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IMPROVING PHOSPHORUS USE EFFECIENCY AND ITS EFFECT ON THE PRODUCTIVITY OF SOME CROPS

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ABSTRACT

A field experiment was carried out in two successive seasons at El- Ismailia Agric. Res. Station, ARC, in El - Ismailia Governorate, Egypt, to study the efficiency use of two different sources of P fertilizer i.e. superphosphate (SP) versus rock phosphate (RP),both of them were used with three levels (0, 22 and 30 Kg P_2O_5 fed^{-1}), combined with two rates(20 & 30 L fed^{-1}) of humic acid as K-humate sprayed over the surface soil layer, some chemical soil properties (soil pH, electrical conductivity (EC) ,OM and available N, P and K) were determined after corn and sesame harvesting. Yield components of both corn and sesame were, also, evaluation along with N, P, and K uptake by corn and sesame (straw, grains and /or seeds).

Data revealed that the use of superphosphate (SP) and rock phosphate (RP) combined with humic acid increased slightly pH, EC and OM values in soil after corn and sesame harvesting. Also, EC in soil at both tested seasons, generally, had increased in presence of RP as compared to SP. Moreover, available N, P and K increased in soil along with the application of P- sources (SP & RP) combined with high rate of HA (30 L fed^{-1}). Also, the application of super phosphate (SP) combined with humic acid (30 L fed^{-1}) was superior as compared to rock phosphate (RP) at both tested soils after corn and sesame harvesting.

Obtained data show that the use of 30kg P_2O_5 from either superphosphate or rock phosphate combined with humic acid (30L fed^{-1}) was superior for increasing the yield components and biological yield of both corn and sesame yields as compared to both control and the other tested treatments. In addition, the application of SP combined with humic acid had a significant positive effect on both corn and sesame yield components(straw, grains and /or seeds and biological yield) as compared to RP treatments.

On the other hand , N, P and K uptake in straw, grains and /or seeds of both corn and sesame plants exhibited a positive significant trend along with the use of both P- sources as compared to the control treatment. Superphosphate increased significantly the uptake of N,P and K in straw and grains and/or seeds for both corn and sesame plants as compared to either rock phosphate or control treatment.

Moreover, the calculated values of P-use efficiency by corn and sesame plants indicated that the presence of high rate of humic acid had enhanced the P-use efficiency of both tested crops, similar results was observed in both P-sources especially for superphosphate. The highest P- use efficiency was obtained with the use of high level from P (30 kg P_2O_5) combined with high rate of humic acid (30L fed^{-1}). P use efficiency increased by increasing the rate of humic acid at both tested P - sources.

Keywords: super phosphate- rock phosphate- humic acid- P- use efficiency - corn- sesame- biological yield.

INTRODUCTION

Phosphorus is an essential nutrient for plant growth and is one of the most important elements in crop production. Despite its wide distribution in nature, it is a deficient nutrient in most soils. Many soils are defined as having high P-fixation capacity, since a substantial amount of any applied P-fertilizer is rendered unavailable. Therefore, the addition of fertilizers is necessary to correct the poor soil fertility (Elsheikh *et al*., 2005). Frequent applications of soluble forms of inorganic P are needed to maintain adequate P levels for plant growth (Rajan *et al*., 1996).

The application of soluble P- fertilizers such as superphosphate (SP) has been widely used, especially for cereal crops . However, much of soluble P applied as fertilizer may react with the soil and be fixed or converted into one of the many sparingly soluble forms, which are less available for uptake by plants. Also, rock phosphate (RP) is the main source for producing phosphate fertilizers and it is a good source of phosphorus. The ineffectiveness of rock phosphate as compared to superphosphate is the result of low water solubility of the rocks. However, treating RP with organic acids helps to dissolve the rock phosphate and increase the availability of phosphorus. Also, phosphorus has long been known to be present in natural organic matter from various sources, and found mainly in humic fractions (Stevenson,1982b).

Recently, Osman *et al*. (2002) and Elsheikh *et al*.(2007) found that rock phosphate and super phosphate significantly increased the dry weight of shoot and root of different crops . Also, such increases were observed in leaf contents of N, P and significantly increased available soil phosphorus with increasing level of the RP and SP while leaf content of K was neither affected by RP nor SP application. Malhi *et al* (2001) and Nesreen (2003) added that phosphorus use efficiency (PUE) and percent phosphorus recovery by wheat plants from P-fertilizer decreased with increasing fertilizer P-rate, while it was improved in the presence of manure.

Many reports have also revealed that various aspects of large quantities of P are found in seeds and fruits, where it is believed essential for seed formation and development. Phosphorus is also a component of phytin, a major storage form of P in seeds. About 60 to 70 per cent in cereal grains is stored as phytin or closely related compounds. An inadequate supply of P can reduce seed size, seed number, and viability. Generally, inadequate amount of P fertilizers slows the processes of carbohydrate utilization, delayed maturity of plants growth, decreased grain crops and disease resistance.

Moreover, Humic acid (HA), the major component of soil organic matter, are the subject of study in various areas of agriculture, such as soil chemistry, fertility, plant bioavailability, plant physiology, pH buffering as well as environmental sciences, because of the multiple roles played by these materials that can greatly benefit plant growth (Tan ,1998, and Hartwigson and Evans, 2000). The major effect of humic acid on plant growth have shown that HA may improve physical and chemical soil properties, favor a higher concentration of ions in soil solution, and act as source and sink for nutrients such as P, N, and K (Vaughan *et al*., 1985).In addition, humic substances are well known as complexing agent for transition metal cations, thereby facilitating enhanced uptake (Shaaban *et al*., 2009). Again, the beneficial effects of HA on plant growth may be related to their indirect increase of fertilizer efficiency or reducing soil compaction , or direct improvement of the overall plant biomass, in particular, the increase of root growth (Vaughan and Malcom, 1985). Their effects appear to be mainly exerted on cell membrane functions, promoting nutrient uptake or plant growth and development by acting as hormone-like substances (Hayes, 1997). The physiological effect of humic acids (HA) on some aspects of plant growth and metabolism are examined. Evidence has been presented that the effect of (HA) on plant growth depends on the source, concentration and the molecular weight of humic fraction, it seems that HA may influence both respiration and photosynthesis (Nardi *et al*., 2002). Concerning the positive effect of humic on yield, Hu Shuixiu and Wang Ruizhen(2001) mentioned that humic acid used as soil treatment or as spray at the seedling stage significantly increased the yield, seeds per plant, seed weight,100 seed weight of Faba bean and chlorophyll content of springing Soyabean plants, also, led to improving crop productivity, nutrient status and yield components.

Therefore, the objective of the present work is to study the efficiency of superphosphate versus rock phosphate as sources of P - fertilizer in combination with different rates of humic acid on corn and sesame yields (straw , grains and /or seeds and biological yield) , nutritional status, P use efficiency and some soil chemical properties.

MATERIALS AND METHODS

A field experiment was conducted in a sandy soil at two successive seasons at El- Ismailia Agric. Res. Station, Agric . Res. center (ARC), in Ismailia Governorate, Egypt, to study the effect of using two different phosphorous fertilizer sources and levels in combinations with different rates of humic acid (HA) on improving P availability in soil and its reflection on some cereal crops productivity. Corn (Zea mays L., cv Giza 10) and sesame (Sesame indicumL.,cv Shandawel) were used as a tested crops. Some physical and chemical properties (Black,1965) of the studied soil are shown in Table (1) .

The experiment was designed in a split- split plot design with three replicates under sprinkler irrigation system . The main plots were P fertilizer sources, while the sub-main plots were for P levels and sub -sub main plots were humic acid (HA) rates.

Phosphorus fertilizer sources were superphosphate (SP)15% P_2O_5 available and rock phosphate (RP)10% P_2O_5 , as total both of them were applied at three levels of 0, 22 and 30 as units of P_2O_5 fed^{-1} .

Phosphorus sources were spread over the plots with the tested levels and thoroughly incorporated into the upper 20 cm soil layer before cultivation. Humic acid (HA) derived from rice straw compost as K-humate and characterized according to Knonova and Bel (1961) was applied at a rate of 20 (H1) and 30 (H2) L fed^{-1} .The chemical composition of HA are shown in (Table 2) .

Humic acid treatments sprayed over the surface soil layer and divided into three doses, the first dose applied before cultivation, while the second and third doses were applied after 15 and 45 days from cultivation, respectively.

Table 1: Some physical and chemical characteristics of the experimental soil

Particle size distribution %	Values
Sand	89.9
Silt	5.30
Clay	4.80
Texture class	sandy
Chemical properties	
$CaCO_3$ %	1.12
pH (1:2.5 soil- water suspension)	7.86
EC dS/m (soil paste)	1.18
Organic matter %	0.27
Available nutrients (mg kg $^{-1}$) soil	
N	24
P	4.2
K	62
Cations meq L^{-1}	
Ca^{++}	5.30
Mg^{++}	2.25
Na^{+}	4.13
K^{+}	0.32
Anions meq L^{-1}	
CO_3^{--}	-
HCO_3^{-}	2.50
Cl^{-}	3.90
SO_4^{--}	5.60

Table 2 . Chemical composition of humic acid

Characteristics	pH	EC dSm^{-1}	OC (%)	Total macronutrients (%)			Total micronutrients mg L^{-1}			
				N	P	K	Fe	Mn	Zn	Cu
Humic acid	**6.10**	**61.5**	**9.50**	**1.29**	**0.25**	**2.00**	**92.3**	**11.6**	**2.65**	**0.36**

All plots received the recommended dose of nitrogen in the form of ammonium nitrate (33.5 %N) at rates of 400 Kg fed^{-1} for corn and 100 Kg fed^{-1} for sesame. Nitrogen was applied in 4 equal split doses after 2,4,6 and 8 weeks from sowing. Potassium was added in the form of potassium sulfate (48%K_2O) at the rate of 100 Kg fed^{-1} and 50 Kg fed^{-1} for both corn and sesame, respectively. Potassium fertilizer was divided into two equal split doses, the first was added at sowing and the second was applied after 30 days from sowing for both corn and sesame, respectively.

At harvest stage, surface soil samples (0-15 cm depth) were collected from each plot. Soil pH, electrical conductivity EC, OM and available N, P and K were determined according to Page *et al*. (1982). Corn and sesame plant samples were collected at harvest stage (120 and 110 days from planting, respectively) to determine the yield components (straw, grains and biological yield) for corn and straw, seeds and biological yield for sesame.

Plant samples were oven dried at 70°C for 48 h, up to a constant dry weight, then ground and prepared for wet digestion using H_2SO_4 and H_2O_2 methods as described by Page *et al*. (1982). The digests were then subjected to the measurement of nutrients N, P and K (Cottenie *et al*., 1982). Phosphorus use efficiency (PUE) was calculated as:

$$PUE= ((Pf-Pc)/P) \times 100$$

Where: Pf and Pc are the total P uptake and check (control) plots, respectively, and P is the applied P in kg fed^{-1} (Iqbal *et al*., 2003).

The obtained results were subjected to statistical analysis and the treatments were compared using the least significant difference (L.S.D.) at 0.05 level of probability, according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Effect of phosphorus sources and levels combined with humic acid on some chemical properties of the experimental soil:

soil reaction (pH)

It is well Known that the pH values is important for healthy plant growth and nutrients availability, thus data presented in Table (3) indicated that application of rock phosphate caused a significant decrease in soil pH as compared to both control and super phosphate treatments in the both soils cultivated with corn and sesame crops.

Also, obtained data clear that, high level of P sources increased pH values in soil cultivated with corn as compared to low level (22 Kg fed^{-1}) and /or control treatment. An opposite trend was obtained for pH values in soil cultivated with sesame plant. Moreover, pH values increased significantly along with increasing the level of HA applied for both corn and sesame crops .Such results are in harmony for both P fertilizer sources (SP and/or RP).Obtained data are in agreement with Hanafi and Salwa(1998) who found that soil pH increased with increasing levels of HA addition .These results, on the other side, may be due to release of charges carried by H^+ and/or OH^- ions to compensate the unbalanced cation-anion uptake at the soil – root interface (Hinsinger *et al*.,2003).

Electrical conductivity (EC)

Obtained results show that values Table 3) of EC in soil at both tested seasons, generally, increased in presence of rock phosphate as compared to super phosphate, In addition EC increased with increasing the rate of humic acid, this may be due the improvement of nutrients availability due to the presence of humic acid, which causes more solubility of nutrients. Moreover, HA contains more nutrients, different elements and function groups with high molecular weight and carbon contents (Fiorentino, *et al*.,2006). Also, organic acids play an important role in improving the bioavailability of soil nutrients, which cause a significant increase in the EC of the soil for both corn and sesame.

Organic matter content in soil.

Data in Table (3) reveal that OM content had positively responded to P sources application. High level of P sources (SP and /or RP) had also a positive significant effect on OM content as compared to control treatments. Moreover , the application of HA with (30 L fed.$^{-1}$), significantly affected OM content in soil after both corn and sesame harvested as compared to low rate (20 L fed.$^{-1}$). These results may be due to the HA is the major component of soil organic matter (Mecan and Petrovic ,1995). As organic materials in the soil decay, macromolecules of a mixed aliphatic and aromatic are formed (Chen and Aviad,1990). Hanafi and Salwa 1998) added that organic carbon increased as HA application increased.

Table 3. Effect of phosphorus sources and levels combined with humic acid on chemical properties of soil for both corn and sesame crops

Treatments			Chemical properties					
			Corn			Sesame		
Phosphorus treatments		Humic rates	pH (1:2.5)	EC (dSm^{-1})	OM (%)	pH (1:2.5)	EC (dSm^{-1})	OM (%)
sources	level							
SP	0	H1	7.60	0.60	0.22	7.60	0.80	0.39
		H2	7.80	0.70	0.40	7.80	0.90	0.41
	22Kg P_2O_5	H1	7.11	0.55	0.40	7.60	0.65	0.49
		H2	8.20	0.60	0.50	7.70	0.65	0.59
	30 Kg P_2O_5	H1	7.50	0.60	0.56	7.60	0.75	0.59
		H2	7.80	0.70	0.60	7.80	0.75	0.62
Mean values of SP			**7.67**	**0.63**	**0.45**	**7.68**	**0.75**	**0.52**
RP	0	H1	7.11	0.60	0.32	7.80	0.65	0.40
		H2	7.13	0.80	0.40	7.90	0.75	0.42
	22Kg P_2O_5	H1	7.12	0.60	0.50	7.20	0.60	0.50
		H2	7.14	0.75	0.54	7.90	0.65	0.59
	30 Kg P_2O_5	H1	7.00	0.60	0.57	7.11	0.65	0.60
		H2	7.30	0.80	0.60	7.50	0.70	0.63
Mean values of RP			**7.13**	**0.69**	**0.48**	**7.57**	**0.67**	**0.52**
Mean values of								
P rate	0		7.41	0.63	0.34	7.78	0.74	0.41
	22 Kg P_2O_5		7.14	0.68	0.49	7.60	0.71	0.54
	30 Kg P_2O_5		7.40	0.93	0.58	7.50	0.77	0.61
HA rate	H1		7.33	0.63	0.43	7.54	0.70	0.50
	H2		7.47	0.85	0.51	7.71	0.72	0.54
L.S.D at 0.05 %								
P source (A)			0.16	0.05	0.01	0.05	0.05	0.01
P rate (B)			0.09	0.03	0.03	0.08	0.03	0.03
Humic rate (C)			0.08	0.02	0.02	0.08	0.02	0.02
A*B			0.13	0.04	0.04	0.12	0.04	0.04
A*C			0.13	0.03	0.03	0.11	0.03	0.03
B * C			0.16	0.04	0.04	0.13	0.04	0.04
A * B * C			0.23	0.06	0.06	0.19	0.06	0.06

On the other hand, soil application of humic acid at a rate of 30 Lfed.$^{-1}$) combined with high level of super phosphate 30 kg P_2O_5 fed^{-1} were more affective in increasing OM content in soil after harvesting of both corn and sesame compared to other treatments. These results may be due to that HA is the major organic constituents of soil , but more importantly because it is very representative of complex environmental chemical system.

Macronutrients (N, P and K) availability in soil.

Concerning the macronutrients availability in soil after harvesting of both corn and sesame crops, data presented in Table (4) indicated significant increases of available N,P and K due to application of P combined with humic acid . Obtained data may be due to that HA has the ability to unlock nutrients in the soil that would otherwise be unavailable to the plant, while it also provides the transport mechanism making these nutrients readily available.

With regard to available N ,the obtained results generally, indicate that it increased significantly by the use of SP as compared to RP in both soils cultivated with corn and /or sesame . Also, high rate of P were more effective as compared to low P rate and /or control treatment. In other words, the application of high rate of HA (30 L fed^{-1}) was reflected on N availability in soil ,which recoded positive significant effect in soils cultivated with both corn and sesame. The interaction between P fertilizer sources and humic acid levels (Table 4) indicates that high rate of HA combined with high level of SP was more effective on N availability as compared to other tested treatments. The increase in available N could be attributed to the N contributed from the native N by the acids fraction, which caused a significant increase in available N in soil (McDonnell *et al*., 2001). Also , available nitrogen in soil cultivated with corn is reduced as compared to sesame may be due to high requirement of corn for nitrogen as compared to sesame.

With respect to P availability in soil , data in Table 4 indicated that available P increased due to application of of SP as compared to RP .This increase was related to the level of P fertilizer. High level of both SP and /or RP increased significantly P availability in soil as compared to low rate and / or control treatment in soil after both corn and sesame harvesting. Similar trend was obtained when HA was applied at high rate (H2)as compared to low rate (H1) .Brams (1973) dominated that HA added to alkaline soils generally reduce P fixation and solubilize insoluble P in soils to make it available for plant growth. In addition ,the effect of HA depends basically on the source of P fertilizer, which reduced soil P fixation and increased plants P availability from 8 to 24 % (Bermudez *et al*.,1993).The increase in available P might also be due to the mineralization of soil organic P (Vaughan *et al*., 1985 and Dusberg *et al*.,1989).

Concerning K availability in soil after corn and sesame harvesting, data in Table (4) indicated that the significant increase of available K due to added P fertilizer sources and HA . Added HA to the soil reduce K fixation and resulted in greater total extractable K and highly labile K, as well as greater plant K uptake (Olk and Cassman,1995). Moreover, application of HA enhanced microbial activity which caused an increased availability of K through dissolution of fixed K. Also, applied HA as K-humate was contributed to increased K-availability in soil. In addition, available K in soil after corn harvested was more passive affective by added both P sources combined with HA may be due to high required of corn plant from K as compared to sesame.

Table 4. Effect of phosphorus sources and levels combined with humic acid on available nutrients in soil of both corn and sesame crops

Treatments			Available nutrients in soil (mg Kg^{-1})					
			Corn			Sesame		
Phosphorus treatments		Humic rates	N	P	K	N	P	K
sources	levels							
SP	0	H1	142	13.1	21.0	168	10.2	48.1
		H2	188	15.7	28.1	187	10.7	55.2
	22Kg P_2O_5	H1	188	19.6	35.1	210	17.8	56.1
		H2	196	19.6	35.1	217	18.6	58.2
	30 Kg P_2O_5	H1	198	20.0	35.0	241	21.0	67.2
		H2	221	27.1	56.2	268	23.6	68.3
Mean values of SP			**189**	**19.2**	**35.1**	**215**	**17.0**	**59.0**
RP	0	H1	132	12.0	14.0	147	9.97	45.1
		H2	184	14.0	21.1	152	10.4	56.2
	22Kg P_2O_5	H1	185	17.4	21.1	170	16.8	56.2
		H2	196	17.7	21.1	188	19.3	63.2
	30 Kg P_2O_5	H1	201	19.8	35.1	227	21.0	64.2
		H2	210	21.0	35.1	255	22.6	65.2
Mean values of RP			**185**	**17.0**	**24.6**	**190**	**16.7**	**58.4**
Mean values of								
P rate	0		161	13.7	21.1	163	10.3	51.2
	22 Kg P_2O_5		191	18.6	28.1	196	18.1	58.4
	30 Kg P_2O_5		208	21.9	40.4	248	21.6	65.7
HA rate	H1		174	16.9	26.9	194	15.9	55.9
	H2		199	19.2	32.8	211	17.4	60.9
L.S.D at 0.05 %								
P source (A)			0.41	0.38	0.70	12.0	0.81	1.57
P rate (B)			0.83	0.61	0.71	3.86	0.42	0.39
Humic rate ©			0.53	0.48	0.30	3.17	0.28	0.31
A*B			1.17	0.87	1.00	5.46	0.60	0.56
A*C			0.76	0.68	0.43	4.51	0.40	0.44
B * C			0.93	0.83	0.52	5.52	0.49	0.54
A * B * C			1.31	1.17	0.74	7.81	0.69	0.77

Effect of phosphorus sources and levels combined with humic acid on nutritional status and yield components of both corn and sesame crops.

Yield components and biological yield.

Data presented in Table (5) reveal that yield components and biological yield of both corn and sesame (straw ,grains and/or seeds as well as biological yield) increased significantly due to tested P-fertilizer sources and levels as well as to the application of different humic acid (HA) rates.

With respect to P-fertilizer sources, obtained data reveal that, applied P- fertilizer as superphosphate (SP) form was superior for both corn and sesame yield components as compared to rock phosphate treatment. These increases reach to 22.3% ,12.3% and 18.6 % for both straw, grains and biological yield for corn, respectively, as well as sesame yield reach to 3.42%,12.4% and 4.93% for straw, seeds and biological yield ,respectively.

This may be due to the relatively low solubility of the P- in rock phosphate and hence, the phosphorus level in the root sorption zone is low, particularly, in early growth stages . It may also be attributed to the low development of plant compared with its rapid growth when soluble form of phosphorus is applied (Hammond *et al*.,1986).

Moreover, high level of SP was superior for both corn and sesame yields production as compared to low level and /or control treatment .Similar results was encountered with high rate of RP, which increased both corn and sesame yield components along with biological yield as compared to low level and/or control treatment.

Table 5. Effect of phosphorus sources and level combined with humic acid on yield components of both corn and sesame crops

Treatments			Yield components (Kg fed. $^{-1}$)					
			Corn			Sesame		
Phosphorus treatments		Humic rates	Straw	Grain	Biological yield	Straw	Seeds	Biological yield
sources	level							
SP	0	H1	1461	1261	2271	1288	243	1531
		H2	1612	1323	2935	1300	250	1550
	22Kg P_2O_5	H1	2450	1610	4060	1470	363	1833
		H2	4270	2013	6283	1890	401	2292
	30 Kg P_2O_5	H1	2660	1717	4377	1960	373	2333
		H2	4830	2310	7140	2100	541	2641
Mean values of SP			**2880**	**1706**	**4586**	**1668**	**362**	**2029**
RP	0	H1	1416	1238	2654	1278	217	1495
		H2	1440	1299	2739	1297	229	1526
	22Kg P_2O_5	H1	2030	1400	3430	1443	304	1747
		H2	2800	1470	4270	1750	332	2082
	30 Kg P_2O_5	H1	2380	1610	3990	1873	357	2231
		H2	3360	1960	5320	2030	464	2495
Mean values of RP			**2237**	**1496**	**3734**	**1611**	**317**	**1929**
			Mean values of					
P rate	0		1482	1280	2763	1291	234.8	1526
	22 Kg P_2O_5		2888	1623	4511	1638	351	1988
	30 Kg P_2O_5		3308	1899	5208	1990	434	2425
HA rate	H1		2066	1473	3539	1552	310	1862
	H2		3051	1729	4781	1728	370	2098
L.S.D at 0.05 %								
P source (A)			511	5.48	70.3	2.87	1.02	1.49
P rate (B)			107	12.4	108	3.15	1.38	3.15
Humic rate ©			71.8	12.9	72.4	2.31	1.34	2.73
A*B			152	17.6	152	4.45	1.95	4.45
A*C			102	18.3	103	3.28	1.90	3.88
B * C			125	22.4	126	4.01	2.33	4.75
A * B * C			177	31.7	178	5.68	3.29	6.72

Also, high increment of corn and sesame yields were observed due to high rate of humic acid (30 L fed^{-1} ,H2) combined with P-fertilizer sources rather than low rate of humic acid (H1) ,Table (5). Also, yield components increased significantly by increasing the rate of humic acid amendments, these data agreed with the results reported by Atiyeh *et al*. (2002).

The application of superphosphate combined with high rate of HA was superior for both corn and sesame yields (straw, grains and/or seeds along with biological yield) as compared to rock phosphate(RP). These results are in agreement with Brannon and Sommers (1985) who mentioned that the increase in crop yield due to the application of HA, may due to improving of P supplying power of the soil together with the improvement in the soil physical environment .

Nutritional status.

Data presented in Table (6) show the effect of P fertilizer sources in combination with different HA rates on the nutrients uptake by corn and sesame grow in sandy soil . Data clear that , the application of both SP and /or RP ,regardless of the application rates ,positively increased N,P and K of both straw and grains and /or seeds of both corn and sesame compared to control treatment. The positive relationship between the increase and the availability of nutrients in the soil with increased absorption of these elements by plant. These results confirmed the findings of Osman *et al*.(2002) and Elsheikh *et al*. (2007) who found that application of rock phosphate or super phosphate significantly improved the leaf content of nitrogen and phosphorus , this may be attributed to increasing solubility of phosphorus forms from different sources with time, hence, enhancing the absorption of P- anion.

Concerning the effect of P rates , mean values, of obtained data show that the application of 30 Kg P_2O_5 fed^{-1} from both SP and /or RP had more positive effect on macronutrients uptake as compared to low rate 22 Kg P_2O_5 fed^{-1}. Also, HA applied with different rates had a positive significant effect on macronutrients uptake ,high rate H2 increased nutrients uptake in both straw and grains and/or seeds for corn and sesame ,respectively. Obtained results may be due to that HA can stimulate plant growth in the presence of vitamins, amino acids, gibrellines and axuxin like growth promoting substances in the organic matter(O' Donnell,1973).

The interaction between P sources and humic acid application (Table 6) reveal that nutrients uptake for both straw and grains of corn plant had positively responded to the use of applied HA, especially at high rate of HA 30 $Lfed^{-1}$ (H2) .Similar trend was recorded with sesame components (seeds and straw) .These increments of nutrients uptake might have influenced plant growth directly, through its effects on ion uptake by the effects on plant growth regulators (Atiyeh *et al*.,2002). Also, Fagbenro and Agboda (1993) and David *et al* .(1994) have reported promoted growth and nutrients uptake of plant due to the addition of HA. The plants take more mineral elements due to the better development of the root systems along with development of proliferate root hair and increasing surface area from branches and root hairs, which should increase the efficiency of the root in uptake of N,P and K (Valdrighi *et al*., 1996)

In addition ,the stimulation of ion uptake in accompanied HA led many investigators to propose that these materials may affect membrane permeability (Zientara ,1983 and Tattini *et al*.,1991) . It is related to the surface activity of humic acid resulting from the presence of both hydrophilic and hydrophobic sites (Chen and Schnitzer, 1978).

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Therefore, HA may interact with phospholipids structure of cell membranes and react as carriers of nutrients through them (Asik *et al*.,2009) .

P- use efficiency

Phosphorus use efficiency from different P- fertilizer sources can be calculated in terms of P- uptake per unit of fertilizer sources. The calculated values of P-use efficiency by corn and sesame plants are represented in Table (7). Data indicated that the presence of high level from humic acid enhance the P-use efficiency of both tested crops Similar results was observed in both P-sources especially for super phosphate . The highest P-use efficiency was obtained with the high level from both P- sources (30kg P_2O_5) and high level from humic acid (30 L fed^{-1}) . However, P use efficiency increased by increasing the rate of humic acid amendments at both tested P –sources , similar results were recorded for both tested crops. These results are in agreement with the findings of (El-Ghamry *et al*. 2009) who found that humic acids had a direct effect on faba bean net yield , due to that HA are extremely important component because they constitute a stable fraction of carbon, thus regulating the carbon cycle and release of nutrients, including N, P and S which decreasing the need for inorganic fertilizers for plant growth. HA stimulates plant growth by the assimilating of major and minor elements enzyme activation and / or inhibition, changes in membrane permeability, protein synthesis and finally the activation of biomass production (Ulukan, 2008).

Table 7 . Effect of phosphorus sources and level combined with humic acid on nutrients uptake of Sesame

Treatments			P- use efficiency	
Phosphorus treatments		Humic rates	Corn	Sesame
sources	level			
SP	0	H1	-	-
		H2	-	-
	22Kg P_2O_5	H1	36.4	13.1
		H2	78.6	20.1
	30 Kg P_2O_5	H1	34.5	18.7
		H2	87.9	24.2
RP	0	H1	-	-
		H2	-	-
	22Kg P_2O_5	H1	21.8	10.4
		H2	33.9	15.2
	30 Kg P_2O_5	H1	25.3	16.4
		H2	45.0	20.5

Conclusion

Application of phosphorus fertilizer sources(super phosphate and /or rock phosphate) combined with humic acid improved P fertilizer for corn and sesame development .The high rate of humic acid 30L fed^{-1} improved the solubility of both P- sources which causes a significant increase in P- use efficiency , nutritional status, yield components and biological yield of corn and sesame especially for super phosphate .

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تحسين كفاءة استخدام الفوسفور وأثره على انتاجية بعض المحاصيل

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تم تنفيذ تجربة حقلية فى موسمين متعاقبين بمحطة البحوث الزراعية بالاسماعيلية – مركز البحوث الزراعية – محافظة الاسماعيلية - مصر - لدراسة كفاءة استخدام مصادر مختلفة من التسميد الفوسفاتى على سبيل المثال السوبر فوسفات (SP) بالمقارنة بصخر الفوسفات (RP) وقد اضيف كل منهما بثلاث معدلات (صفر، 22، 30 كجم فو2أ5 / فدان) مختلطة مع معدلين من حامض الهيوميك (20، 30 لتر / فدان) كهيومات بوتاسيوم تم اضافتهما على سطح التربة ودراسة اثر ذلك على بعض الخواص الكيميائية للتربة مثل رقم الحموضة (pH) والتوصيل الكهربى (EC) والمادة العضوية ، تركيز عناصر النيتروجين والفوسفور والبوتاسيوم الميسر بعد حصاد كل من الذرة والسمسم. كما تم تقديرمحصولى الذرة والسمسم ومكوناتهما(قش ، حبوب او بذور) وكميات النيتروجين والفوسفور والبوتاسيوم الممتصة لكل منهما.

أشارت النتائج أن استخدام السوبر فوسفات وصخر الفوسفات مختلطا مع حامض الهيوميك يسبب زيادة طفيفة لقيم لكل من pH ، EC والمادة العضوية فى الارض بعد حصاد كل من الذرة والسمسم . علاوة على ذلك و بصفة عامة تزيد قيم EC فى وجود RP بالمقارنة بالسوبر فوسفات . وجد ان قيم النيتروجين والفوسفور والبوتاسيوم الميسر فى الارض تزيد عند اضافة كل من SP&RP مختلطا مع 30 لتر / فدان من حامض الهيوميك.

وقد وجد أن اضافة السوبر فوسفات مختلطا بحامض الهيوميك (30 لتر / فدان) قد تفوق فى محتوى التربة من عناصر النيتروجين والفوسفور والبوتاسيوم الميسرة بالمقارنة بصخر الفوسفات بعد حصاد الذرة والسمسم

أظهرت النتائج ان استخدام 30 كجم فو2أ5 من السوبر فوسفات أو صخر الفوسفات مختلطا مع حامض الهيوميك 30 لتر/ فدان قد سبب زيادة فى مكونات المحصول والمحصول البيولوجى لكل من الذرة والسمسم بالمقارنة بالكنترول او المعاملات الاخرى . بالاضافة إلى ذلك فقد ادت اضافة السوبر فوسفات مع حامض الهيوميك الى زيادة معنوية موجبة لكل من محصولى الذرة والسمسم (قش – حبوب او بذور) والمحصول البيولوجى بالمقارنة بمعاملات صخر الفوسفات .

من جهة اخرى فقد وجد ان هناك اتجاها معنويا موجبا لامتصاص العناصر (النيتروجين ، الفوسفور والبوتاسيوم) فى القش والحبوب او البذور لكل من محصولى الذرة والسمسم عند استخدام كل من مصدرى الفوسفور بالمقارنة بمعاملة الكنترول ويزيد امتصاص هذه العناصر معنويا فى القش والحبوب او البذور عند اضافة السوبر فوسفات لكل من الذرة والسمسم بالمقارنة بصخر الفوسفات ومعاملة الكنترول

علاوة على ذلك ، فان القيم المحسوبة لكفاءة استخدام الفوسفور بواسطة نبات الذرة والسمسم ، أكدت أنه فى وجود المعدل العالى من حامض الهيوميك فإنه يحسن كفاءة استخدام الفوسفور لكل من المحصولين تحت الاختبار. ونفس النتائج وجدت ايضا بالنسبة لمصدرى الفوسفور خاصة السوبر فوسفات – قد تم الحصول على أعلى معدل لكفاءة استخدام الفوسفور باستخدام المعدل العالى من الفوسفور (30 كجم فو2أ5 / فدان) . وتزيد كفاءة استخدام الفوسفور بزيادة معدل حامض الهيوميك لكل من مصدرى الفوسفور المستخدمين.

قام بتحكيم البحث

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Table 6. Response of phosphorus sources and rates combined with humic acid on nutrients uptake by both corn and sesame crops

Treatments			Nitrogen uptake (kg fed^{-1})				Phosphorus uptake (kg fed^{-1})				Potassium uptake (kg fed^{-1})			
			Corn		Sesame		Corn		Sesame		Corn		Sesame	
Phosphorus treatments		Humic rates	Straw	Grains	Straw	Seeds	Straw	Grains	Straw	Seeds	Straw	Grains	Straw	Seeds
sources	level													
SP	**0**	**H1**	**42.1**	**40.8**	**35.4**	**7.10**	**5.50**	**4.83**	**4.47**	**1.34**	**33.3**	**39.5**	**32.7**	**5.52**
		H2	**46.9**	**43.7**	**35.7**	**7.82**	**6.67**	**5.16**	**4.98**	**1.60**	**36.7**	**41.5**	**33.2**	**5.71**
	22 Kg P_2O_5	**H1**	**71.7**	**52.9**	**41.0**	**11.4**	**11.1**	**7.25**	**6.07**	**2.61**	**55.9**	**50.6**	**37.7**	**8.28**
		H2	**130**	**71.5**	**53.2**	**12.9**	**20.1**	**9.06**	**8.00**	**3.01**	**97.6**	**63.2**	**48.7**	**9.17**
	30 Kg P_2O_5	**H1**	**81.4**	**60.5**	**55.6**	**13.1**	**13.2**	**7.84**	**8.43**	**3.17**	**60.7**	**54.2**	**50.7**	**8.52**
		H2	**151**	**82.5**	**59.6**	**19.1**	**28.0**	**11.1**	**9.10**	**4.98**	**111**	**72.6**	**54.5**	**12.4**
Mean values of SP			**87.2**	**58.7**	**46.8**	**11.9**	**14.1**	**7.54**	**6.84**	**2.79**	**65.9**	**53.6**	**42.9**	**8.27**
RP	**0**	**H1**	**40.3**	**40.3**	**35.1**	**6.52**	**5.25**	**4.70**	**4.60**	**1.19**	**32.2**	**38.7**	**32.7**	**4.86**
		H2	**45.6**	**42.3**	**35.6**	**7.67**	**5.96**	**5.31**	**5.02**	**1.53**	**32.8**	**40.8**	**33.3**	**5.17**
	22 Kg P_2O_5	**H1**	**60.1**	**48.4**	**39.8**	**10.4**	**8.73**	**6.02**	**5.77**	**2.31**	**46.3**	**43.9**	**37.2**	**6.90**
		H2	**84.4**	**52.0**	**48.6**	**11.6**	**12.4**	**6.32**	**7.23**	**2.66**	**54.3**	**46.3**	**45.1**	**7.58**
	30 Kg P_2O_5	**H1**	**71.1**	**55.9**	**52.3**	**13.3**	**10.4**	**7.41**	**7.80**	**3.08**	**63.9**	**50.7**	**48.4**	**8.17**
		H2	**102**	**69.6**	**56.9**	**17.4**	**15.2**	**9.99**	**8.80**	**4.09**	**76.9**	**61.9**	**52.5**	**10.6**
Mean values of RP			**67.4**	**51.5**	**44.7**	**11.2**	**9.66**	**.63**	**6.54**	**2.48**	**51.1**	**47.1**	**33.3**	**39.5**
Mean values of														
P rate	**0**		43.7	41.8	35.5	7.28	5.84	5.00	4.77	1.42	33.8	40.1	32.9	5.32
	22 Kg P_2O_5		86.6	56.2	45.7	11.6	13.1	7.16	6.77	2.65	63.5	51.0	42.2	7.98
	30 Kg P_2O_5		101	67.1	56.1	15.7	16.7	9.08	8.53	3.83	78.3	59.9	51.5	9.93
HA rate	**H1**		61.1	49.8	43.2	10.3	9.03	6.34	6.19	2.28	48.7	46.3	39.9	7.04
	H2		93.4	60.3	48.3	12.8	14.7	7.82	7.19	2.98	68.3	54.4	44.6	8.44
L.S.D at 0.05 %														
P source (A)			13.9	5.80	2.32	1.12	2.67	0.86	0.65	0.14	2.46	0.14	0.58	0.09
P rate (B)			8.96	1.82	1.19	0.71	1.27	0.66	0.92	0.12	2.19	0.54	0.62	0.13
Humic rate(C)			5.31	2.01	0.96	0.53	0.96	0.53	0.51	0.09	1.83	0.44	0.45	0.05
A*B			12.7	2.58	1.69	1.01	2.21	0.93	1.30	0.17	3.09	0.76	0.88	0.18
A*C			7.54	2.86	1.36	0.76	1.36	0.75	0.73	0.13	2.61	0.62	0.64	0.06
B * C			9.24	3.50	1.66	0.93	1.67	0.91	0.89	0.15	3.19	0.76	0.78	0.08
A * B * C			13.1	4.95	2.35	1.32	2.36	1.29	1.26	0.22	4.51	1.08	1.10	0.11