sulfuric acid. This increases the concentration and activity of hydrogen ion in the soil solution in addition it dissolves some phosphorus compounds in the soil and then releases the phosphorus held or retained in the soil, which corresponds with the results of (19,20,21).

Table (3) shows the effect of the phosphate and sulfuric (agricultural and wettable) fertilizer application and their overlap on the amount of dissolved phosphorus in and out of the rhizosphere after 70 days of planting. The results of the statistical analysis indicate that there is no significant effect at a significant level of 0.05 except for the treatment of (P3), which is significantly more than the control treatment. The highest level of soluble phosphorus in the soil obtained at the application of the level (90) kg P. h^{1-} of phosphorous fertilization made (0.58 and 0.63) µg. g^{1-} in the soil of the rhizosphere and outside it, respectively.

This has an increase of (56.75 and 53.65%) as compared with the control treatment, which gives the lowest value of dissolved phosphorus in the soil (0.37 and 0.41) µg. g^{1-} in and out the soils of the rhizosphere, respectively. Because of the absorption of phosphorus in the root zone, the dissolved phosphorus in all of the treatments in and outside the rhizosphere during this period (flowering phase) is applied to phosphorus that is far from the rhizosphere, which causes its low concentration in the soil outside the rhizosphere as well. It is also noted that the greatest reduction in the treatments that treated with sulfur types and interference with phosphate fertilization decreases the degree of interaction of soil (pH) and increases the availability of dissolved phosphorus. This is resulting in plant absorption rising and thus reduces its amount in the soil solution because of clouds by the roots.

Yellow corn is a highly absorbent crop of various nutrients, which absorb dissolved phosphorus efficiently. Because of the low solubility of the phosphorus element and slow movement in soil, it can be rapidly consumed in the rhizosphere, resulting in a gradient in a radial direction away from the root surface, which is consistent with (4).

Table (3): Dissolved Phosphorous Concentration (µg. g1-) after 70 Days of the Planting Date.

Treatments		Sampling Location	
Fertilization	Treatments	Rhizosphere	Outside of Rhizosphere
Phosphorous Fertilization	Cont.	0.37	0.41
	P1	0.45	0.47
	P2	0.52	0.60
	P3	0.58	0.63
	Average	**0.50**	**0.52**
Phosphorous Fertilization with Agricultural Sulfur	SaP0	0.40	0.44
	SaP1	0.38	0.46
	SaP2	0.45	0.49
	SaP3	0.51	0.58
	Average	**0.43**	**0.50**
Phosphorous Fertilization	SP0	0.38	0.41
	SP1	0.42	0.49

with Wettable Sulfur	SP2	0.48	0.50
	SP3	0.50	0.57
	Average	**0.44**	**0.50**
LSD (0.05)		0.217*	

Cont. = Control Treatment, P = Phosphorus Level, Sa = Agricultural Sulfur, S = Wettable Sulfur

Table (4) explains the effect of phosphate and sulfur fertilizers application on the dissolved phosphorus in and out of the rhizosphere soil after 100 days of planting. Dissolved phosphorus concentration in the soil is increased insignificantly at a significant level of 0.05 with increasing levels of fertilization. The treatment of (P3) of (90) kg P. h^{1-} shows the highest amount of dissolved phosphorus (0.55, 0.59) µg. g^{1-} with an increase of (57.14 and 42.00%) as compared with the control treatment that has the lowest amount of dissolved phosphorus of (0.35, 0.42) µg. g^{1-} in and out the soil of the rhizosphere, respectively. The absence of significant differences in the values of dissolved phosphorus in the periods (70 and 100) days is due to the increase in plant growth. Therefore, increasing the consumption of the element and the fertilization is not enough to compensate for the consumption of the plant and thus decreases its quantities.

The results in Tables (2, 3, and 4) present that the dissolved phosphorus has continued to decline in all the studied times for both of in and out rhizosphere area. This increase in phosphate fertilizer levels has increased its quantities, Figure (1). Decreasing the dissolved phosphorus in and out of the rhizosphere soil indicates that this element is translocated from the outside of the rhizosphere to the area of the biosphere to compensate the element deficiency. Phosphate fertilizer without interference with sulfur fertilizer (P1, P2, and P3) (Tables 2, 3 and 4) increases dissolved phosphorus but decreases with the growth period of the plant in the soil. The application of phosphate fertilizer and the interaction with sulfur fertilizer (SaP, SP) has led to a decrease in dissolved phosphorus values as plants growth period increase. This indicates the absorption of this element easily by the plant. The transformation of ionic phosphorus type from the soil solution into unstable soil state phosphorus with time in addition to deposition of phosphorus through its reaction with dissolved calcium ions in the soil solution leads to its retention on the surface of the colloids, which is consistent with (8).

Table (4): Available Phosphorous Concentration (µg. g1-) after 100 Days of the Planting Date.

Treatments		Sampling Location	
Fertilization	Treatments	Rhizosphere	Outside of Rhizosphere
Phosphorous Fertilization	Cont.	0.35	0.42
	P1	0.42	0.48
	P2	0.50	0.57
	P3	0.55	0.59
	Average	**0.45**	**0.51**
Phosphorous Fertilization with Agricultural Sulfur	SaP0	0.36	0.41
	SaP1	0.38	0.43
	SaP2	0.40	0.46
	SaP3	0.46	0.51
	Average	**0.40**	**0.45**
Phosphorous Fertilization with Wettable Sulfur	SP0	0.35	0.39
	SP1	0.36	0.47
	SP2	0.41	0.47
	SP3	0.43	0.49
	Average	**0.40**	**0.45**
LSD (0.05)		0.216*	

Cont.= Control Treatment, P = Phosphorus Level, Sa = Agricultural Sulfur, S = Wettable Sulfur

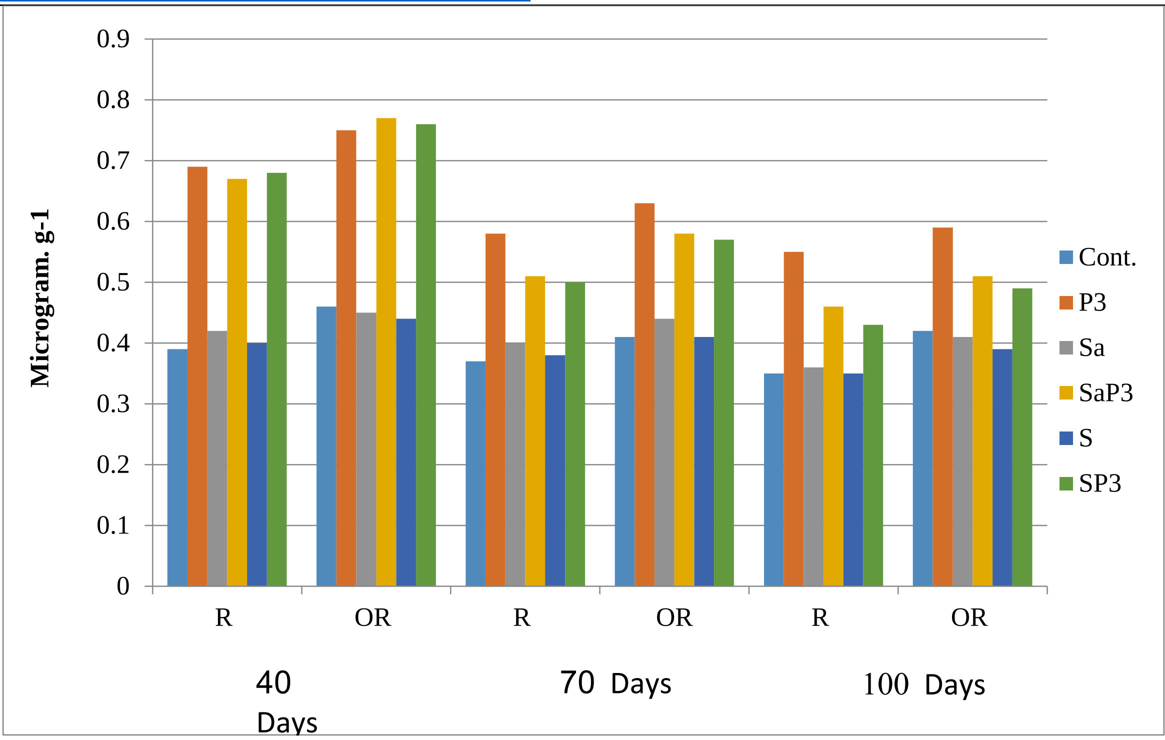

Figure (1): The Effect of Phosphate and Agricultural Sulfur and Wettable Sulfur Fertilizers Application on the Dissolved Phosphorous in and out the Rhizosphere Areas. R: Rhizosphere , OR : Outside of Rhizosphere

References

[1] Hinsinger ,P .2001. Bioavailability of soil inorganic P in the rhizosphere as affected by the root-induced chemical change: a review. Plant and soil, 237: 173- 195.

[2] Shin H, Shin HS, Dewbre GR, Harrison MJ .2004. Phosphate transport in Arabidopsis: Pht1;1 and Pht1;4 play a major role in phosphate acquisition from both low- and high-phosphate environments. Plant J 39: 629–642.

[3] Ai P, Sun S, Zhao J, Fan X, Xin W, Guo Q, Yu L, Shen Q, Wu P, Miller AJ et al .2009. Two rice phosphate transporters, OsPht1;2 and OsPht1;6, have different functions and kinetic properties in uptake and translocation. Plant J 57: 798–809.

[4] Shen, J.; Lixing, Y.; Junling, Z.; Haigang, L.; Zhaohai, B.; Xinping, C.; Weifeng, Z .and Fusuo, Z.2011. Phosphorus dynamics: from soil to plant. Plant Physiology, July, Vol. 156, pp. 997–1005, www.plantphysiol.org. American Society of Plant Biologists.

[5] Marschner, H. 1995. Mineral nutrition of higher plants. 2nd edn., Academic Press, London, p 889.

[6] Neumann G, Ro¨mheld V .2002. Root-induced changes in the availability of nutrients in the rhizosphere. In Y Waisel, A Eshel, U Kafkafi, eds, Plant Roots, The Hidden Half, Ed 3. Marcel Dekker, Inc., New York, pp 617–649.

[7] Barber, S. A. 1980. Soil-plant interaction in the phosphorus nutrition of plants in Chassagne F. E. et al (Eds) the role of phosphorus in Agriculture ASA. Medison, Wiskon Sin, USA. Pp 951-618.

[8] Pagel, H.1983.On the transformation of phosphorus in tropical soils.6th. Int. Sci. Con. 165-210.

[9] Pierzynski, G. M., and McDowell, R. W. 2005. Chemistry, cycling, and potential movement of inorganic phosphorus in soils, in: Phosphorus: Agriculture and the Environment, edited by: Sims, J. T. and Sharpley, A. N., Agronomy Monograph, 46, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI, 53–86.

[10] Achal, V.; V. Savant. and V. Reddy MS.2007. Phosphate solubilization by a wild-type strain and UV-induced mutants of Aspergillus tubulogenesis. Soil Biol Biochem 39:695-699.

[11] Sposito, G. .2008.The chemistry of soils. Oxford University Press.

[12] Jackson, M.L. 1958. Soil chemical analysis. prentice-Hall. Inc. Engelwood. Cliffs, N.J **.**

[13] Black, C.A. 1965. Methods of soil Analysis.AM.Soc. Agron. No.9 Part 1. Madison, Wisconsin. The USA. Pp.374-390.

[14] Page, A, L., R.H. Miller. And D.R.Keeny(Eds).1982. Methods of soil analysis. Part2. 2nd edition. Chemical and Microbiological properties. Am.Sco. of Agr,.s.s.s.Am.inc., Madison, Wisconson, USA.

[15] SAS. 2012. Statistical Analysis System, User's Guide. Statistical. Version 9.1th ed. SAS. Inst. Inc. Cary. N.C. The USA.

[16] Jabr, Abdel-Salam, Hussein Mahmoud Shukri, and Walid Fleih Hassan al-Zahidi .2007. Effect of Agricultural Sulfur, Poultry Residues and Phosphate Rock in the Preparation of Phosphorus and Some Nutrient Elements and the Growth and Value of Bread Bread. Journal of Iraqi Agricultural Sciences. 75-60: (2) 38.

[17] Panahi, S.V.S.; Farhad, M and Mohammad, R.A. 2016. Sulfur application effect on pH measurement of wheat rhizosphere in calcareous soils. Biological Forum – An International Journal 8(1): 199-203.

[18] Jumaili, Abdul Wahab Abdul Razak and Hamed Allah Sulaiman Rahi. 2000. Effect of foam sulfur on some soil properties in the plastic house and in the laboratory. Journal of Iraqi Agricultural Sciences. Volume 31. Issue 3: 1-10.

[19] Al-Hassoun, Samira Nasser Hassoun .2010.Effect of Sulfur, Magnesium and Phosphate Levels in Phosphorus Freezing and Potato Extraction of Triticum aestivum L .. Master Thesis, Faculty of Agriculture. Baghdad University.

[20] Imran, Rashad Adel, Haifa Jassim Hussein, and Abdul Zahra Taha Zaher. 2016. Effect of Agricultural Sulfur and Super phosphate Concentrate in the Preparation and Concentration of Phosphorus in Sorghum bicolor L. During its Various Growth Stages. Dhi Qar University Journal of Agricultural Research, vol. 5. Number 1.

[21] Kazem, Anmar Hamoudi .2016. The role of the addition of agricultural sulfur at different levels and dates in the degree of soil interaction and the readiness of some micronutrients and their effect on the growth and productivity of two varieties of wheat (Triticum aestivum L.). Faculty of Agriculture, Al - Muthanna University.