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Effect of Ionic Strength and Soil Texture in Evaluation of Phosphorous Extraction Using Olsen And 1% Formic Acid Methods In Wheat Cropped Soil.

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ABSTRACT

An experiment was conducted in the field of olive house of the Department of Horticulture at the Faculty of Agriculture University of Baghdad by using three soil textures, silty clay loam, loam, and sandy loam to study the effect of soil texture and ionic strength expressed in ionic strength levels of 0.026, 0.025, 0.078, and 0.104 mol.l-1 produced from adding a mixture salt of calcium chloride, magnesium chloride, and sodium chloride at (1:1:2) on available phosphorous concentration that extracted by Olsen and 1% formic acid methods and the growth and yield of wheat crop. Results showed that the increase of ionic strength led to a significant decrease on the dry weight of before flowering and the phosphorous content in the vegetative part of plant, also it affected the amount of phosphorous uptake by plant where there was a significant decrease in the uptake of phosphorous in the three soil textures. Soil texture influences plant growth significantly in the silty clay loam soil, loamy soil, and the sandy loam soil respectively. Correlation coefficient between extracted phosphorous from soil and uptake phosphorous in plant at flowering stage in wheat crop showed the superiority of 1% formic acid other than olsen solution in silty clay loam soil by giving the highest correlation coefficient before planting and before flowering of wheat crop, while Olsen solution has the superiority than 1% formic acid solution in sandy loam soil before planting and before flowering of wheat crop while Olsen solution and 1% formic acid methods were even determining extracted phosphorous before planting, while 1% formic acid method was superior before flowering in loamy texture soil.

Keywords: ionic strength, soil tecture, Olsen.

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INTRODUCTION

The main objective of selecting soil phosphorus is to determine its optimal concentration and required for plant growth. There are a large number of methods of extracting phosphorus from soil which are designed to suit different soil types and fit the mechanism that controls soil phosphorus chemistry (Jackobson and havlen 1994). Soil type, chemical and physical properties and texture class (fine, medium, coarse) cause differences in measurement due to the different soil components in terms of nature and properties, and phosphorus availability in calcareous soil affected by the amount of carbonate minerals and their properties in terms of crystallization and the size of crystals. The type of salts present in the soil solution affects the efficiency and ionic strength, or so-called ion stress. Through ionic strength, high levels of salts have a high impact on phosphorus availability. The ionic strength has great importance in calculations of the efficiency of these ions. The charge density in saline solutions plays a major role in controlling the interactions between soil surfaces and soil solution. Where ion exchange plays an important role in the leaching and the availability of nutrients, regulating soil reaction and thus the availability of certain nutrients and reducing the availability of other nutrients, including phosphorus (Awad 1986, Abdulkadhum 2016). Calcium, magnesium, sodium and potassium chlorides form the majority of soil salts in arid and semi-arid regions, and the effect of salts on phosphorus availability varies depending on the positive ion type in the saline structure, the chemical behavior of these ions with phosphorus, the effect of these ions and their concentrations in adsorption and release of phosphorus from the soil (Almaamoori 2017). Holford1997, and Ali et al 2014 have pointed out that the plant is limiting in this field because the measurement represents the amount of the element that can be absorbed in the period of plant growth. Mahoush 2003 and Wunscher 2013 have referred to the importance of comparing the results of extraction solutions with the amount absorbed or consumed by the plantto investigate the role of the extraction solution in different soil textures. Several tests were performed using one or two or three plants and concluded that if the extraction solution itself gave the highest correlation with all the plants, it is considered the best solution for extraction (Broeshart and Fried 1967). The factors affecting the tests in addition to the type of extraction solution, plant, and the conditions of plant growth is the type of soil and its chemical and physical characteristics and its texture if it is fine, medium and coarse, which cause a difference in the tests to vary the components in terms of nature and properties such as oxides and carbonates (Karadaghi 2006).

An experiment was conducted in Greece by Latrou et al 2014 to compare Mehlich-3 and Olsen methods in the extraction of the available phosphorus for nearly 200 soils with different levels of soil reaction and contents of calcium carbonate 10.3-48.3%. The results showed that the Mehlich-3 method requires less effort than the Olsen method and provides the advantage of multiple element degradation. However, the Olsen method is more used in Greece because of its suitability for calcareous soil and the accuracy of its results in the estimation of available phosphorus. The results showed the correlation between the two methods in the extraction of the available phosphorus in calcareous soils except for soil with a reaction of less than 5, where there is a correlation between these two methods. A study was conducted by Rajan et al 1992 to compare 2% organic citric acid and 2% organic formic acid and neutral ammonium citrate in phosphorus extraction on three different phosphorous content soils that contains phosphate rock and 12% of calcium carbonate where results showed that phosphorous amount determined by these different methods are highly correlated (r=0.82-0.99) and the formic acid method was the best parameter for the agricultural activity and the detained phosphorous by soil for those three soils. The need to test more than one way to extract phosphorus is evident. In Iraq, trials were made and still to determine the efficiency of the different methods of extraction to find the most appropriate and suitable for the Iraqi soils. Muhawish 2003 has carried out a study to evaluate the most common phosphorous extraction methods and comparing them on a wide spectrum of soils in Iraq, where he chose new methods as an attempt to find an efficient method of available phosphorous determination in Iraqi soils. He showed that Olsen and 1% formic acid methods were the best for the accurate quantitative determination of available phosphorous and its relationship to yield. And as a continue to this study, and for the determination of both methods efficiency and suitability for the Iraqi calcareous soils, this study aims to:

1- Determination of the effect of the ionic strength of the soil solution and the soil texture in the amount of phosphorus collected by Olsen and 1% Formic acid methods in calcareous soils.
2- Evaluation of extraction methods and knowing the most efficient in determining the amount of available phosphorus in the soil under the difference of ionic strength and soil texture.

MATERIALS AND METHODS

The soil of the first treatment was selected with silty clay loam soil texture from the fields of the plant protection department at the Faculty of Agriculture, University of Baghdad / Abu Ghraib (the old campus) from the depth of 0-30 cm, and the second soil with a loamy texture collected from the field of the Faculty of Agriculture University of Baghdad, Jadriya behind the soil department, while the third was with a sandy loam texture taken from the Faculty of Agriculture University of Baghdad near the College of Sports Soil and depth 0-30 cm. these soils were classified as Typic Torrifluvents alluvial soils according to soil survey staff 2006. Soils were collected and air dried, grinded, and sieved with 2 mm openings and physicochemical analysis were conducted due to Bashour and Saigh 2007, Jackson 1958. Table 1 shows some physical and chemical properties of soils of the study. The objective of this research was to study the effect of ionic strength and soil texture in evaluating phosphorous extraction by Olsen and 1% formic acid under wheat plant where a factorial experiment with CRD was conducted including 60 experimental units (4*3*5=60) replicates combined from two factors of ionic strength (0.026, 0.052, 0.087, and 0.104 mol.l^{-1} applied as saline solution composed of calcium, magnesium, and sodium chlorides at 1:1:2 rate and three soil textures of sandy loam, loam, and silty clay loam with five replicates. Wheat crop seeds (Triticum Aestivum) IPA class were planted in 10 kg pots of 8 kg soil with ten seeds per pot lessened to five plants per pot after one week of emergency.

NPK was applied due to the fertilization recommendation of wheat (120, 80, 200) kg.ha-1 (Altimimi et al 2014) for the three soil textures. The phosphorus was added in a superphosphate (20% P) and at 80 kg P.Ha^{-1} in one batch mixed with the soil at planting and nitrogen was added at the level of 200 kg N. Ha^{-1} in the form of urea fertilizer (46% N) 100 kg N^{-1} with phosphate fertilizer when mixed with soil and the second batch was added after 45 days of application of the first batch with irrigation water.

Potassium was added to the level of 120 kg K.Ha^{-1} as potassium sulphate (41.5% K) mixed with the soil at planting and all treatments to ensure good production. Water was used in the irrigation process. Water was drained at 50% of the water available to deliver moisture to 80% of the field capacity during the period of growth of the plant by weighing the soil with the soil and the plant and adding the water every three days based on the missing from the available water.

Soil samples and all treatments were taken at two time intervals 48 hours prior to planting after zero time and before plant fertilization (90 days after planting) to study the effect of ionic strength and soil texture and the addition of phosphorus and the interaction of these factors in the behavior of phosphorus Readiness in soil and its relation to plant growth, while plant samples were taken at a pre-flowering stage and the plants were dried and the dry matter of the plant (vegetative part) was calculated. The concentration of phosphorus in the dry matter of the plant and the absorbed amount of the phosphorus element was estimated by the plant during the pre-flora phase. The efficiency of the method of phosphorus extraction from soil in both methods (sodium bicarbonate and 1%formic acid) was determined by giving it the best Correlation Coefficient (r)) Between the prepared extract in the soil and absorbed by the plant for the stage before flowering.

Table 1: Some physical and chemical properties of the study soils

Property	Value			Unit
	T1 Abu Ghraib	T2 Jadiriya	T3 Jadiriya	
1:1 Soil reaction pH	7.30	7.37	7.45	-
1:1 Electrical Conductivity EC	1.84	1.48	1.30	dS.m-1
Cation Exchange Capacity CEC	23.45	19.18	17.50	Cmolec.kh-1 soil
Soil Organic Matter	8.23	7.71	7.00	gm.kg-1 soil
Gypsum	0.26	0.15	0.13	
Carbonates	221.12	180.00	170.00	
Soluble cations				Mmole.L-1
Ca^{2+}Calcium	5.20	4.60	3.50	
Mg^{2+}Magnesium	2.60	2.10	2.00	
Na^{+} Sodium	1.83	0.85	0.63	
Potassium K^{+}	0.63	0.58	0.41	
Soluble anions				

CO_3^{2-}Carbonates		Nil	Nil	Nil	
HCO_3^-Bicarbonates		1.78	1.40	1.25	
SO_4^{2-} Sulfate		1.38	0.91	0.78	
Chloride Cl^-		14.20	11.40	10.20	
Available N		28.31	20.81	18.11	Mgm.kg-1 soil
Available P		16.36	16.08	15.04	
Available K		76.71	69.33	35.97	
Field Capacity		0.33	0.24	0.21	cm^3.cm^3
Wilting point		0.19	0.10	0.07	
Particle sizes	Sand	146.00	392.00	572.00	gm.kg-1
	Silt	554.00	400.00	260.00	
	clay	300.00	208.00	168.00	
Texture		Silty Clay Loam	Loam	Sandy Loam	

RESULTS AND DISCUSSION

Tables 2 and 3 show the effect of soil texture and ionic strength of soil solution on the concentration of phosphorus in soil extracted byOlsen (sodium bicarbonate)from soil prior to planting and before fertilization and after addition of salts. The results showed a significant effect of ionic strength in the concentration of phosphorus in soil where the concentration of phosphorus was reduced with increasing ionic strength of the soil solution with significant differences among all treatments. The highest value in treatment I_1 was 15.83 mg. P. kg $^{-1}$ soil followed by treatment I_2, I_3 and I_4at 13.74, 13.39 and 11.38 mg P. kg^{-1} soil respectively that decreased directly with increasing the amount of salts added.

Results showed that I_2 and I_3 were significantly superior to I_4. In the pre-flowering phase, the highest value (Table 3) in treatment I_1 was 16.35 mg. Kg-1 soil followed by treatment I2, I3 and I4 was 14.83, 13.78 and 11.86 mg P. kg^{-1} soil, respectively, Salts added. This is due to the added amount of calcium, magnesium and sodium chloride salts to soils. The salts applied to the soil solution affect the efficiency and strength of the ions, or the ionic strength, through the ionic strength of the soil solution and the positive ionic charge on the surface. High levels of salts play a major role in determining the availability of phosphorus and its solubility (Awad, 1986, Amauri and others, 2017). The ability of salts, especially monocrystals, such as sodium chloride, to dissolve calcium carbonates and release more calcium, which contributes to its concentration in soil solution. This is reflected in the accelerated deposition of phosphorus in soil (Giesler et al., 2003). This result is consistent with what happened to Al Hadidi (2009), Al Azzawi (2010), Ateiwi (2011), Fakhar (2016), Al Amouri and others (2017). The results showed a higher concentration of phosphorus available in the three soils in the pre-flowering phase compared to pre-planting and fertilization phase. The reason for this was the application of the triple superphosphate fertilizer according to the fertilizer recommendation for each soil which contributed to the concentration of phosphorus in the three soils.

The results of the analysis showed a significant effect of the soil texture in the available phosphorus insoil, which showed significant differences among the treatments. Table (2) was highest in T_1 and then in T_2 and finally In T_3were 14.54, 14.22 and 12.00 mg P. kg $^{-1}$ soil respectively, and the results showed that the correlation of T_1 and T_2 was significantly superior to T_3. Table 2 showed highest values of available phosphorus in T_1, T_2 and T_3that reached 15.37, 14.28 and 12.97 mg P. kg^{-1} soil respectively. This may be related to the variation in the soil content of the clay minerals and their original content of phosphorus (Mahoush, 2003). Also,soil that absorbs a large amount of phosphorus releases and breakdown more phosphorus into the soil solution and that there is a linear relationship between the soil content of adsorbed phosphorus and the amount of released phosphorus (Kaloi et al., 2011). The results showed the increase and convergence of the phosphorus concentration in the three soils in the pre-flowering stage compared to the pre-planting and fertilization phase. This was due to the addition of the triple superphosphate fertilizer according to the fertilizer recommendation of each soil which contributed to raising the concentration of phosphorus available in the three soils when planting the seeds of the wheat plant.

Table 2: Concentration of available phosphorus in the soil (mg / kg-1 soil) extracted with sodium bicarbonate solution before planting.

Ionic Strength (I)	Available Phosphorus (mg P / kg-1 soil) before planting			
	Soil Texture (T)			Average
	T_1	T_2	T_3	
I_1	16.36	16.08	15.04	15.83
I_2	14.26	14.23	12.74	13.74
I_3	13.87	13.64	12.67	13.39
I_4	13.67	12.92	7.56	11.38
Average	14.54	14.22	12.00	
LSD 0.05	T	I	T.I	
	0.79	0.91	1.58	

Table 3: Concentration of available phosphorus in the soil (mg P kg .g -1 soil) extracted by Olsen (sodium bicarbonate solution) before flowering

Ionic Strength (I)	Available phosphorus (mg P. kg-1 soil) before flowering			
	Soil Texture (T)			Average
	T_1	T_2	T_3	
I_1	17.71	16.23	15.11	16.35
I_2	15.93	14.91	13.64	14.83
I_3	14.82	13.97	12.54	13.78
I_4	13.01	12.00	10.57	11.86
Average	15.37	14.28	12.97	
LSD 0.05	T	I	T.I	
	0.61	0.71	N.S	

The results of the statistical analysis (Table 2) showed a significant effect, with the highest value of phosphorus in the soil being 16.36 mg. P kg $^{-1}$ soil in the treatment T_1I_1, while the minimum value of phosphorus in the soil was 7.56 mg P. kg $^{-1}$ soil treatment T_3I_4. As for the effect of bilateral interaction of pre-flowering stage, the results of the statistical analysis (Table 3) showed no significant differences among treatments. Tables 4 and 5 show the effect of soil texture and ionic strength of the soil solution on the concentration of phosphorus in soil using 1% formic acid extraction before planting and fertilization. After addition of salts and before flowering, the results showed a significant effect of ionic strength in phosphorus concentration in soil with increasing ionic strength of the soil solution. Table 4 shows that the highest value in treatment I_1 was 22.51 mg. P. kg $^{-1}$ soil followed by treatment I_2, I_3 and I_4at 21.64, 20.79 and 17.91 mg P. kg $^{-1}$ soil respectively, and the decrease was direct with the increase in the amount of salts applied. The results showed that I_1 was significantly higher than I_3 and I_1 and I_2 were significantly higher than I_4 and I_2 and I_3 were significantly higher than I_4. The results of Table 5 showed that the highest value in treatment I_1 was 22.40 mg. P. kg $^{-1}$ soil followed by treatment I_2, I_3 and I_4 was 21.08, 18.86 and 17.87 mg. P. kg $^{-1}$ soil respectively, and the decrease was direct with increasing the amount of salts applied. This is due to the added amount of calcium, magnesium and sodium chloride salts to soils. The salts present in the soil solution affect the efficiency and energy of the ions, or the ionic activity, through the ionic strength of the soil solution and the positive ions of the surface played a major role in determining the availability of phosphorus (Awad, 1986 and Amauri, 2017).

The increased concentration of calcium in the soil solution has a negative effect on the availability of phosphorus in the soil. The decrease in phosphorus levels and the rapid transition to other compounds are directly proportional to the added level of calcium (Chitopher et al., 2009; Al-kaysi and Al-Mamooree, 2015). The ability of salts, especially monocrystals, such as sodium chloride, to dissolve calcium carbonates and release more calcium, which contributes to its concentration in soil solution. This is reflected in the accelerated precipitation of phosphorus in soil (Giesler et al., 2003). When comparing the results of the extraction using1%

formic acid with Olsen method results, the Olsen method gave values for phosphorus in the three soils less than in 1% formic acid and can be expressed as the available quantity of the plant according to the needs of the plant which is closest to the reality of these soil as a calcareous soils are grown and fertilized from what is expected to be the level of phosphorus available in this range. While, results of 1% formic acid showed higher phosphorus concentrations in soil when comparing extracted concentrations to Olsen ($NaClO3$) at pre-planting and fertilization stage and before flowering due to the nature of the compounds used in the extraction process. 1% formic acid has pH value of 3.35 and the values of the Olsen method ($NaHCO3$) were pH = 8.5, which dissolved large amounts of soil phosphorus and then increased its concentration in soil solution. The effectiveness of this acid in the release of phosphorus in the soil may also be due to its ability to interact with calcium phosphate compounds and release phosphorus through the reaction of the carboxylic root ($COOH$) with calcium ions, and thus reduces the concentration of calcium in the solution and increases the reaction towards the release of phosphorus (Oburgeret al., 2011 and Desouza et al., 2014). The complex that is composed of the reaction of carboxylic root with calcium may be the calcium formate and is consistent with what Mahoush(2003) found about calcium formate formation. As well as with Worsfold et al. (2005) , Wei et al. (2009) and Kratz et al. (2016) on the role of formic acid in the extraction of phosphorus soil.

The effect of soil texture on the concentration of phosphorus in the soil prior to planting and fertilization extracted 1% formic acid. The results of the analysis showed a significant effect of the soil texture in the available phosphorus in soil that showed significant differences between the treatments (Table 4) where T_1, T_2, and finally T_3averaged at 21.93, 20.44 and 19.77 mg P. kg^{-1} soil respectively. In Table 5, significant differences were found between T_1 and T_2 and T_3 at 21.69, 19.68 and 18.79 mg / kg respectively. This may be due to variations in soil properties, or possibly to their original content of phosphorus in soil or to the nature of phosphorus compounds (Mahoush, 2003). Soil with high clay content is more fixating to phosphate complexes, and finetexture soils have more phosphorus than coarse soils (Ali et al., 2014). In addition, Desouze et al. (2014) found that the application of organic acids to clayey soils and sand mixtures reduced phosphorus adsorption in all treatments, reducing phosphorus adsorption by 25.8% in clay soil and 16.7% in sandy soil compared to the sample without organic acids. This came in line with what Shukri (2002) and Ahmad et al (2006) found. The results showed the approximate concentration of phosphorus in the three soils in the pre-flowering stage compared to pre-planting and fertilization phase. The reason was that the addition of the tri-superphosphate fertilizer according to the fertilizer recommendation of each soil which contributed to raising the concentration of phosphorus available in the three soil textures when planting the seeds of the wheat crop.

The results of the statistical analysis in Table 4 showed significant effect of ionic strength and soil texture. The highest value of phosphorus in the soil was 24.42 mg. p. Kg $^{-1}$ soil in T_1I_1 while the lowest value of phosphorus in the soil was 17.11 mg P. Kg $^{-1}$ soil in T_3I_4 treatment. Table 5 shows that the highest value of available phosphorus in soil is 24.74 mg P. Kg^{-1} soil in treatment T_1I_1 while the lowest phosphorus content in the soil was 17.27 mg P. Kg^{-1} soil in T_3I_4 treatment.

Table 4: Concentration of phosphorus in soil extracted with 1% formic acid before planting.

Ionic Strength (I)	1% formic acid (mg P kg-1 for soil) before planting			
	Soil Texture (T)			Average
	T_1	T_2	T_3	
I_1	24.42	21.97	21.15	22.51
I_2	23.13	21.19	20.59	21.64
I_3	21.22	20.91	20.23	20.79
I_4	18.94	17.69	17.11	17.91
Average	21.93	20.44	19.77	
LSD 0.05	T	I	T.I	
	0.77	0.89	1.55	

Table 5: Concentration of phosphorus prepared in soil extracted with 1% formic acid before flowering.

Ionic Strength (I)	1% formic acid (mg P kg-1 for soil) before flowering			
	Soil Texture (T)			Average
	T_1	T_2	T_3	
I_1	24.74	21.85	20.61	22.40
I_2	23.37	20.61	19.27	21.08
I_3	20.11	18.45	18.02	18.86
I_4	18.55	17.80	17.27	17.87
Average	21.69	19.68	18.79	
LSD 0.05	T	I	T.I	
	0.38	0.44	0.76	

Concentration of phosphorus in the vegetative group of wheat plant:

Table 6 shows the effect of soil texture and ionic strength of the soil solution in the phosphorus concentration in the vegetative population of the plant at pre-flowering stage. The results showed a significant effect of the ionic strength in the phosphorus concentration in the vegetative part of the plant. The concentration of phosphorus decreased with the increase of ionic strength of the soil solution in pre-flowering stage. The plant showed significant differences among the treatments. The highest phosphorus value of pre-flowering in treatment I_1 was 0.46% followed by the treatment of I_2, I_3 and I_4 of 0.41, 0.37 and 0.31%, respectively.

Table 6: Concentration of phosphorus (%) in the plant in pre-flowering phase

Ionic Strength (I)	Phosphorus (%) in the plant at harvest			
	Soil Texture (T)			Average
	T_1	T_2	T_3	
I_1	0.29	0.27	0.13	0.23
I_2	0.22	0.15	0.09	0.16
I_3	0.19	0.12	0.08	0.13
I_4	0.14	0.10	0.07	0.10
Average	0.21	0.16	0.09	
LSD 0.05	T	I	T.I	
	0.01	0.01	0.01	

This is due to the fact that the salts found in the soil affect the soil solution and the efficiency and energy of the ions, or ion stress, through ionic strength. High levels of salts play a major role in limiting phosphorus availability in soil and uptake by plant (Awad, 1986). Al-Zaidi (2011) showed that the microbiology of soil affected by increased salinity, especially the solubility of phosphates and fungi of the roots (Mycoriza) negatively, and reduces the reachability of phosphorus to the roots and then to the rest of the plant parts. As Chritopher et al. (2009) and Al-kaysi and Al-Mamooree (2015) have shown, increasing calcium concentration in the soil as a result of adding salts to the soil can cause phosphorus precipitation and thus decrease its plant uptake. Buehrer (2001) referred to the effect of salts on the efficiency of phosphate fertilizers and the ability of salts, especially monocrystals such as sodium chloride, to dissolve calcium carbonate and release more calcium, which contributes to its concentration in the soil solution. This is reflected in the accelerated phosphorus adsorption mechanism.

Sharma et al. (2005) and Dahuki et al. (2013) pointed out that salinity caused harmful effects on plant growth, both direct and indirect. The direct effect is the inability of the plant to absorb water to increase the osmotic pressure of the soil solution and the phenomenon of imbalance in plant uptake of nutrients, which are ultimately reflected on the growth and yield of the plant. Or the competition between chloride and phosphate ions when chloride concentration is increased in soil solution due to saline conditions, where Al-Rekaby (2010) found that increasing chlorine ion concentration reduces the uptake of $H_2PO_4^{-1}$ ion by the plant due to antagonism and the high concentration of chlorine ion in the soil. This result is consistent with the findings of Ahmed et al., (2006) and Alauda (2009) when they studied that on wheat plants. The effect of soil texture on the concentration of phosphorus in the vegetative group of plant and wheat grains showed a significant effect of the soil texture in phosphorus in vegetative group of plant and in wheat plant grains, where there were significant differences amongall treatments. The highest content of phosphorus in plant was in treatment T_1 then in T_2 and finally at T_3at 0.42, 0.39 and 0.36% respectively. This is due to the fact that the silty clay loam soil contains a higher percentage of clay, which has a total phosphorus balance than the coarse texture soils, which have a high cation exchange capacity (CEC), rich in nutrients and high water content, And the number of soil minutes (Ali et al., 2014).Hassan (1985) and Hassan (2012) explained that the bonding energy between phosphates and soil was different depending on the clay content. Al-Rawi and Al-Hayati (1984) further confirm that the amount of phosphorus uptake in plants is higher in fine texture soils with higher total phosphorus content compared to coarse texture soilsof low phosphorus content.

The results of the statistical analysis showed a significant effect of ionic strength and soil texture, with the highest phosphorus value in the vegetative group. The wheat plant before flowering was 0.50% in T_1I_1 while the lowest value was 0.30% In the T_3I_4treatment.

Dry weight of vegetation:

Table 7 shows the effect of soil texture and ionic strength of the soil solution in the dry weight of the vegetative group in the pre-flowering phase. The results showed a significant effect of the ionic strength in the dry weight of the vegetative group. The dry weight of the vegetative group decreased with the increase of ionic strength of the soil solution. Among all treatments, the highest value in dry weight of the plant before flowering was in treatment I_1that was to 1.33 g.Plant^{-1} followed by I2, I3 and I4 were 0.97, 0.66 and 0.36 g. Plant^{-1} respectively, was decreasing directly with increasing the ionic strength of the soil solution. The decrease of the dry weight of the vegetative group was due to the increase in the ionic strength of the soil solution that happened due to the addition of salts to the soil, which led to increase the salinity of the soil which negatively affected the growth of the plant and the absorption of water and nutrients which also led to a decrease in plant growth and dry weight of the vegetative group (Mensah, 2006). Where all the biological processes in the plant are affected by the lack of water, which not only reduces the overall growth rate but also changes the shape and nature of the plant, where the proportion of roots to the vegetative part and increase the thickness of the cell walls and the amount of Lignin and cutin and reduce the leaf surface area and closing the stomata, Photosynthesis and breathing rate increases, resulting in an increase in the consumption of stored carbohydrates, which constitute a high proportion of dry weight as an energy source, thus reducing the dry weight of the vegetative group (Desingh and Kanagaraj, 2007).

Table 7: The dry weight of the vegetative group (gm.plant-1) in the pre-flowering stage

Ionic Strength (I)	The dry weight of the vegetative group (gm.plant-1) before flowering			
	Soil Texture (T)			Average
	T_1	T_2	T_3	
I_1	1.82	1.41	0.76	1.33
I_2	1.28	1.10	0.53	0.97
I_3	1.03	0.59	0.36	0.66
I_4	0.50	0.34	0.23	0.36
Average	1.16	0.86	0.47	
LSD 0.05	T	I	T.I	
	0.07	0.08	0.14	

The effect of soil texture on the dry weight of the vegetative group of wheat plant showed a significant effect of soil texture on dry weight of the plant. Significant differences were found in the dry weight before flowering in T1, T2 , T3 at 1.16 , 0.86 and 0.47 g. Plant-1 respectively. The superiority of the silty clay loam soil in the dry weight of the vegetative group is related to its nitrogen, phosphorus and potassium content that are higher and also have greater cation exchange capacity, clay and organic matter than the loam and sandy loam soil (Jarallah, Janabi, 2014, Suner and Galantini, 2015).

The bi-interaction had a significant effect on the dry weight of the vegetative compound of the plant, with the highest value in dry weight of the wheat plant before flowering at 1.82 g. Plant^{-1} in the treatment T_1I_1 while the lowest value was 0.23 g. Plant^{-1} in T_3I_4 treatment.

Uptake of the element of phosphorus (mg. Kg-1 dry matter) by the wheat plant in the stage before flowering:

Table 8 shows the effect of soil texture and ionic strength of the soil solution on uptake nutrients by the plant in the pre-flowering phase. The results showed a significant effect of ionic strength phosphorus contentin plant. The concentration of phosphorus uptake decreased with the increase of ionic strength of the soil solution in pre-flowering in the vegetative part of the plant with significant differences among the treatments. The highest value of phosphorus uptake in the plant prior to flowering in treatment I_1 was 6.32 mg P. Kg $^{-1}$ followed by treatment I_2, I_3 and I_4at 4.03, 2.48 and 1.13 mg P.kg^{-1}respectively, where it was direct decrease with increasing the ionic strength of the soil solution. This result is in line with Ahmad, et al., (2006), Zaidi (2011), Azooz et al., (2011), Elsayed et al., (2011), Which found a significant decrease in the uptake of phosphorus by increasing the salinity of the soil, which can cause the deposition of phosphorus and thus decrease the availability for plant, in addition to the reduction of the dry matter of the plant and reduction of phosphorus uptake.

Table 8: The Uptake amount of phosphorus (mg / kg-1 dry matter) by the plant for pre-flowering phase

Ionic Strength (I)	Phosphorus uptake in dry weight (mg / kg-1 dry matter) before flowering			
	Soil Texture (T)			Average
	T_1	T_2	T_3	
I_1	9.10	6.76	3.11	6.32
I_2	5.63	4.51	1.96	4.03
I_3	4.12	2.12	1.22	2.48
I_4	1.65	1.05	0.69	1.13
Average	5.12	3.61	1.74	
LSD 0.05	T	I	T.I	
	1. 03	1. 04	1.14	

The effect of soil texture on the concentration of phosphorus uptake in the dry weight of the vegetative group of wheat plant showed a significant effect of the soil texture in the phosphorus uptake in the vegetative parts of the plant. Where there were significant differences among the treatments, the highest treatment was in the phosphorus absorbed in the vegetative group of the plant in pre-flowering stage of the plant inT_1, T_2 and T_3at 5.12, 3.61 and 1.74 mg P. Kg^{-1} respectively, and this is due to the fact that the silty clay loam soil is superior to the sandy loam in increasing the uptake of phosphorus to different physical and chemical properties of soils. T_1 has the highest content of clay, surface area, organic matter, cation exchange capacity and nitrogen, phosphorus and potassium content (Table 1). This has been agreed with many researchers on the superiority of fine textured soils compared to the coarse ones in increasing the amount of phosphorus uptake in wheat plant from soil, Jarallah and Janabi (2014), Suner and Galantini (2015).

The effect of the binary interference on the concentration of phosphorus absorbed in the dry weight of the vegetative population of the plant showed that the results of the statistical analysis showed significant effect of ionic strength and soil texture in the absorbed phosphorus with the highest value of phosphorus absorbed in the vegetative group of the wheat plant before flowering 9.10 kg. T1I1 while the lowest value was 0.69 gg-1 in T3I4.

Correlations between the amount of phosphorus extracted by Olsen and 1% formic acid and the amount of phosphorus uptake by the wheat plant:

Table 9 shows the correlation between the amount of phosphorus extracted by Olsen and 1% formic acid for the three soil textures of the study, with the application of phosphorus and its uptake. It is noted from the table that the amount of phosphorus extracted at the beginning of the experiment was increased then decreased with the length of extraction time, where it was the highest was at the beginning of the application of the zero time fertilizer while the lowest quantity was before the wheat plant was at pre-flowering stage due to uptake the phosphorus by the growing plant In addition to the conversion of phosphorus over time to other formulas that is not available in the soil and cannot be extracted by both methods.

Table 9: Correlations between phosphorus extracted and uptake for different plant stages

Stage	Extraction method		Texture class	Notes
	Olsen	1%Formic acid		
Before planting	%55	%94	T_1	Phosphorus extracted before planting with phosphorus uptake before flowering
	%68	%68	T_2	
	%76	%72	T_3	
Before	%90	%91	T_1	Phosphorus extracted before flowering with phosphorus uptake before flowering
	%85	%93	T_2	
	%87	%84	T_3	

1 - Phosphorus extracted before planting with phosphorus uptake before flowering:

The results of the pre-planting stage and before the addition of phosphate fertilizers indicated that the 1% formic acid method was superior to the Olsen method, where the correlation coefficient values were 0.94 and 0.55 respectively for the silty clay loam soil (T_1) while the values were equal between the two methods (T_2), but the Olsen method was superior to 1% formic acid for soil in T_3.

2 - Phosphorus uptake and extracted at pre-flowering stage:

The results showed that the method 1% formic acid was superior to the Olsen method of the silty clay loam soil (T_1). The correlation coefficient values were 0.91 and 0.90 respectively and the loamy soil (T_2). The correlation coefficient values were 0.93** and 0.85** respectively, while the Olsen method was superior to 1% formic acid in soil with sandy loam texture (T_3), with correlation values of 0.87**and 0.84** respectively.

The results of the correlation relationship generally indicated that 1% formic acid was superior to the Olsen method in T_1 soil for both stages pre-planting and during plant growth. This may be due to increased clay content of this texture and thus increase the bonding energy of phosphate ions with the exchange complex compared to the two other textures (T2 and T3), which makes the formic acid method more efficient because it kept the soil pH level lower and increased the phosphorus release from the exchange complex to the soil solution compared to the alkali pH of Olsen. Besides, increased carbonate and organic matter content and cation exchange capacity (Table 1).Thus increasing the retention of phosphorus (Al-Salma, 2008, Jarallah and Janabi, 2014). Thus, the acidic 1% formic acid extraction method increases phosphorus release and further extraction. Formic acid has the ability to interact with calcium phosphate compounds in the soil and release phosphorus through the reaction of carboxyl group with calcium ions, which reduces calcium concentration in the soil solution, reduces phosphorus reaction with it and the composition of precipitated compounds (Oburger et al., 2011a and Desouza et al., 2014).

For T_2 soil, the Olsen method is equal to the 1% formic acid method of phosphorus extracted pre-planting with the amount uptake by the plant before flowering, while the 1% formic acid method is superior to the Olsen method of the phosphorus phase extracted from the soil before flowering with the amount uptake by plant at pre-flowering stage where that is related to the reasons mentioned above.

The results of Table 9 show that the Olsen method was superior to 1% formic acid in general for the phosphorus stages extracted from the soil prior to planting and before flowering with the phosphorus uptake in the wheat plant before flowering that was studied in the sandy loam soil. This may be due to the lack of clay, organic and carbonate content that increase the ability to absorb phosphorus on their surfaces.

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