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Phosphate Fertilizer –Humic Acid Interaction and Its Effect on Soil Properties and Fertility As Well As Quality and Quantity of Maize Production

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Abstract

Two field experiments were designed to quantify the effect of combined phosphate fertilizer with humic acid on maize growth, i.e., plant height and dry weight plant^{-1} ; yield components, namely ,number of rows ear $^{-1}$,number of grains ear $^{-1}$ and 100-grain weight; yield parameters (grain, stover and biological yields) ;N,P and K uptake as well as soil properties and fertility after maize harvest . The experiments were conducted at Sids Agriculture Research Station, A.R.C , Beni Suef Governorate ,Egypt during two successive seasons of 2017 and 2018 .The treatments were : Phosphorus levels (0.0 ,37.0 and 74.0 kg P ha^{-1}) and humic acid (without,0.2% foliar spraying and 24 kg ha^{-1}humic acid) .The results revealed that increasing phosphorus levels up to 74.0 kg P ha^{-1} improved soil available phosphorous after harvest ,while other soil properties and fertility did not affect . Also, it increased all studied growth parameters, yields and yield components as well as N,P and K uptake , except number of grains row^{-1} .Added humic acid as soil application improved soil pH ,EC ,soil organic matter and the availability of N,P and K in soil after harvest . Humic acid, whether as foliar or soil application enhanced maize growth, yields and its components and N,P and K uptake ,where added humic as soil application have more pronounced affect . The interaction between phosphorous and humic acid show that ,combined 37.0 kg P h^{-1} with 24 kg ha^{-1}humic acid as soil application produced equal affect as 74.0 kg ha^{-1} on the studied quality and quantity of maize , which means the possibility of save about 37.0 kg ha $^{-1}$ by using humic acid as soil application .

Key words: Humi cacid, phosphorous fertilizer, maize growth parameters, yield, yield components, N, P and K up take.

Introduction

Maize (Zea maize L.) is the most important cereal crop after rice and wheat in the world, concerning cultivated area and production, maize grains is commonly used as human consumption, animal feeding, starch industry and oil productivity. Maize grains have great nutritional value as it contain 72% starch, 10% protein, 4,8% oil, 8.5% fibr, 3% sugar and 1.7% ash (Hassanien, 2018).Also, because of its worldwide distribution and lower price, relative to other cereals, maize has a wide range of uses than other cereals . It is the stable food crop and the base of most rural diets, as well as a cash money crop, In poor communities, it is the main source of calories and protein, as well as the primary weaning food for babies.

Phosphorus is the most important nutrient after nitrogen limiting factors in agricultural production .Many factors affected the P availability for plants, include the native soil P, the type of applied phosphorus, soil pH (Kogbe and Adediran (2003). The deficiency of phosphours occur widely in alluvial soil and therefore plant production is responded to P application. Many authors reported that maize plants were significantly responded to phosphorus fertilization such as Majidian et al (2006), Mazengia (2011),Omar (2014),Salem (2000),Hussain et al (2006),Yosefi et al (2011),Amhakhian and Osemwota (2012).

Humic acid(HA) is the derivative product of decomposed organic material that soluble in alkali and insoluble in acid (Mikkelsen ,(2005)and Pena – Mendez et al .,2005).The structure molecule of HA consist of six carbon aromatic rings of the basis of di-or tri –hydroxy phenols linked by –O-,-NH-,-N-,-S and contain –OH group and quinine (O-C_6H_4-O-) ‹Tan,(1998).Humic acid (HA) is acyclic organic compound having high molecular weight ,long chain and active carboxyl group (-COOH) and phenolic(-OH),which are amphoteric ,binding of cations and anions at certain pH dependent charge (Stevenson ,1994;Bohn et al .,2001;Pena-Mendez et al .,2005 ; Khaled and Fazy,2011).Addition of HA to soil increases the rate of absorption of ions on root surfaces and their penetration into the cells of the plant tissue .The effect of HA on the availability of P and micronutrients has been given particular attention because of observed increases in uptake rates of these nutrients following application of HA (Ayuso et al .,1996). The aim of this study was to determine the effect of phosphorus and humic acid as soil or foliar application on the soil properties (pH,EC, organic matter ,bulk density and N,P and K availability),the efficiency of phosphorus fertilizer and maize productivity .

Materials and methods

Two field experiments were conducted in the Experimental Farm of Sids Agricultural Research

Station, ARC, Beni-Suef Governorate, Egypt to study the effect of using humic acid to improve the efficiency of using phosphorus fertilizer and its effect on maize productivity and some soil properties after maize harvest. A factorial design in complete randomized blocks with two factors in four replications was used in the two growing seasons (2017 and 2018 seasons).The first factors was phosphorus fertilizer levels (0.0, 37.0 and 74.0 kg P ha^{-1}), while the second factor were humic acid (without, 0.2% foliar spraying of humic acid and 24.0 kg ha^{-1} humic acid as soil application).Each plot consisted of five ridges, 3.0 mlong, 70 cm apart (10.5 m^2) and 25 cm between hills. The maize grains, variety Single Cross 10 were sown at May 13^{th} and 17^{th} in the two seasons respectively .Thinning was done before first irrigation to one plant /hill.Phosphorus treatments were done before planting during land preparation .The soil application of humic acid were done by prepare 1:10 humic acid (powder form): water solution and added to soil through irrigation water at rate of 24 $kgha^{-1}$in two equal doses , the first through . first irrigation and the second through the second irrigation . However , the foliar spraying of humic acid(liquid form) by spraying humic acid (2cm^3 liquid humic to one liter water) twice on maize plant , the first before first irrigation and the second after one month later at rate of 400 and 800 liter ha^{-1} for the two spraying ,respectively . The preceding crop was wheat for the two seasons. Other cultural practices for maize production were done as at in district. Soil samples (0-30 cm) were collected before sowing from experimental sites in the two growing seasons to determine some physical and chemical properties according to A.O.A.C.(1990) and listed in Table 1.Five plants were randomly taken from each plot during tasseling –silking stage (about 60 days age) from the two inner rows to measure some growth parameters ,i.e., plant height (cm) ,dry weight /plant (g) ,number of leaves /plant and leaf area (cm^2) .At harvest , five plants were taken from each plot from the two inner rows to measure some yield components ,i.e., number of rows/ear ,number of grains/row and 100-grain weight (g).Grain and stover yield were determined for each plot and converted to Mg ha^{-1}.Nitrogen ,phosphorous and potassium concentration in both grains and stover were determined according to A.O.A.C.(1990) .After harvest , soil samples (0-30cm) from each plots were taken to determine some soil properties ,i.e.,pH,EC and soil organic matter as well as soil available N,P and K. The data were subjected to the proper statistical analysis according to Snedecor and Cochran(1980).The treatments were compared by L.S.D test at 0.05 probability.

Table1. Physical and chemical properties of the experimental soil.

Soil properties	2016/2017	2017/2018
Particle size distribution		
Clay %	53.47	54.37
Silt %	30.17	29.95
Sand %	16.36	15.68
Texture grade	Clay	Clay
pH (1:2.5 soil-water suspension)	8.03	8.07
EC, dSm^{-1} (soil paste exteract)	1.25	1.36
Organic matter (%)	1.36	15.7
$CaCO_3$ (%)	21.3	25.1
Soil available N (mg kg^{-1})	22.5	20.8
Soil available P (mg kg^{-1})	10.1	11.3
Soil available K (mg kg^{-1})	182	176
Soulble cations meg L^{-1}		
Ca^{+2}	4.45	4.8
Mg^{+2}	4.12	4.42
Na^{+}	2.03	2.30
K^{+}	1.87	2.00
Soulble anions meg L^{-1}		
CO_3^{-2}	—	—
HCO_3^{-}	1.56	1.61
Cl^{-}	4.65	4.79
SO_4^{-2}	6.26	7.12

Results and Discussion

Soil properties:

Data in Table (2) represent the effect of phosphorous and humic acid applications on some soil properties, namely soil pH , soil EC and soil organic matter . The data clearly indicate that soil properties were significantly affected by humic acid only, while phosphorous fertilization did not change it. Added humic acid as soil application decreased soil pH value by about 0.04 and 0.05 units in the two growing seasons, respectively when compared with control or humic acid as foliar spraying. Also ,humic acid as soil application improved both salinity and soil organic matter , where decreased EC value by about 1.6 and 2.3 % over control or foliar spraying treatment in both seasons ,respectively . However, these treatment of humic acid increased soil organic matter by about 3.7 and 3.2 % over control in both seasons ,respectively . The decreasing of soil pH caused by humic acid may be due to the replacement of soil solution of salt ions with H^+humic acid resulted.

In lowered of the pH of the solutions (Khaled and wzfy, 2011). As for the salinity, Pena-Mendez, et al (2005) mentioned that humic acid canincrease the aggregate stability, consequently improve soil salinity . The increment of soil organic matter due to added humic acid as soil application may be attributed to , beside it contain organic carbon,addidion of humic acid results in root development for plants (Baldotto et al, 2011),hence increased soil organic matter . Similar results were obtained by Ali and Mindari (2016).

Table 2. Soil properties and fertility affected by phosphorus application and humic acid after harvest.

Phosphorus kg Pha^{-1} A	**Humic Acid B**	**Soil properties**						**Soil fertility ($mgkg^{-1}$)**					
		pH		**EC**		**Organic matter %**		**Soil available N**		**Soil available P**		**Soil available K**	
		2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
0.0	**0.0**	8.01	8.06	1.23	1.33	1.35	1.56	22.0	20.5	10.0	11.1	180	175
	Foliar	8.01	8.06	1.23	1.33	1.35	1.55	22.2	20.4	10.0	11.2	180	176
	Soil	7.97	7.99	1.20	1.30	1.37	1.59	25.1	23.8	12.2	13.3	186	181
Mean		7.99	8.04	1.22	1.32	1.36	1.57	23.1	21.57	10.7	11.8	182	177.3
	0.0	8.01	8.06	1.23	1.33	1.35	1.56	22.0	20.5	12.5	13.6	180	176
37.0	**Foliar**	8.01	8.06	1.23	1.33	1.35	1.56	22.2	20.4	12.5	13.7	181	176
	Soil	7.97	7.99	1.20	1.30	1.37	1.59	25.2	23.7	14.3	15.2	186	182
Mean		7.99	8.04	1.22	1.32	1.36	1.57	22.1	21.5	13.1	14.2	182	178
	0.0	8.01	8.06	1.23	1.33	1.35	1.56	22.1	20.5	14.2	15.5	181	176
74.0	**Foliar**	8.02	8.06	1.23	1.33	1.35	1.56	22.2	20.5	14.3	15.6	181	176
	soil	7.97	8.99	1.20	1,29	1.38	1.60	25.3	23.8	16.0	17.8	187	183
Mean		8.00	8.37	1.22	1.32	1.36	1.57	23.2	21.6	14.8	16.3	183	178.3
	0.0	8.01	8.06	1.23	1.33	1.35	1.56	22.0	20.5	12.2	13.4	180.3	175.7
mean of	**Foliar**	8.01	8.06	1.23	1.33	1.35	1.56	22.2	20.4	12.3	13.5	180.7	176
humic acid	**Soil**	7.97	8.32	1.20	1.30	1.37	1.59	25.2	23.7	14.2	15.4	186.3	182
L.S.D at 0.05	**A**	NS	NS	NS	NS	NS	NS	NS	NS	1.25	1.27	NS	NS
	B	0.02	0.01	0.01	0.02	0.03	1.35	1.10	1.36	1.36	1.38	2.26	2.53
	AB	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Soil fertility:

The data in Table (2) represent the availability of N,P and K in soil after maize harvest. The data show that phosphorus application improved only phosphorus availability in soil after harvest. Increasing phosphorus level up to 74.0 kg P ha^{-1} increased soil available phosphorus by about 36.2 and 37.8 % when compared with no phosphorus fertilization in the two seasons, respectively. This may be due to, the presence of P as phosphorus fertilizer promoted the diffustion of P away from the root zoon (Osman ,2015) . These results are in the line with those obtained by Cavusoglu et al (2017) and Rosa et al (2018).

As for the effect of humic acid , the data reveal that added humic acid as soil application had a positive effect on the availability of N,P and K in soil after maize harvest , while added humic acid as foliar spraying did not affect the nutrient availability .In this concern,Urrutia et al (2014) pointed out that humic acid increased P availability in the soil through blocking P adsorption sites and developing a repulsive negative electrostatic field around then , and through complexation of Ca ,Fe and Al , preventing precipitation of P .Tan (2003) pointed out that humic acid can improve the solubility of insoluble P in soil with its chelation capacity ,and chelated metals are available for plant adsorption.Moreover , the promotive effect of humic acid could be explained by the effect of humic acid on increasing microbiogicalactivitity (Petrovic et al,1982) and decreasing soil pH (Li and Wang , 1998) .These results are in harmony with those obtained by Bezuglova et al (2017) , Cavusoglu et al (2017) and Rosa et al (2018) .

Growth and yields and its components:

The data in Tables (3,4) show the effect of phosphorus and humic acid application on growth and yields and its components of maize . As for the effect of phosphorus, it is worthy to mention that maize produce greatest yield, in turn require much more nutrients than other cereal plants. It is needed high P and it is sensitive to low P supply (Mazengi , 2011) .

The data clearly show that increasing P levels up to 74 kg Pha^{-1} had a positive effect on all studied growth and yields and yield components in both seasons, except number of grain row^{-1} which did not affect. Relatively better plant height , dry weight plant $^{-1}$, number of leaves plant^{-1} , number of rows ear^{-1} ,100-grain weight , grain yield , stover yield and biological yield were obtained from 74.0 kg P ha^{-1}which were 6.1,10.4,13.1,4.7,4.2,4.2,19.4,12.0 and 14.6% than the obtained from no P . The promotive effect of P on maize growth is mainly due to phosphorus consider is an essential factor for all division because it is a constituent nutrient of nucleoproteins , which are involved in cell reproduction process (Gul et ,2015).The results are in accordance with those obtained by Yosefi et el (2011) and Hassanien (2018). Concerning the effect of humicacid , the data indicate that added humic acid, whether as foliar or soil application had a positive effect on all studied maize growth , yield and yield components, except number of grains row^{-1} in both seasons. The relative increasing of plant height , dry weight plant^{-1} ,number of leaves plant $^{-1}$,number of rows ear^{-1} and 100 – grain weight as well as grain , stover and biological yields due to foliar applications were 0.9,1.8,4.1,1.4,1.9,1.0,7.5,4.8 and 6.3% over control in the first seasons . The corresponding increasing due to soil application were 3.9,7.8,15.6, 6.6, 6.0,4.5,15.2,13.7 and 14.9 % .Similar trends were obtained for the second one. It is obvious to notice that the effect of humic acid was more pronounced when added as soil application than foliar spraying. Respectively in the first season. Similar trends were obtained in the second season.

Table 3. Growth and yield components parameter of maize as affected by phosphorus and humic acid application.

Phosphorus kgpha-1 (A)	Humic acid (B)	Plant height (cm)		Dry weight/plant (g)		Number of leaves/plant		leaf area cm2		Number of rows /ear		Number of grains/row		grain-100 weight (g)	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
	0.0	165.3	162.3.	72.5	71.6	11.2	11.0	480.3	475.6	14.1	14.0	33.5	33.3	33.1	33.0
0.0	Foliar	166.5	163.4	73.8	73.5	11.9	11.5	486.1	481.1	14.3	14.2	33.5	33.3	33.4	33.2
	spraying	172.3	169.5	78.3	77.9	13.5	13.2	501.6	496.6	14.9	14.6	33.6	33.4	34.2	34.0
mean	Soil	168.03	165.1	74.9	74.3	12.2	11.9	489.3	484.4	14.4	14.3	33.5	33.3	33.6	33.4
	0.0	171,6	169.7	78.0	77.2	12.2	12.0	493.7	487.7	14.4	14.2	33.5	33.4	33.7	33.5
	Foliar	178.0	171.1	79.6	79.0	12.9	12.6	499.8	493.3	14.8	14.6	33.5	33.4	33.9	33.6
37.0	spraying	180.4	178.6	85.1	84.3	14.3	14.1	533.5	527.1	15.5	15.2	33.4	33.3	35.6	35.4
	Soil														
	application														
mean		175	173.1	80.6	80.2	13.1	12.9	509	502.7	14.9	14.7	33.5	33.4	34.4	34.2
	0.0	176.6	173.4	80.3	79.5	13.2	13.0	497.7	491.9	14.7	14.4	33.5	33.3	34.4	34.1
74.0	Foliar	178.0	175.2	81.5	80.3	13.8	13.5	505.6	500.6	14.9	14.6	33.6	33.4	34.8	34.5
	spraying	180.4	178.5	85.3	84.4	14.4	14.2	534.2	527.7	15.4	15.2	33.6	33.3	35.7	35.4
	]Soil														
	applicatio														
mean		178.3	175.7	82.4	8 .9	13.8	13.6	512.5	506.7	15	14.7	33.6	33.4	35	34.7
	0.0														
mean of humic acid	foliar	171	168.5	76.93	76.1	12.2	12	490.57	485.1	14.4	14.2	33.5	33.4	33.7	33.5
	spraying	172.5	169.5	78.3	77.6	12.7	12.5	497.17	491.6	14.7	14.5	33.53	33.36	34.03	33.7
	Soil	177.7	175.5	82.9	82.2	14.1	13.8	513.1	517.3	15.3	15.0	33.53	33.3	35.2	34.6
	application														
L.S.D at 0.05															
A		2.11	2.08	1.78	1.71	0.62	0.57	6.35	6.10	0.13	0.15	NS	NS	0.22	0.21
B		1.00	0.86	0.69	0.66	0.22	0.21	2.77	2.34	0.10	0.10	NS	NS	0.11	0.10
AB		2.36	2.40	2.01	1.93	0.81	0.79	7.25	7.31	0.17	0.17	NS	NS	0.34	0.33

Table 4. Grain, stover and biological yields of maize as affected by phosphorus and humic acid application.

Phosphorus kg P ha^{-1} A	Humic Acid B	Yield (Mg ha^{-1}) Grain yield 2017	Grain yield 2018	Stover yield 2017	Stover yield 2018	Biologicl yield 2017	Biologicl yield 2018
0.0	**0.0**	**5.06**	**4.94**	**6.13**	**6.01**	**11.16**	**10.97**
	Foliar	**5.33**	**5.17**	**6.52**	**6.43**	**11.80**	**11.62**
	Soil	**5.81**	**5.63**	**7.33**	**7.27**	**13.17**	**12.88**
mean		**5.4**	**5.3**	**6.6**	**6.57**	**12.04**	**11.82**
37.0	**0.0**	**5.63**	**5.56**	**6.93**	**6.85**	**12.53**	**12.41**
	Foliar	**6.14**	**5.90**	**7.21**	**7.16**	**13.38**	**13.04**
	Soil	**6.74**	**6.49**	**7.78**	**7.70**	**14.50**	**14.19**
mean		**6.17**	**5.98**	**7.31**	**7.24**	**13.47**	**13.21**
74.0	**0.0**	**6.04**	**5.93**	**7.03**	**6.96**	**13.04**	**12.91**
	Foliar	**6.53**	**6.22**	**7.36**	**7.30**	**13.85**	**13.53**
	Soil	**6.74**	**6.50**	**7.79**	**7.72**	**14.51**	**14.20**
mean		**6.45**	**6.22**	**7.39**	**7.33**	**13.8**	**13.55**
	0.0	**5.58**	**5.48**	**6.71**	**6.61**	**12.24**	**12.10**
mean of humic acid	**Foliar**	**6.0**	**5.76**	**7.03**	**7.03**	**13.01**	**12.73**
	Soil	**6.43**	**6.21**	**7.63**	**7.63**	**14.06**	**13.76**
L.S.D at 0.05	**A**	**0.16**	**0.14**	**0.18**	**0.16**	**0.27**	**0.25**
	B	**0.13**	**0.12**	**0.25**	**0.21**	**0.34**	**0.30**
	AB	**0.19**	**0.18**	**0.22**	**0.19**	**0.43**	**0.31**

Table 5. N, P and K uptake in grains and stover of maize as affected by phosphorus and humic acid.

Phosphorus Kg P ha-1 A	Humic acid B	Grains (kg $^{-1}$) N 2017	N 2018	P 2017	P 2018	K 2017	K 2018	Stover (kg ha^{-1}) N 2017	N 2018	P 2017	P 2018	K 2017	K 2018
0.0	**0.0**	63.5	62.4	15.8	15.7	51,3	50.9	66.2	65.4	17.0	16.9	77.0	76.5
	Foliar	68.0	66.8	18.3	18.1	56.9	55.7	73.0	78.3	20.3	20.7	85.5	85.4
	Soil	77.4	76.2	21.0	21.2	63.4	62.1	85.1	85.2	25.0	25.6	98.0	98.2
mean		69.0	68.5	18.4	18.3	57.2	56.2	74.8	76.3	20.9	21.1	86.8	86.7
	0.0	75.7	72.3	19.2	19.4	56.9	57.3	74.7	74.7	22.1	22.5	87.4	86.7
37.0	**Foliar**	79.3	76.9	22.5	22.3	65.2	63.3	81.3	80.8	25.1	25.6	94.2	94.6
	Soil	90.1	87.7	27.0	27.7	73.3	71.5	90.4	90.2	29.3	29.4	104.6	103.8
mean		81.7	79.0	23.1	23.2	65.1	64.0	82.1	81.9	25.5	25.8	95.4	95.0
	0.0	75.9	74.9	21.8	21.8	61.7	61.6	75.1	75.8	24.0	73.7	88.6	89.2
74.0	**Foliar**	84.4	80.8	24.9	24.4	69.9	66.7	81.8	82.6	26.6	75.4	97.0	96.1
	Soil	89.8	87.8	27.1	27.5	73.3	71.7	90.5	90.3	29.4	79.5	105.0	103.5
mean		83.4	81.2	24.6	24.6	68.3	66.7	82.5	82.9	26.7	76.2	96.9	96.3
mean of humic acid	**0.0**	71.7	69.9	18.9	19.0	56.6	56.6	72.0	72.0	21.0	21.0	84.3	84.1
	Foliar	77.2	74.8	21.9	21.6	64.0	61.9	78.7	80.6	24.0	23.9	92.2	92.0
	Soil	85	83.o	25.0	25.5	70.0	68.4	88.7	88.6	27.9	28.2	102.5	101.8
L.S.D. at 0.05	**A**	2.21	2.46	1.62	1.65	2.16	2.65	2.61	2.58	1.46	1.61	2.71	2.86
	B	2.03	2.15	1.53	1.59	2.40	2.51	2.52	2.66	1.39	1.55	2.54	2.62
	AB	3.15	3.60	2.86	2.90	3.69	3.73	3.75	3.69	2.51	2.71	4.01	4.13

The promoting effect of humic acid, especially as soil application may be due to humic acid application resulted in higher water consumption, confirming a better global plant growth (Luiakis and Petsas , 1995) . Eyheraguibal, et el (2008) mentioned that humic acid increase the lateral root emergence and induce the production of smaller and secondry roots .Furthermore ,humic acid improve soil fertility by improve physical , chemical and biological properties of soil (Albayrak and Cornas ,2005 and Natesan et al,2006) . Nardi, et al (2002) summarized the effect of humic acid , on improving seed germination , seeding growth ,root initiation , root growth ,shoot development and nutrients uptake .The results are in line with those obtained by Clik, et al (2008), Eyheraguibel et al (2008) and Ismail et al (2016) . Regarding humic acid as foliar spraying ,Bezuglova et al (2017) mentioned that the positive effect of humic acid as foliar application is mainly due to it increased the intensity of respiration , photosynthesis , water exchange , the concentration of chlorophyll and ascorbic acid . Also , it enhance the processes of transcription and translation of the protein-synthesizing system ,the state of ribosomes and the mitotic activity of meristematic tissue and the permeability of membrane . Similar results were obtained by Sangeetha and Singaram (2005) and Munazza, et al (2010). In contrary,Rezazadeh et al (2012) reported that foliar spraying of humic acid had no significant effect on maize growth.

As for the interaction effect , the data reveal that, all the above mentioned parameters, were significantly affected by the interaction between humic acid and phosphorus levels . Combined humic acid as soil application with 37 kgPha^{-1} exhibited growth and yields and its componants equal to those under the high level of phosphorus+humic acid as soil application . In this concern ,Fu et al (2013) stated that humic acid can improve phosphorus availability in the soil.Similar results were obtained by Wang et al (1995) who reported that added humic acid and some phosphatic fertilizer to plants resulted in increasing P absorption percentage by about 25% higher than no humic acid application , hence the requirement of cutting down on phosphatic fertilizer is needed .In general , the highest value of maize growth and productivity were obtained for maize plants treated with 74 or 37 kg Pha^{-1} + humicacid as soil application , while the lowest ones were recorded for plants without phosphorus and humic acid application .

Nutrient uptake

It was observed according to Table 5 and 6 that increasing phosphorus level up to 74 kg P ha^{-1} were significantly increased N,P and K uptake in grains and stover as well as total uptake . The highest N,P and K uptake were observed under added 74.0 kg P ha^{-1} ,while the lowest nutrient uptake were recorded under control The relative increasing of total N,P and K due to 74.0kgP ha^{-1} reached to 18.9,31.2 and 14.6% when compared with no phosphorus treatment in the first season ,respectively .Similar trends were obtained in the second season . The positive effect of phosphorus on nutrient uptake can be explain by the effect of phosphorus on both grain and stover yields (Tables 4 and 5), since nutrient uptake was calculated by multiplying nutrient concentration by grain or stover . Similar results were obtained by Rezazadeh et al (2012) and Cavusoglu et Concerning the effect of humic acid ,the obtained data indicate that humic acid was significantly enhanced N,Pand K in grains and/or stover . It is obvious to notice that this affect was more pronounced under added humic acid as soil application .Humic acid as soil application resulted in increasing total N,P and K by about 11.9 and 21.6 and 15.5, and 32.8 and10.4 and22.4% over added humic acid as foliar spraying and no humic , respectively in the first season . Same trend was obtained in the second season . The promotive effect of soil humic acid application may be due to application of humic acid to soil solution causes an improving in the root branches and root growth , consequently enhanced nutrient absorption (Samavat and Malakoti ,2010). Furthermore ,Canellas et al (2002) indicated that humic acid produced a hyperinduction of lateral root site emergence on maize . The elongation and proliferation of these secondary roots resulted in an increase of total length and root surface area , hence increased nutrient absorption . The results agree with may investigators such as, Cimrin and Yilmaz (2005),Ghorbani etal (2010),Osman (2015) . On the other hand , as for foliar spraying , Srivastava (1995) cleared that foliar application of humic acid may increased nutrient uptake from the soil and translocation of these nutrient to plant and help the plants to absorb and transport the nutrients without any energy and without loss in transit .Sunitta (2003) and Elayaraja et al (2014) reported that foliar spraying of humic acid improved nutrient uptake by plants al (2017).

As for the interaction , the results clearly reveal that N,P and K uptake by grains and /or stover were significantly affected by the interaction between phosphorus fertilization and humic acid . Combined humic acid as soil application with 37.0 kgPha^{-1} resulted in N,Pand K uptake significantly equal to those under 74.0 kgPha^{-1} + humic acid . This is mainly due to the promotive effected of humic acid on increasing the efficiency of phosphorus fertilizer , which in term added the moderate level of phosphorus under humic acid application induce soluble nutrients in bar with those under the high P level . In addition ,Ghosal and Chakaborty (2012) indicated that both yield and uptake of rock P were higher as a result of humic acid application , which caused in decreasing soil pH . Similar results were obtained by Sarwar et al (2008) and Osman (2015) . In general,the treatment of 37.0 kg P ha^{-1} or 74.0 kgP ha^{-1} +humic acid assoil application exhibited the highest nutrient uptake .Whereas , the treatment of without both phosphorus and humic acid recorded the lowest nutrient uptake.

Table 6. Total N, P and K uptake of maize as affected by phosphorus and humic acid application.

Phosphorus kg P ha $^{-1}$ B	Humic acid A	N kg ha^{-1} 2017	2018	P kg ha^{-1} 2017l	2018	K kgha-1 2017	2018
0.0	**0.0**	129.5	127.6	32.7	32.5	128.1	127.2
	Foliar	141.2	145.0	38.5	38.9	142.3	141.0
	Soil	162.7	161.2	46.2	46.6	161.5	160.4
mean		144.5	144.6	39.1	39.3	144.0	142.9
	0.0	150.1	147.1	41.2	41.7	144.1	144.2
37.0	**Foliar**	160.7	157.6	47.7	47.8	159.2	157.7
	Soil	180.6	177.9	56.4	57.1	177.8	175.2
mean		163.9	160.9	48.4	48.7	160.4	159.03
	0.0	151.3	150.8	45.8	45.6	150.2	150.8
74.0	**Foliar**	166.3	163.2	51.5	49.9	166.8	162.6
	Soil	180.4	178.0	556.5	57.1	178.0	175.3
mean		166.0	164.0	51.3	50.9	165.0	162.9
mean of humic acid	**0.0**	143.6	141.8	39.9	39.8	140.8	140.7
	Foliar	156.1	155.3	45.9	45.5	156.1	153.8
	Soil	174.6	172.4	53.0	53.6	172.4	170.3
L.S.D at 0.05							
A		4.35	3.96	2.01	2.13	4.72	4.61
B		3.19	3.31	1.15	1.26	4.35	4.10
AB		5.26	5.06	4.21	4.36	6.01	5.66

Conclusion

In respect to the results of these study , it can suggested to use humic acid as soil application at rate of 24kg P ha^{-1} in combined with 37.o kg P ha^{-1} as superphosphate fertilizer to improve soil properties and fertility after maize harvest as well as growth, yield, and its components and nutrient uptake . This means that it can be save about 37.0 kg P ha^{-1} by using humic acid to gave maximum maize quality and quantity, beside improving soil properties and fertility.

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تداخل السماد الفوسفاتى مع حامض الهيومك وتاثيرهم على خواص التربة وخصوبتها و كمية ونوعية محصول الذرة .

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أقيمت تجربتان حقليتان بمحطة البحوث الزراعية بسدس – مركز البحوث الزراعية – محافظة بنى سويف فى موسمى النمو 2017 –2018 لدراسة تأثير حامض الهيومك (بدون ٬رش 2% حامض هيومك مرتان ٬أضافة 24 كجم حامض هيومك أرضى) وثلاث مستويات من سماد السوبر فوسفات (صفر ٬37٬74كجم فو سفور/هكتار) على صفات النمو (طول النبات والوزن الجاف للنبات) ومكونات المحصول (عدد الصفوف فى الكوز ٬ عدد الحبوب فى الصف ٬وزن المائة حبة) والمحصول (محصول الحبوب ومحصول البوص والمحصول البيولوجى) ٬ إمتصاص النيتروجين والفوسفور والبوتاسيوم لنبات الذرة ٬وكذلك على صفات التربة (الحموضة ٬ الملوحة ٬نسبة المادة العضوية) وخصوبة التربة (النيتروجين والفوسفور والبوتاسيوم الميسر) بعد الحصاد.

- أدى زيادة التسميد الفوسفاتى إلى زيادة كل صفات النمو ومكونات المحصول وإمتصاص العناصر ٬ما عدا عدد الحبوب فى الصف.
- أدى زيادة التسميد الفوسفاتى إلى زيادة صلاحية عنصر الفوسفور فقط بعد الحصاد .
- أدى إضافة حامض الهيومك إلى زيادة فى صفات النمو ومكونات المحصول والمحصول وإمتصاص العناصر ما عدا عدد الحبوب فى الصف التى لم تتأثر ٬ وكانت الزيادة أكثر فى حالة إضافة حامض الهيومك أرضى عن الرش.
- أدى أضافة حامض الهيومك أرضى إلى خفض درجة حموضة التربة والملوحة وزيادة نسبة المادة العضوية فى التربة وصلاحية عناصر النيتروجين والفوسفور والبوتاسيوم فى التربة بعد الحصاد ٬ بينما رش الهيومك لم يؤثر على صفات وخصوبة التربة.
- أدى أضافة حامض الهيومك مع 37كجم فو هكتار إلى انتاجية وجودة الذرة الشامية مساوى لإضافة المحصول التالى من الفوسفور (74كجم فوهكتار).
- تشير نتائج الدراسة إلى إمكانية توفير 37كجم فو هكتار بإضافة 24 كجم حامض هيومك للهكتار وعلية يمكن التوصية بأضافة 24كجم حامض هيومك مع 37 كجم فو هكتار للحصول على أعلى إنتاجية كما ونوعا من الذرة.