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INORGANIC PHOSPHORUS FORMS IN ALLUVIAL AND CALCAREOUS SOILS AS AFFECTED BY DIFFERENT PHOSPHORUS APPLICATION LEVELS AND INCUBATION PERIODS.

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ABSTRACT

There is a debate concerning the optimum time of phosphorus application under Egyptian soil conditions. For this purpose, a laboratory incubation experiment was carried out at Soils Department, Faculty of Agriculture, Mansoura University to determine the inorganic phosphorus forms (Olsen-P, Ca-P, Oc-P, Al-P and Fe-P) in calcareous and non-calcareous (alluvial) soil types after different times of incubation. Phosphorus was applied at rates of 10, 20 and 30 mg / kg soil. Inorganic phosphorus forms was determined in both soils at the beginning of the experiment (at zero time of phosphorus application), and after one, two, three, four and five weeks from application. Results indicated that inorganic phosphorus forms increased with increasing phosphorus application rate. Available phosphorus form recorded the highest value after the immediate phosphorus application. Available phosphorus concentration decreased gradually over the time to reach the lowest value after the fifth week of application. On the other hand, the other precipitated phosphorus forms were increased over the time of application. Available P form was converted to unavailable P forms in the order Ca-P> Oc-P>Al-P>Fe-P. Results also showed that the fixation power of the calcareous soil was higher than the non-calcareous soil. Based on the obtained results of our experiment, it is recommended to add phosphorus fertilizers at the critical stage of phosphorus needed by plants.
Keywords: phosphorus forms, Alluvial and calcareous soils, incubation periods.

INTRODUCTION

Phosphorus is an essential element for plant nutrition. It plays important roles in plant physiology as it is participating in the structure of genetic and energy compounds. Phosphorus is a vital component of DNA, the genetic "memory unit" of all living things. It is also a component of RNA, the compound that reads the DNA genetic code to build proteins and other compounds essential for plant structure, seed yield, and genetic transfer. The structures of both DNA and RNA are linked together by phosphorus bonds. Phosphorus also is a vital component of ATP, the "energy unit" of plants. Thus phosphorus is essential for the general health and vigor of all plants. Some specific growth factors that have been associated with phosphorus are stimulated root development, increased stalk and stem strength, improved flower formation and seed production, more uniform and earlier crop maturity, increased nitrogen N-fixing capacity of legumes, improvements in crop quality, and increased resistance to plant diseases.

Available phosphorus after fertilizer addition reacts with calcium carbonate, clay minerals, iron, and aluminum compounds in the soil to be converted rapidly to less available forms by the process of phosphorus fixation. Because of these fixation mechanisms, cultivated crops seldom absorb more than 20 percent of fertilizer phosphorus in most soil conditions (Diez *et al*., 1992).

Although, most of soils in Egypt have high calcium carbonate content and could be considered as a calcareous soil, a little is known about the chemistry of P in these soils. Also, reports about the most efficient strategy for increasing P-fertilizers use efficiency are scarce. Most of Egyptian farmers are used to add the whole dose of P-fertilizers during soil ploughing. This will lead to a rapid fixation of substantial amounts of P-fertilizers before the critical stage of P absorption by plants.

There are two important pathways for increasing P-fertilizers use efficiency. The first pathway is works on changing the chemistry of soil surface layer through adding different mineral or organic amendments. Both added manure or litter and native organic matter (humic materials) have significant effects on P availability. Manure not only affects sorption and precipitation of P, but also it contains significant amounts of the element, which is thereby – deliberately or incidentally – added to the land (Wandruszka, 2006). The second pathway works mainly on the fertilizer product through various strategies viz. granulation of the product to decrease the contact area with the soil, splitting the fertilizer dose and changing the time of application. El-Ghamry *et al*., (2009) studied the effect of P fertilization splitting at different application time on P-fertilizer use efficiency, and they found that adding half the recommended phosphorus fertilization rate at sowing and the other half before the first irrigation was the best treatment to enhance phosphorus fertilizer use efficiency, contributing to an increased uptake of phosphorus by cowpea, reflected in the higher phosphorus concentration in the grains. Despite intensive work done in Egypt about the effect of different application times on the availability of P, a little is known about forms of inorganic P forms under different circumstances. Information on the chemical forms of phosphorus is fundamental for understanding phosphorus dynamics and its interactions in calcareous soils that is necessary for management of P.Some of the studies show that availability of P fertilizer in calcareous soils negatively correlate with $CaCO_3$ content of soil. However, there are some other reports suggested that P availability is mainly correlated with Ca^{2+} ions (Borggard *et al*., 1990 and Afif *et al*., 1993).

The main aim of this study is to investigate the effect of different P application rates and different incubation periods on forms of inorganic P under calcareous and non-calcareous soils **(**alluvial**)**.

MATERIALS AND METHODS

Soil sampling and analysis

Two surface soil samples (0-30 cm) were collected, the first was from a private farm in Talkha district, Dakahlia Governorate to represent alluvial (non-calcareous soil).and the other sample was collected from El-Hammam district, Matrouh Governorate to represent a calcareous soil. The obtained samples were air dried, crushed and passed through a 2-mm sieve. Some Physical and chemical analysis of soil samples were carried out according to the standard methods as mentioned down.

The experiment layout.

A laboratory experiment was carried out at Soils Department, Faculty of Agriculture, Mansoura University to investigate the effect of different incubation times for different P levels on mineral P forms. Main plots were assigned to P levels as 10, 20 and 30 mg P/ kg soil added in the form of KH2PO4. However, p-forms analysis times (i.e. at zero time of application and after one, two, three, four and five weeks of application) was represented in sub plots. Plastic dishes (13 cm diameter and 10 cm depth) were used for carrying out the incubation experiment. The used plastic dishes were filled with 100 g air-dry soil. Water was added to the soil to reach the field capacity, and the assumed water content was readjusted by weight every two days. Inorganic P forms (i.e. available form, Ca-P, Fe-P, Al-P and Oc-P ,) were determined before application and at the different incubation time mentioned above. Particle size distribution of the soil was carried out using the pipette method (Dewis and Fertias, 1970). Soil field capacity was determined by the method described by Richard’s (1954). Soil reaction (pH), and soil electrical conductivity (EC) were determined in the saturated soil paste, and the saturated soil paste extract, respectively, according to Richard’s (1954). Total carbonate was estimated gasometrically using Collin's Calcimeter and calculated as calcium carbonate according to Dewis and Fertias, (1970). The amounts of soluble ions (meq L^{-1}) in the soil were determined in saturation extract by method according to (Hesse, 1971) . Available soil phosphorus was extracted using Olsen method and determined colorimetrically by using a Spectrophotometer (Jackson,1958).The measured soil characteristics are listed in Table**1.** Fractionation of inorganic phosphorus forms was carried out by the method described by Hesse (1971).

At the first, the non-occluded Al+Fe bound P was removed by shaking 1 g of soil in 50 ml of 0.1 N NaOH-1 M NaCl for 17 h. The suspension was centrifuged, filtered through Whatman 42 paper and the solution saved for P analysis. The residue was then extracted for Ca–P by shaking with 50 ml of 1 N HCl for 1 h. Again, the suspension was centrifuged, filtered and the solution collected separately. Phosphorus concentrations in all the solutions were determined colorimetrically by the single solution method of Murphy and Riley (1962) and measured on a spectrophotometer at 882 nm. All analyses were done using duplicate samples. Occluded P (Oc-P) was estimated by extraction by adding 30 mL of 0.1M NaOH, shake for 1 hour and centrifuged.

Table (1): Some soil physical and chemical characteristics.

Soil characteristics			Calcareous soil	(Alluvial) Non-calcareous soil
Sand (%)			**58.5**	**23.05**
Silt (%)			**25.4**	**25.05**
Clay (%)			**16.0**	**50.00**
Soil texture			**Sandy loam**	**Clay**
Field capacity (%)			**19.0**	**35.0**
Calcium carbonate (%)			**14.5**	**4.00**
OM(%)			**0.50**	**1.10**
pH*			**8.20**	**7.80**
EC (dSm^{-1})**			**3.10**	**1.50**
soluble* ions**	**Soluble cations (meq L^{-1})**	Ca^{++}	**4.20**	**2.50**
		Mg^{++}	**1.30**	**0.70**
		Na^{+}	**5.90**	**3.10**
		K^{+}	**2.20**	**1.00**
	Soluble anions (meq L^{-1})	CO_3^{--}	**-**	**-**
		HCO_3^{-}	**0.85**	**0.40**
		Cl^{-}	**6.00**	**3.40**
		SO_4^{--}	**6.80**	**3.80**
Olsen-p (mg/kg soil)			**2.90**	**3.90**
Total P (mg/kg soil)			**374.9**	**1010**
Inorganic P forms (mg Kg^{-1})		**Ca-p**	**250**	**871**
		Oc-p	**111.6**	**93.6**
		Al-p	**10.1**	**3.5**
		Fe-p	**----**	**37.8**

***Soil pH was determined in soil paste.**
****Soil Electrical Conductivity (EC) was determined in soil paste extract.**
***** soluble ions were determined in soil paste extract.**

RESULTS AND DISCUSSION

Data presented in Tables 2 and 3 show the concentration (mg / Kg soil)and percentage (%)from the added P amount for the inorganic P forms in non-calcareous and calcareous soil, respectively as affected by phosphorus application rates and incubation periods.

Olsen (available) P form

Data illustrated in Tables 2 and 3 as well as in Fig.1 reveal that the available **P** form decreased sharply with increasing the incubation periods. On the other hand it can be said that the fixed **P** amount increased with increasing the incubation periods. Even at zero incubation period(after application immediately) the available **P** form decreased 9,6and 5.4%from the added **P** amount of 10,20 and 30 mg P/ Kg soil, respectively for the Non-calcareous soil. this figures increased under using the calcareous soil where the available **P** form decreased 11**,** 7.5 and 6.7 %for the above mentioned added **P** amount, respectively.

As shown from Table,2 the percentages of fixed amount from the added **P** decreased with raising the applied **P** from 10to 20 and 30 mg P/ Kg soil. So under using the Non-calcareous soil, the available **P** form represented 91**,** 68**,** 50**,** 35**,** 25and20**%**from the 10 mg P/ Kg soil after zero, 1**,** 2**,** 3**,** 4 and 5 weeks incubated period.

The available **P** form was 94**,** 74**,** 57.5**,** 43.5 **,**35and27.5**%**from the 20 mg P/

Kg soil for the same incubation periods, respectively. When the applied **P** increased to 30 mg P/ Kg soil the available **P** form increased to be 94.6**,**78.0**,**64.0**,**52.0**,**45.3and 41**%**from the added **P ,** for the same incubation periods , respectively.

The percentages of olsen **P** forms decreased under the three rates of **P** applied when using the Calcareous soil (Table 3 and Fig.1) . The percentages of the olsen- **P** form decreased from 89 to1% when the incubation period increased from zero to 5 weeks and the applied **P** was 10 mg P/ Kg soil. When the applied **P** increased to 20 mg P/ Kg soil, the percentage of available **P** form decreased from 92.5to12.5%**,**while it decreased from 93.3to 18.6%when the applied **P** was 30 mg P/ Kg soil and the incubation period increased from zero to 5 weeks.

It can be noticed from data in Tables 2,3 that the percentages of fixed amount decreased with raising the rate of applied **P** under the both used soils .On the contrarily, the percentage of the fixed **P** increased sharply with increasing the incubation period .So it is advisable to apply phosphorus fertilizer when the plant needs it i.e after one to two weeks from sowing not before planting.

Table (2): Concentration (mg/Kg soil) and percentage from the added p amount for the Inorganic P- forms In Non- calcareous Soil.

incubation period \ P -forms		Olsen- P		Ca –P		Oc –P		Al –P		Fe –P		Fixation power %
		Con.	%	Con.	%	Con.	%	Con.	%	Con.	%	
10 mg P/ kg soil	I.A.	3.9	0.0	871	0.0	93.6	0.0	3.5	0.0	37.8	0.0	0.0
	zero	13	91	871.4	4	93.8	2	3.6	1	38	2	9
	One week	10.7	68	872.9	19	94.3	7	3.7	2	38.1	3	32
	Two week	8.9	50	874	30	94.8	12	3.7	2	38.2	4	50
	Three week	7.4	35	874.9	39	95.2	16	3.8	3	38.2	4	65
	Four week	6.4	25	875.4	44	95.5	19	3.9	4	38.3	5	75
	Five week	5.9	20	875.7	47	95.6	20	4.0	5	38.4	6	80
20 mg P/ kg soil	I.A.	3.9	0.0	871	0.0	93.6	0.0	3.5	0.0	37.8	0.0	0.0
	zero	22.7	94	871.5	2.5	93.9	1.5	3.7	1	38	1	6
	One week	18.7	74	874	15	94.9	6.5	3.9	2	38.2	2	26
	Two week	15.4	57.5	875.9	24.5	95.75	10.75	4.1	3	38.4	3	42.5
	Three week	12.6	43.5	877.3	31.5	96.5	14.5	4.3	4	38.6	4	56.5
	Four week	10.9	35	878.3	36.5	96.8	16	4.45	4.7	38.8	5	65
	Five week	9.4	27.5	878.9	39.5	97.2	18	4.6	5.5	39	6	72.5
30 mg P/ kg soil	I.A.	3.9	0.0	871	0.0	93.6	0.0	3.5	0.0	37.8	0.0	0.0
	zero	32.3	94.6	871.7	2.3	94	1.3	3.7	0.6	38.1	1.0	5.4
	One week	27.3	78	874.7	12.3	95.5	6.3	3.9	1.3	38.3	1.6	22
	Two week	23.1	64	877.1	20.3	96.8	10.6	4.15	2.1	38.5	2.3	36
	Three week	19.5	52	879	26.6	97.9	14.3	4.35	2.8	38.7	3.0	48
	Four week	17.5	45.3	880	30	98.5	16.3	4.5	3.3	38.8	3.3	54.7
	Five week	16.2	41	880.6	32	98.9	17.6	4.55	3.5	38.9	3.6	59

I.A: Initial amount (mg/kg); con :concentration (mg p/kg soil)

$$\% = \frac{\text{con.} - \text{I.A.}}{\text{added amount (mg/kg)}} \times 100$$

Table(3): Concentration (mg/Kg soil) and percentage from the added p amount for the Inorganic P- forms In Calcareous Soil.

incubation period \ P -forms		Olsen- P Con.	Olsen- P %	Ca –P Con.	Ca –P %	Oc –P Con.	Oc –P %	Al –P Con.	Al –P %	Fe –P Con.	Fe –P %	Fixation power %
10 mg P/ kg soil	I.A.	2.9	0.0	250	0.0	111.6	0.0	10.1	0.0	0.0	0.0	0.0
	zero	11.8	89	250.7	7	111.9	3	10.2	1	0.0	0.0	11
	One week	8.9	60	252.5	25	112.7	11	10.2	1	0.0	0.0	40
	Two week	6.7	38	254	40	113.3	17	10.2	1	0.0	0.0	62
	Three week	4.9	20	255.2	52	113.7	21	10.3	2	0.0	0.0	80
	Four week	3.8	9	255.8	58	114	24	10.4	3	0.0	0.0	91
	Five week	3	1	256.4	64	114.2	26	10.4	3	0.0	0.0	99
20 mg P/ kg soil	I.A.	2.9	0.0	250	0.0	111.6	0.0	10.1	0.0	0.0	0.0	0.0
	zero	21.4	92.5	250.9	4.5	112	2	10.2	0.5	0.0	0.0	7.5
	One week	16.2	66.5	254.4	22	113.4	7	10.3	1	0.0	0.0	33.5
	Two week	12.1	46	257.4	37	114.3	13.5	10.3	1	0.0	0.0	54
	Three week	8.9	30	259.7	48.5	115	17	10.3	1	0.0	0.0	70
	Four week	6.9	20	261.2	56	115.5	19.5	10.3	1	0.0	0.0	80
	Five week	5.4	12.5	262.1	60.5	115.9	22	10.3	١	0.0	0.0	87.5
30 mg P/ kg soil	I.A.	2.9	0.0	250	0.0	111.6	0.0	10.1	0.0	0.0	0.0	0.0
	zero	30.9	93.3	251.1	3.7	112.1	1.7	10.3	0.7	0.0	0.0	6.7
	One week	23.5	68.6	256.5	21.7	114	8	10.3	0.7	0.0	0.0	31.4
	Two week	17.9	50	260.5	35	115.5	13	10.3	0.7	0.0	0.0	50
	Three week	13.7	36	263.5	45	116.5	16	10.4	1.0	0.0	0.0	64
	Four week	10.7	26	265.6	52	117.3	19	10.4	1.0	0.0	0.0	74
	Five week	8.5	18.6	267.2	57.3	117.9	21	10.4	1.0	0.0	0.0	81.4

I.A: Initial amount (mg/kg); con :concentration (mg p/kg soil)

$$\% = \frac{\text{con.} - \text{I.A.}}{\text{added amount (mg/kg)}} \times 100$$

As shown from the data , **P**- availability decreased in the calcareous soil more than the Non-calcareous one, this could be attributed to the high content of $CaCO_3$ in the Calcareous soil which led to decrease **P** – availability by various mechanisms. It is possibly that high influx of dissolved calcium ions may interact with $H_2PO_4^-$ ions to convert it in a precipitated form. The second mechanism may be attributed to the dominant Ca cation on the clay surfaces. Calcium is the dominant cation on the active clay surfaces in calcareous soils. In this respect, clays saturated with this ion can retain greater amounts of phosphorus than those saturated with sodium or other monovalent cations (Tisdale *et al*., 2003). The elevated amounts of organic matter on decreasing **P** precipitation is related to various mechanisms. One of these mechanisms is the competitive adsorption between low molecular weight organic acids and phosphate, which delaying **P** adsorption on active surfaces (Staunton and Leprince, 1996). In addition, the existence of organic matter in the soil matrix will promote the activity of phosphatase enzyme as phosphatase hydrolyses the phosphate esters into inorganic phosphorus (Malcolm and Vaughan, 1979).

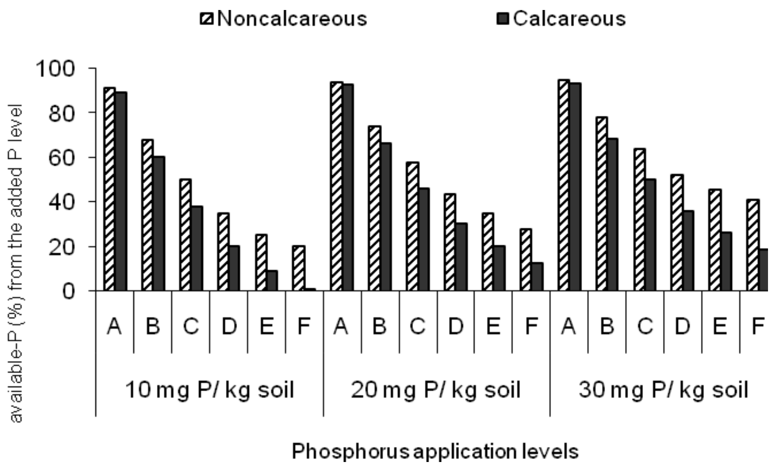

Figure (1): Available soil phosphorus percentages after different incubation periods for the three application levels.
A: After application immediately; B: One week after application; C: Two weeks after application; D: Three weeks after application; E: Four weeks after application; F: Five weeks after application

Ca-p form

Data in Tables 2 and 3 reveal that the calcium phosphate(Ca-p) is the highest inorganic form in the alluvial(Non-calcareous) and calcareous soil under study. The initial Ca-p values were 871 and 250 mg P/ Kg soil in the alluvial and calcareous soil, respectively.

Data in Tables 2 , 3 and Fig.2 reveal also that most of the decrease in olsen-p (available-p) was converted to the calcium phosphate which is considered the highest insoluble or unavailable inorganic form compared to the other insoluble inorganic forms i.e Oc-P, Al-P and Fe-P.

Due to the abundancy in Ca ions in alluvial and calcareous soil, so the first step in retaining available-p in soil is forming calcium phosphate Ca3 (PO4)2.which will be converted to apatite with aging Under using the alluvial soil (Non-calcareous)and with applying 10mg P/ Kg soil the formed Ca-P represented 4**,** 19**,** 30**,** 39**,** 44 and 47**%** from the applied **P** after zero**,**1 **,**2 **,**3 **,**4 and 5 weeks incubation periods **,** respectively**.** With applying 20 mg P/ Kg soil, the percentages of the formed Ca-P values were 2.5**,** 15**,** 24.5**,** 31.5**,** 36.5and 39.5**%** for the above incubation periods **,** respectively**.** The formed Ca-P represented 2.3**,** 12.3**,** 20.3**,** 26.6**,** 30 and 32**%** from the applied 30mg P/ Kg soil after zero**,** 1**,** 2**,** 3**,** 4 and 5 weeks incubation periods , respectively. The same trend was found with the calcareous soil but the formed Ca-P values were higher than the Non-calcareous due to it is higher contents from soluble and exchangeable calcium ions as well as the highest $CaCO_3$content .when applying 10 mg P/ Kg soil the formed Ca-P represented7**,** 25**,** 40**,** 52**,** 58 and 64**%**from the applied **P** after the incubation periods of zero**,**1**,**2**,**3**,**4and5 weeks , respectively. with applying 20 mg P/ Kg soil, the percentages of the formed Ca-P from the applied **P** increased from 4.5 to 60.5%with increasing the incubation period from zero to 5 weeks. whereas the percentages increased from 3.7 to 57.3% when the applied **P** was 30 mg P/ Kg soil with increasing the incubation period from zero to 5 weeks.

The present results are in harmony with those obtained by Afif *et al*., (1993) who demonstrated that, in calcareous soils, precipitation of insoluble Ca-phosphates form is believed to be a major factor in the loss of availability of applied P, although the relative contribution of adsorption and precipitation processes to P fixation in calcareous soils seems to depend on P application rate.

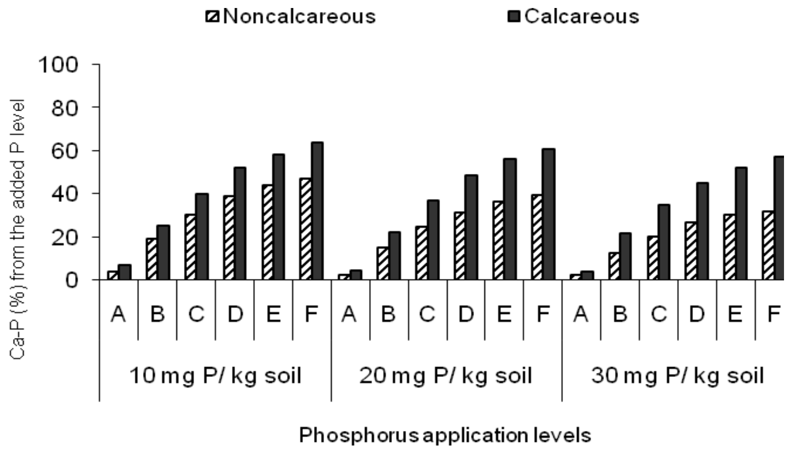

Figure (2): Ca-P percentages after the different incubation periods for the three levels of application.

A: After application immediately; B: One week after application; C: Two weeks after application; D: Three weeks after application; E: Four weeks after application; F: Five weeks after application

Occluded-P (Oc-P)

Occluded phosphates are little available and consist of calcium phosphate occluded in calcium carbonate, aluminum phosphate occluded in iron (III) oxides and reductant – soluble iron phosphate also occluded in iron (III) oxides.

Data in Tables 2 , 3 and Fig.3 show that ,in both used soils , the values of Oc-P formation come after the Ca-P . in the case of alluvial (Non-calcareous) soil, the formed Oc-P represented 2**,** 7**,** 12**,** 16**,** 19 and 20**%**when the added **P** was 10 mg P/ Kg soil **,**or 1.5**,** 6.5**,** 10.75**,** 14.5**,** 16.0and 18%with adding 20 mg P/ Kg soil and 1.3**,** 6.3**,** 10.6**,** 14.3**,** 16.3 and 17.6with applying 30mg P/ Kg soil after zero**,** 1**,** 2**,** 3**,** 4 and 5 weeks incubation periods , respectively.

Concerning the calcareous soil ,the formation rate of Oc-P increased compared with the alluvial soil . when the added **P** was 10 mg P/ Kg soil the formed Oc-P increase from 3 to 26 %,while with adding 20 mg P/ Kg soil it increased from 2 to 22% and when applying 30 mg P/ Kg soil, it raised from 1.7 to 21% when the incubation period increased from zero to five weeks.

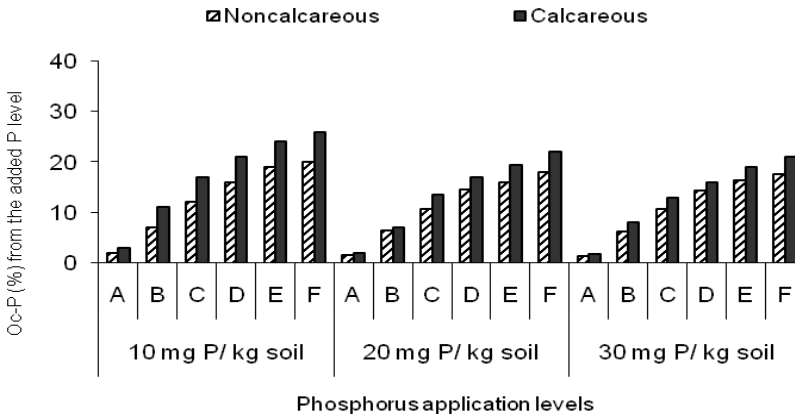

Figure (3): Oc-P percentages after different incubation periods for the three levels of application.

A: After application immediately; B: One week after application; C: Two weeks after application; D: Three weeks after application; E: Four weeks after application; F: Five weeks after application

Aluminum Phosphates (Al-P)

Data in Tables 2, 3 and Fig.4 reveal that the formation of the inorganic Al-P such as variscite comes the 3rd order after Ca-P and Oc-P, So the rate of its formation is too low than the above mentioned forms . Also the formation rate is higher in alluvial (Non-calcareous) soil than the calcareous one . In the case of alluvial soil and when **P** was added at the rate of 10 mg P/ Kg soil, the formed Al-p represented 1**,** 2**,** 2**,** 3**,** 4 and 5% only from the added **P** . while it represented1**,** 2**,** 3**,** 4**,** 4.7and5.5%from the added 20 mg P/ Kg soil, and when **P** applied at the rate 30 mg P/ Kg soil, Al-P form0.6 **,** 1.3**,** 2.1**,** 2.8**,** 3.3 and 3.5% from it were precipitated .

The formation of Al-P was lower in the case of calcareous soil compared to the alluvial (Non-calcareous) one under the three **P** application rates .For example when **P** applied at the rate of 30 mg P/ Kg soil, only 0.7to1%from it was precipitated in the Al-P form . this is may be attributed to the low Al content in calcareous soil than the alluvial one due to the low clay content in the former than the latter one .

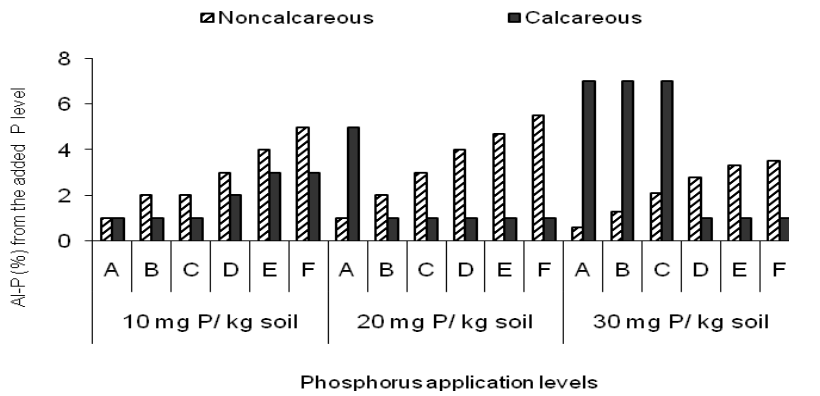

Figure (4): Al-P percentages after different incubation periods for the three levels of application.

A: After application immediately; B: One week after application; C: Two weeks after application; D: Three weeks after application; E: Four weeks after application; F: Five weeks after application

Iron Phosphate (Fe-P)

As shown from data in Tables 2,3 and Fig.5 , the conversion of added soluble p to unavailable Fe-P such as strengite was too little and similar to Al-p in alluvial soil. Fe-p was not detected or formed in the calcareous soil (Table3).

In the alluvial soil, Fe-P form represented from 2 to 6% from the applied 10 mg P/ Kg soil while 1 to 6% of the added 20 mg P/ Kg soil was converted to Fe-p forms . When **P** was added at 30 mg P/ Kg soil, only 1.0 to 3.6% from it was precipitated in the form of Fe-P . when the incubation period increased from zero to five weeks.

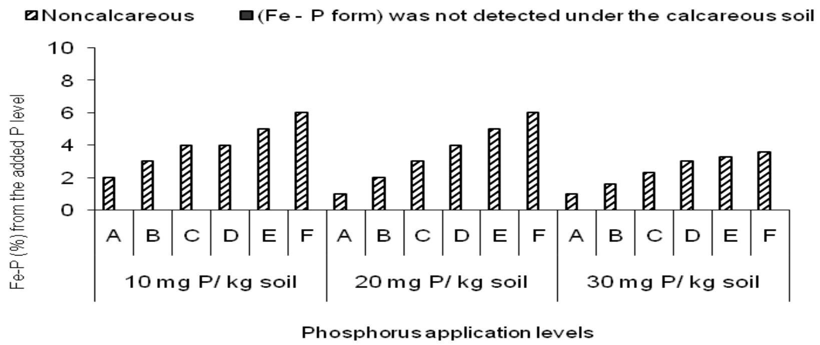

Figure (5): Fe-P percentages after different incubation periods for the three levels of application.

A: After application immediately; B: One week after application; C: Two weeks after application; D: Three weeks after application; E: Four weeks after application; F: Five weeks after application

Phosphorus fixation power

Data in Table 2 and 3 reveal that the fixation power of calcareous soil is greater than non-calcareous soil. It is also cleared that the fixation power of both soil types increased over time; however, the rate of increase in the calcareous soil is higher than in non-calcareous soil.

Concerning the non-calcareous soil (Table2) the fixation percentages after 5 weeks incubation periods reached 80**,** 72.5and 59**%**when added P was 10**,** 20and 30 mg P/ Kg soil, respectively .In the case of calcareous soil(Table3), the fixation percentages after five weeks incubation , were 99**,** 87.5 and 81.4**%** when added P was 10**,** 20 and 30 mg P/ Kg soil, respectively

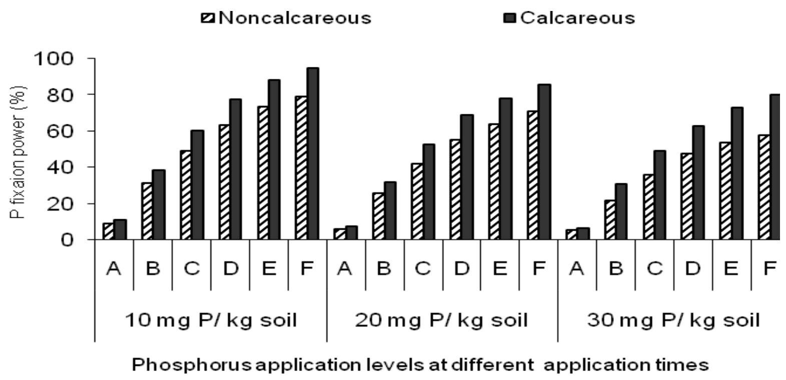

Figure (6): P fixation percentages after different incubation periods for the three levels of application

A: After application immediately; B: One week after application; C: Two weeks after application; D: Three weeks after application; E: Four weeks after application; F: Five weeks after application

CONCLUSION

Based on the obtained results of this study it could be concluded that phosphorus availability decreased over the time due to fixation in different inorganic forms, especially in calcareous soils. Therefore, it is recommended to add phosphorus fertilizers at the critical time of phosphorus requirement by plants.

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صور الفسفور الغير عضوي في الأراضي الرسوبيه والجيريه وتأثرها بإضافة الفسفور إلي التربة بنسب وفترات تحضين مختلفة

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هناك جدل واسع حول الوقت الأمثل لإضافة الفسفور تحت ظروف الأراضي المصرية. لهذا الغرض أجريت تجربة تحضين معملية بقسم الأراضي – كلية الزراعة – جامعة المنصورة لدراسة صور الفسفور المعدني في نوعي تربة جيرية و رسوبيه (غير جيرية) بعد أوقات تحضين مختلفة. تم إضافة الفسفور بمعدلات ١٠، ٢٠ و ٣٠ ملليجرام/ كجم تربة. تم تقدير صور الفسفور المعدني في كل من نوعي التربة في بداية التجربة (في نفس وقت الأضافة) وبعد اسبوع، أسبوعين، ثلاثة أسابيع، أربعة أسابيع وخمسة أسابيع من الإضافة. أظهرت النتائج زيادة تركيز صور الفسفور المعدني بزيادة معدل إضافة الفسفور. سجلت قيم الفسفور الصالح أعلي أرقامها بعد وقت الإضافة مباشرة. انخفضت قيم الفسفور الصالح تدريجيا بمرور الوقت لتسجل أقل قيمها بعد خمسة أسابيع من الإضافة. علي الجانب الاخر، صور الفسفور المترسبة الأخري ازدادت بمرور وقت الإضافة. أظهرت النتائج أيضا أن القوة التثبيتية للتربة الجيرية أعلي من مثيلتها في التربة الغير جيرية. بناءا علي النتائج المتحصل عليها من هذه التجربة يوصي باضافة الأسمدة الفوسفاتية في المرحلة الحرجة لاحتياج النبات للفسفور(الاضافه بعد الزراعه باسبوعين) .

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