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EFFECT OF PHOSPHORUS FERTILIZER RATES AND APPLICATION METHODS OF HUMIC ACID ON PRODUCTIVITY AND QUALITY OF SWEET POTATO

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ABSTRACT

Two field experiments were conducted on sweet potato (*Ipomoea batatas* L.) cv. Beaure Gard at the Horticulture Research Farm of El-Bramoon, El-Dakahlia Governorate, during the two successive summer seasons of 2007 and 2008 to evaluate the effects of different rates of phosphorus (15, 30 and 45 kg P_2O_5/fed) either single and/or in combination with application methods of humic acid (control, foliar spray, transplant treatment and soil application) on plant growth, yield and its components, as well as chemical constituents and storability of tuber roots.

In general, results showed that the increasing of applied phosphorus rate from 15 kg P_2O_5 up to 45 kg P_2O_5/fed significantly increased main stem length, canopy dry weight plant leaf area, total chlorophyll and carotenoides as well as total and marketable yield, dry matter percentage of tuber root and tuber root weight and diameter, Moreover, Application phosphorus at 45 kg P_2O_5/fed significantly increased N, P, K, carbohydrate and total sugars in tuber roots. This P-rate had the most interesting observation was the enhancing of storability and reduced decay percentage. On the other hand, application methods of humic acid had a significant effect on all studied characters in both seasons. Soil application method of humic acid had a significant increases in plant growth characters, photosynthetic pigments, total and marketable yield and tuber root quality. Besides, this application method significantly increased chemical composition of tuber roots and reduced the weight loss and decay percentages.

The combined treatments of P-rates and application method of humic acid were generally more effective on the most studied parameters than with single ones. The best results were obtained by application 30 kg P_2O_5/fed with soil application method of humic acid. This treatment achieved increases in vegetative growth characters, total and marketable yield, average of tuber root weight and diameter as well as concentrations of N, P, K, carbohydrate and total sugars in tuber roots. In addition, this combined treatment enhanced the tuberous roots storability and reduced decay% comparing with the other ones.

Therefore, this treatment could be recommended for raising sweet potato yield and improving tuberous roots quality as well as reduced the need for chemical P-fertilizer by about 33.3 %, thereby reducing costs and environment pollution under similar conditions to this work.

INTRODUCTION

Phosphorus element is one of the main nutrients for most plant species including sweet potato plants (*Ipomoea batatas* L.). The necessity of phosphorus as a plant nutrient is emphasized by the fact that it is an essential constituent of many organic compounds that are very important for metabolic processes, blooming and root development (Purekar *et al*., 1992).

In most soils, in spite of the considerable addition of P-fertilizers, the amount available for plants is usually low since it is converted to unavailable form by its reaction with the soil constituents (Marschner, 1995). This could be explained why the cultivated soils in Egypt needs a high amount of mineral P-fertilization to fulfill requirements of plants, However, the increase in the rate of applied P-fertilizer may be at the expense of increasing production costs. Therefore, it has become essential to use some substances to enhancing solubility of phosphorus and other nutrients, consequently, improve its availability to plants.

In this respect, humic acid has a one of potential benefits for plants, increased water and nutrient holding capacity, enhanced solubility of P, Zn, Fe, Mg and Cu (Bryan and Stark, 2003; Mikkelsen, 2005). Besides, Rizk *et al*. (2010) mentioned that humic substances are recognized as the most chemically active compounds in soils, with cation and anion exchange capacities far exceeding those of clays and help to break up clay and compacted soils. On the other hand, Sarir *et al*. (2006) mentioned that humic coal applied at 2000 g/ha^{-1} seem to be more conductive for P availability and suppress P fixation either through chelation, acidifying mechanism or microbially induced mineralization process.

Several investigators reported that addition of specific amount of humic substances as soil application can enhance the growth of roots, shoots and leaves, and encourage nutrient absorption by plants. In this respect, Bryan and Stark (2003) found that averaged across years and P rates, humic acid application increased total yield, marketable yield and gross return of potato crop. Shankle *et al*. (2004) indicated that application of humic acid plus nutrients to soil increased total marketable yield of sweet potato than the standard fertility program.

Verlinden *et al*. (2009) found that tuber production of the potato field trial showed a high response to the application of humic substances. Total potato yield increased with 13 and 17% for humifirst liquid (liquid solution to the soil) and humifirst incorporated (solid incorporated in mineral fertilizers), respectively. Moreover, some researchers showed that the foliar spray of humic acid enhanced nutrient uptake, plant growth and yield (Delfine *et al*., 2005 on wheat and Sangeetha *et al*., 2006 on onion).

On the other hand, numerous trials have been carried out to explain the efficiency of P-nutrition on growth and productivity of sweet potato plants. In this respect, Rhodes (1988); Li and Yen (1988); Marcano and Diaz (1994); Abdel-Fattah and Abdel-Hameid (1997); El-Morsy *et al*. (2002) and Hassen *et al*. (2005) they reported that P–fertilizer application positively increased sweet potato productivity compared with the untreated control.

Thus, this study was planned to determine the effects of some P rates and application methods of humic acid as important goal to Improving availability of phosphorus in soil, and also facilitate other elements, to improve productivity and storability of sweet potato under the conditions of Dakahlia Governorate.

MATERIALS AND METHODS

Two field experiments were carried out at El-Bramoom Agricultural Research Farm, Dakahlia Governorate, during the two successive summer seasons of 2007 and 2008, to investigate the effects of different rates of phosphorus fertilizer, application methods of humic acid and their interactions on plant growth, yield and its components, as well as chemical constituents and storability of tuberous roots of sweet potato (*Ipomoea batatas* L.) cv. Beaure Gard.

Randomized samples were collected from the experimental soil at 0.0 to 50.0 cm depth, before planting to determine the physical and chemical properties in accordance to the methods of Page (1982). Data of soil analysis is presented in Table (1).

Table (1): Some physical and chemical properties of experimental soil (average two seasons).

Physical properties (%)					Chemical properties						
clay	Silt	Fine sand	Coarse sand	texture	TSS (%)	O.M (%)	E.C. (ds/m^{-1} at 25^{o} C)	Total N (%)	Avail P (ppm)	Exch. K (ppm)	pH (1:2.5 w/v)
40.5	33.6	18.1	7.71	Clay loam	0.49	1.92	1.11	0.22	11.82	298.0	8.12

Each experiment included 12 treatments which were 3 rates of phosphate fertilizer and 4 application methods of humic acid as follows:

a- Phosphate fertilizer rates:

1- 15 kg P_2O_5/fed.
2- 30 kg P_2O_5/fed.
3- 45 kg P_2O5/fed recommended rate (as a control).

b- Application methods of humic acid:

1- Control treatment (without).
2- Foliar application: Humic acid solution at the rate of 0.5% sprayed at 30 days from transplanting.
3- Transplant treatment: Soaking transplants in humic acid solution 0.5% for four hr and hence transplanted in the presence of water.
4- Soil application: Humic acid 0.5% was added beside the transplants with first irrigation.

Humic acid was produced in Soil, Water and Environment Res. Institute.

The experiments were designed as split-plot with 3 replicates. Phosphorus fertilizer rates were in the main plots, which subsequently subdivided into 4 sub plots, each contained one of the humic acid application method. Each experimental plot area was 17.5 m^2 and consisted 5 rows, 5m long and 0.7m wid.

The transplanting was carried out during the second week of April, in both seasons of the study. Nearly similar top slips (cuttings), 20 cm length were manually planted on the third top of slope ridge at 25 cm apart. The added amount of phosphorus were equally divided and applied before planting and 30 days after transplanting.

Agricultural practices other than the forementioned treatment were conducted according to the recommendations of the Agric. Res. Center in Egypt. Harvesting was done 120 days after transplanting in both seasons.

Recorded Data:

Plant growth parameters:

At 90 days after transplanting, a random sample (3 plants) was taken from each experimental unit to measure stem length, number of branches/plant, plant leaf area (Koller, 1972), canopy dry weight/plant and Total chlorophyll (A + B) Commar and Zscheile (1941).

Yield and its components:

At harvest time, all tuber roots of plants grown in the rows of each sub-plot were weighted in kg and data were calculated as total yield/fed. Tuber root sample (10 storage roots) was randomly chosen from each treatment to determine tuberous root traits (weight, length and diameter).

Chemical constituents of tuberous roots:

Five uniform sized of tuber roots from each treatment were cleaned, cut, dried, ground and analyzed to determine total carbohydrates content, total carotene as well as concentrations of N, P, and K according to the methods described by Michel *et al.,* (1956),Booth (1958), A.O.A.C (1990), John (1970), and Brown and Lilleland (1946), respectively.

Storability:

After curing, a randome sample (10 kg of marketable tuber roots) was taken from each treatment, cleaned with dry clean towels, poked in plastic boxes and stored at the normal room conditions and weight loss percentage was recorded monthly during storage period and Decay percentage at the end of storage period (4 months).

All recorded data were subjected to statistical Analysis of Variance and least significance differences (L.S.D) was used to separate means, as mentioned by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Vegetative growth

Effect of P-rates.

Data in Table (2) show that, all growth parameters of sweet potato plants were significantly increased with increasing P rate from 15 up to 45 kg P_2O_5/fed. Plants which received 45 kg P_2O_5/fed had significant increases in most vegetative growth traits, compared to the other rates in both studied seasons. Meanwhile, there are no significant differences between 45 and 30 kg P_2O_5/fed in total chlorophyll and carotenoids in both seasons. These increases may be due to the beneficial effect of P-element on the activation of photosynthesis and metabolic processes of organic compounds in plants and hence increasing plant growth (Purekar *et al*., 1992). These results are in agreement with those obtained by Prasad and Rao (1986); El-Gamal and Abdel-Nasser (1996), El-Morsy *et al*. (2002) and Hassan *et al*. (2005) they found that increasing applied P-rate to sweet potato plants significantly increased plant length, plant leaf area, canopy dry weight, total chlorophyll and carotenoids.

Table (2): Vegetative growth of sweet potato as affected by P-rates, application methods of humic acid and their interactions in 2007 and 2008 seasons.

Parameters / Treatments		Main stem length (cm)		Canopy dry weight (g)		Leaf area/plant (cm)		Total chlorophyll (a + b) (mg/g f. w.)		Carotenoids (mg/g f.w.)	
Treatments		**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
P-rates											
15kg P_2O_5/fed		113.5	102.4	227.67	237.10	419.80	414.70	1.55	1.39	0.86	0.88
30kg P_2O_5/fed		122.6	118.2	273.58	251.24	476.62	442.80	1.63	1.46	0.91	0.95
45kg P_2O_5/fed		124.4	122.5	290.26	262.21	498.24	456.44	1.66	1.49	0.94	0.98
LSD at 5%		000.9	004.2	002.76	2.52	8.23	6.11	0.03	0.06	0.07	0.03
Humic app. meth.											
Control[1]		106.4	100.6	235.42	225.80	384.06	363.42	1.46	1.36	0.78	0.81
Foliar app.[2]		117.4	111.1	259.74	245.21	448.61	426.96	1.59	1.41	0.89	0.89
Transplant tr.[3]		126.2	118.4	273.08	260.63	494.39	466.10	1.68	1.47	0.95	1.00
Soil app.[4]		130.6	127.4	287.10	269.09	520.49	495.42	1.72	1.54	1.00	1.05
LSD at 5%		003.2	003.4	2.48	2.17	8.17	9.63	0.03	0.04	0.07	0.05
Interaction											
P-rates	**Humic app. meth**.										
15kg P_2O_5/fed	1	96.0	85.5	202.48	214.31	338.57	328.77	1.39	1.30	0.73	0.77
	2	108.9	99.9	219.93	228.78	415.30	409.90	1.51	1.36	0.83	0.84
	3	120.7	107.1	237.51	248.95	450.40	433.03	1.63	1.43	0.92	0.93
	4	128.3	117.1	250.76	256.37	474.93	487.10	1.67	1.47	0.96	0.98
30kg P_2O_5/fed	1	107.8	103.6	240.54	223.21	380.30	370.10	1.46	1.37	0.79	0.80
	2	119.4	112.9	264.74	242.67	434.26	421.50	1.61	1.41	0.89	0.89
	3	130.0	123.1	282.40	262.27	505.77	479.60	1.69	1.47	0.92	1.02
	4	133.3	133.2	306.63	276.82	550.13	500.00	1.77	1.58	1.03	1.10
45kg P_2O_5/fed	1	115.4	112.8	263.25	239.89	433.30	391.40	1.53	1.41	0.82	0.85
	2	123.8	120.3	294.55	264.17	496.27	449.50	1.65	1.46	0.94	0.94
	3	127.9	125.1	299.33	270.67	527.00	485.67	1.72	1.51	1.00	1.05
	4	130.4	131.9	303.92	274.09	536.40	499.20	1.73	1.57	1.01	1.07
LSD at 5%		005.6	5.8	4.30	3.75	14.15	16.68	0.06	0.67	0.11	0.08

app.= application & tr.= treatment & meth.=method

Effect of application methods of humic acid.

Data recorded in Table (2) demonstrate that all growth parameters of sweet potato plants expressed as main stem length, canopy dry weight, leaf area/plant, total chlorophyll (a+b), and carotenoids were significantly influenced by application methods of humic acid compared to the control treatment in both seasons. The highest values of these traits were obtained with the soil application method. These results may be due to the important role and beneficial effects of humic substances on the growth of plants as they can produce various morphological, physiological and biochemical effects on plants (Nardi *et al.*, 2002). In this respect, several investigators shown that the addition of a specific amount of humic substances to plant can enhance vegetative growth parameters, i.e., plant length, number of main stems/plant, foliage fresh and dry weight/plant (Awad and EL-Ghamry, 2007 and Verlinden *et al*., 2009)

Effect of the interaction between P-rates and application methods of humic acid.

The interaction between P-rates and application methods of humic acid on growth of sweet potato plants are shown in Table (2). It is clear from the data that, the combined treatments were much superior effect than single ones. The data declared that, plant main stem length, canopy dry weight/plant, leaf area, total chlorophyll and carotenoids were significantly influenced by the combination treatments in both seasons, moreover, the highest value of these traits were recorded with 30 kg P_2O_5/fed combined with the soil application method of humic acid in comparison with the other treatments. These pronounced positive effects on vegetative growth parameters of sweet potato plants, may be attributed to the role of humic acid in increasing water and nutrient holding capacity particularly at the higher P-rates, increasing reserve of slow release of P nutrient, enhanced solubility of phosphorus, and potassium, improved soil aggregation, reduce the interaction phosphorus with calcium, ferric, magnesium, and aluminum and make these elements in available form for plants; enlarged root system and increased stimulation of plant growth due to hormones (Bryan and Stark, 2003; Mikkelsen, 2005). Sarir *et al*. (2006) mentioned that humic coal applied at 2000 g/ha (soil application) seem to be more conductive for P availability and suppress P fixation either through chelation, acidifying mechanism or microbially induced mineralization process.

Yield and its components:

Effect of P-rates:

Data in Table (3) show that P-rates reflected a significant effect on total and marketable tuber yield, tuber dry matter, average tuber root weight and tuber root diameter in both seasons. Yield and its components were increased with increasing P-rate from 15 kg P_2O_5/fed up to 45 kg P_2O_5/fed in both seasons. Also, data show no significant differences between 30 or 45 kg P_2O_5/fed data on tuber root diameter in the first season only. The increases in total tuber yield were about 8.32 and 19.74 % for P_2O_5 at 45 kg/fed over the P_2O_5 at 15 kg/fed in the first and second seasons, respectively. These increments may be due to the important role of phosphorus as an essential component of many organic compounds in plant, such as phosphoproteins, phospholipids, nucleic acids and nucleotides, which indirectly may reflect positively on yield (Marschner, 1995). Similar results reported by El-Gamal and Abdel-Nasser (1996), Abdel-Fattah and Abdel-Hamed (1997), El- Morsy *et al*. (2002) and Hassan *et al*. (2005) they found that fertilization of sweet potato plants with P-fertilizer caused significant increases in total and marketable yield.

Table (3): Yield and its components of sweet potato as affected by P-rates, application methods of humic acid and their interactions in 2007 and 2008 seasons.

Parameters / Treatments		Total tuber yield (ton/fed)		Marketable yield (ton/fed)		Dry matter of tuber roots (%)		Average tuber root weight (g)		Tuber root diameter (cm)	
Treatments		**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**	**2007**	**2008**
						P-rates					
15kg P_2O_5/fed		12.97	13.48	12.12	12.35	26.84	26.37	150.30	155.80	4.80	4.20
30kg P_2O_5/fed		13.39	15.42	12.64	14.37	29.09	28.09	157.79	164.73	5.05	4.78
45kg P_2O_5/fed		14.05	16.14	13.56	15.36	30.47	29.64	161.46	169.27	5.17	5.03
LSD at 5%		0.12	00.31	00.07	00.18	00.14	0.20	1.973	0.88	0.28	0.24
						Humic App. Meth.					
Control[1]		10.54	13.08	9.46	11.77	24.97	24.53	141.60	141.57	4.42	3.94
Foliar app.[2]		13.02	14.54	12.30	13.59	28.17	27.10	153.04	159.80	4.74	4.44
Transplant tr.[3]		14.62	15.59	14.04	14.70	30.28	29.30	162.50	172.61	5.21	4.92
Soil app.[4]		15.68	16.85	15.28	16.07	31.78	31.20	168.92	179.09	5.64	5.37
LSD at 5%		0.27	0.16	00.23	00.19	00.11	0.20	3.189	3.61	0.43	0.33
						Interaction					
P-rates						**Humic app. meth**.					
15kg P_2O_5/fed	1	9.99	11.99	8.61	10.40	23.15	22.80	136.60	132.93	4.30	3.63
	2	12.33	13.01	11.40	11.93	26.19	25.65	147.97	153.23	4.53	4.13
	3	14.29	14.05	13.69	12.99	28.37	27.53	153.70	164.30	4.97	4.37
	4	15.26	14.87	14.77	14.10	29.65	29.49	162.93	172.73	5.40	4.67
30kg P_2O_5/fed	1	10.03	13.31	8.81	11.92	24.79	24.55	140.60	143.13	4.37	3.93
	2	12.76	14.10	11.90	13.11	28.31	26.65	153.20	158.93	4.70	4.43
	3	14.77	16.10	14.15	15.19	30.20	28.95	165.40	173.40	5.33	5.03
	4	15.98	18.00	15.71	17.28	33.05	32.20	171.97	183.46	5.80	5.73
45kg P_2O_5/fed	1	11.61	13.95	10.95	12.98	26.96	26.23	147.60	148.63	4.60	4.27
	2	13.99	16.32	13.61	15.72	30.00	28.99	157.97	167.23	5.00	4.77
	3	14.80	16.62	14.29	15.91	32.29	31.41	168.40	180.13	5.33	5.37
	4	15.79	17.67	15.37	16.82	32.65	31.91	171.87	181.07	5.73	5.70
LSD at 5%		00.47	00.28	0.398	00.33	00.24	0.35	5.52	6.25	0.74	0.57

app.= application & tr.= treatment & Meth.=method

Effect of application methods of humic acid:

It is evident from data in Table (3) that the application methods of humic acid had a significant effect of total and marketable yield, dry matter of tuber roots, and tuber root weight and diameter compared to untreated once in both seasons. The highest values were obtained from soil application method of humic acid in both seasons. Theses increases in total tuber yield may be due to hormonal effect of humic acid that improve the nutrient status of plants. These results were agreement with those reported by Verlinden *et al*. (2009), Selim *et al.*, (2009) and Ezzat *et al.*, (2010) they found that application of humic substances to potato enhanced tuberous yield quantity and quality.

Effect of the interaction between P-rates and application methods of humic acid:

Data in Table (3) indicate that the combined treatments seemed to be more effective than the single ones. It is obvious from such data that total yield, marketable yield and average tuber root weight and diameter were significantly influenced in both seasons. In general, plants fertilized with 30 kg P_2O_5/fed with the soil application method of humic acid achieved great yield which was not significantly different from that produced by using 45 kg P_2O_5/fed alone. It is notable that, there were no differences between 30 or 45 kg P_2O_5/fed with soil application method in the tuber root weight and diameter in both seasons. These increases were accordance with those of Bryan and Stark (2003) who found that averaged across years and P rates, humic acid application increased total yield, marketable yield and gross return of potato crop. Similar results reported by Ayuso *et al.* (1996) on maize and El-Shabrawy *et al*. (2010) on cucumber.

Chemical constituents of tuber roots:

Effect of P-rates:

Data presented in Table (4) show that P-rates markedly affected most studied chemical contents in tuber roots of sweet potato. Irrespective of the control treatment, increasing the applied P-rates from 15 to 45 kg P2O5/fed significantly increased concentrations of N, P and K as well as total carbohydrate content, total sugars. Application of P_2O_5 at 45 kg/fed, increased significantly K contents, in both seasons, whereas, no significant differences were evidence between 45 or 30 kg P_2O_5/fed in N and P content as well as total carbohydrates and total sugars in the first season. This could be due to higher availability of the nutrients with increase in the fertilizer application (P) which ultimately resulted in better root growth and increased physiological activity of roots to absorb the nutrients (Marschner, 1995). The obtained results coincide with those of Prasad and Rao (1986), Li and Yen (1988), and Rhodes (1988) and El-Morsy *et al*. (2002) they demonstrated that an increase in the rate of applied-P from 15 to 60 kg P_2O_5/fed to sweet potato plants caused an increase in N, P and K contents as well as total carbohydrate and total sugars in tuber roots of sweet potato.

Effect of application methods of humic acid:

It is obvious from the data in Table (4) that all application methods of humic acid for sweet potato plants exerted significant increases in tuber root contents, i.e. N, P and K concentration as well total carbohydrate and total sugars compared with the untreated ones. However, there were no significant differences between transplant treatment and soil application methods on P and K concentrations in the first season only. Soil application method of humic acid gave the highest values in all chemical constituents in both seasons. These effects are considered as an important action of humic substances on plant nutrient acquisition and in the uptake of nutrients is the root system of plants (Quagiotti *et al.*, 2004). Similar results were obtained by Verlinden *et al*. (2010) they found that nitrogen, phosphorus and potassium uptake at the first grass pastures cut was higher after application of humic acid substances at 8.3 kg/ ha.

Table (4): Chemical composition of sweet potato as affected by P by P-rates, application methods of humic acid and their interactions in 2007 and 2008 seasons.

Parameters / Treatments		N (%) 2007	N (%) 2008	P (%) 2007	P (%) 2008	K (%) 2007	K (%) 008	Carbohydrates (%) 2007	Carbohydrates (%) 2008	Total sugars (%) 2007	Total sugars (%) 2008
P-rates											
15kg P_2O_5/fed		1.69	1.63	0.302	0.295	2.48	2.33	60.12	58.83	7.85	8.05
30kg P_2O_5/fed		1.75	1.68	0.318	0.313	2.61	2.45	62.68	60.22	8.03	8.23
45kg P_2O_5/fed		1.77	1.72	0.323	0.322	2.66	2.54	63.28	61.83	8.12	8.34
LSD at 5%		0.06	0.03	0.005	0.003	0.05	0.05	0.67	0.22	0.13	0.02
Humic app. methods.											
Control[1]		1.64	1.55	0.293	0.286	2.42	2.29	57.83	56.77	7.79	7.99
Foliar app.[2]		1.69	1.66	0.311	0.303	2.54	2.40	61.23	59.89	7.93	8.13
Transplant tr.[3]		1.77	1.72	0.320	0.318	2.62	2.48	63.50	61.35	8.09	8.26
Soil app.[4]		1.85	1.79	0.332	0.332	2.76	2.57	65.24	63.16	8.19	8.43
LSD at 5%		0.05	0.04	0.006	0.005	0.04	0.04	0.92	0.18	0.08	0.07
Interaction											
P-rates	**Humic app. meth**.										
15kg P_2O_5/fed	1	1.61	1.46	0.283	0.268	2.34	2.19	56.56	54.61	7.65	7.89
	2	1.65	1.61	0.299	0.288	2.44	2.30	59.65	57.93	7.79	7.99
	3	1.71	1.68	0.307	0.302	2.53	2.39	61.48	60.41	7.93	8.09
	4	1.78	1.76	0.319	0.323	2.61	2.43	62.79	62.37	8.03	8.22
30kg P_2O_5/fed	1	1.65	1.56	0.296	0.284	2.43	2.29	58.92	56.73	7.76	7.96
	2	1.70	1.65	0.313	0.305	2.55	2.36	61.31	59.75	7.95	8.14
	3	1.76	1.72	0.323	0.324	2.63	2.47	63.52	60.79	8.09	8.27
	4	1.90	1.83	0.341	0.340	2.84	2.66	66.96	63.61	8.29	8.55
45kg P_2O_5/fed	1	1.66	1.62	0.299	0.306	2.50	2.40	58.01	58.96	7.96	8.13
	2	1.71	1.70	0.322	0.319	2.62	2.52	62.73	61.99	8.05	8.27
	3	1.85	1.77	0.331	0.329	2.71	2.59	65.49	62.86	8.23	8.41
	4	1.87	1.79	0.338	0.333	2.82	2.64	66.87	63.50	8.25	8.53
LSD at 5%		0.08	0.07	0.010	0.008	0.07	0.07	1.60	0.31	0.14	0.12

app.= application & tr.= treatment & Meth.=method

Effect of interaction between P-rates and application methods of humic acid.

The interaction between P-rates and application methods of humic acid had a significant effect of chemical constituents of sweet potato tuber roots, in both seasons (Table 4). The highest value of N, P and K, carbohydrates and total sugars were obtained from soil application of 30 kg P_2O_5/fed combined with the soil application method of humic acid. Data also, shown no significant differences between 30 or 45 kg P_2O_5/fed under the same application method of humic acid in both seasons. These results are in harmony with those reported by Selim *et al.* (2009) they stated that the application of humic acid combined NPK fertilizers significantly increased N, P and K nutrient concentrations in potato tissues.

Storability:

Effect of P-rates:

The data presented in Table (5) show that the most interesting observation was reducing weight loss and decay percentages in tuber roots by increasing the applied P-rates up to 45 kg P2O5/ fed. The favourable effects of P-fertilizer on weight loss percentage during the storage period and decay at the end of storage period could be explained through the great role of P-element which is extremly important as a structural part of many compounds in plant, such as phosphoproteins, phospholipids, nucleotides and notable nuclic acids (Gardener *et al*., 1985). The obtained results coincide with those of Kolbe *et al*. (1995), El-Morsy *et al*. (2002) and Saif-El-Deen (2005) they found that weight loss and decay were negatively correlated with P-rates application. Also, increasing P-rate up to 60 kg P_2O_5/fed significantly decreased the percentages of the above mentioned parameters during storage.

Effect of application methods of humic acid:

It is obvious from data in Table (5) that application of humic acid significantly reduced weight loss percentage of tuber roots during the storage period at 30, 60, 90 and 120 days than with the untreated control. Soil application method of humic acid gave the best records of weight loss and decay percentages than the other application methods in both seasons. It is well known that humic acid enhanced elements in available form for plants, enlarged root system and increased stimulation of plant-growth due to contribute some hormones and supply plants with P-element as well as certain micronutrients which in turn reflects on storability of sweet potato (Bryan and Stark, 2003; Mikkelsen, 2005).

Effect of interaction between P-rates and application methods of humic acid.

Data in Table (5) show the interaction effect of the applied P-rates with application methods of humic acid on storability and decay of sweet potato tuber roots. In general, the combined treatments were more useful than single applications. The combinations significantly reduced weight loss percent in tuber roots during storage period at 30, 60, 90 and 120 days and decay at 120 days as compared with single ones. The minimum values of weight loss percent were attained by fertilizing with 30 or 45 kg P_2O_5/fed with the soil application method of humic acid. Similar results were obtained by El-Morsy *et al*. (2002) and Saif-El-Deen (2005).

From the obtained results, it could be concluded that the sweet potato plants fertilized by 30 kg P_2O_5/fed with soil application method of humic acid is recommended for increasing plant growth and yield as well as improving quality and storability of tuber roots. This treatment achieved great values were superior for that produced by using 45 kg P_2O_5/fed without application of humic acid. Therefore, the soil application of humic acid reduced the need for chemical P-fertilizer by about 33.3 %, thereby reducing costs and pollution of environment.

Table (5): Weight loss percentage during the storage period and decay of sweet potato tubers as affected by by P-rates, application methods of humic acid and their interactions in 2007 and 2008 seasons.

Parameters / Treatments		Weight loss (%) 30 DAS 2007	30 DAS 2008	60 DAS 2007	60 DAS 2008	90 DAS 2007	90 DAS 2008	120 DAS 2007	120 DAS 2008	Decay (%) 2007	Decay (%) 2008
P-rates											
15kg P_2O_5/fed		9.83	10.09	18.74	19.43	28.70	29.96	34.62	36.11	15.96	16.21
30kg P_2O_5/fed		9.16	9.42	18.07	18.67	27.80	29.29	33.70	35.38	15.53	15.80
45kg P_2O_5/fed		8.98	9.31	17.79	18.43	27.46	29.06	33.19	34.80	15.43	15.41
LSD at 5%		0.11	0.11	00.05	00.13	00.09	00.15	00.02	00.18	00.04	00.10
Humic app. methods.											
Control[1]		9.64	10.23	18.61	19.36	28.60	29.75	34.82	37.01	16.25	16.21
Foliar app.[2]		9.39	9.83	18.40	18.89	28.18	29.50	33.88	35.86	15.90	15.91
Transplant tr.[3]		9.28	9.37	18.11	18.74	27.85	29.37	33.52	34.81	15.41	15.75
Soil app.[4]		8.97	9.00	17.67	18.37	27.33	29.13	33.14	34.04	15.00	15.36
LSD at 5%		0.12	0.11	0.12	00.06	00.19	00.14	0.08	00.13	00.17	00.13
Interaction											
P-rates	**Humic app. meth.**										
15kg P_2O_5/fed	1	10.18	10.84	19.01	20.25	29.06	30.45	35.82	37.66	16.35	16.47
	2	9.84	10.15	18.85	19.43	28.86	29.98	34.56	36.59	16.14	16.30
	3	9.74	9.80	18.68	19.13	28.73	29.78	34.20	35.54	15.73	16.13
	4	9.54	9.56	18.45	18.91	28.15	29.63	33.91	34.65	15.62	15.94
30kg P_2O_5/fed	1	9.48	9.99	18.59	19.07	28.62	29.60	34.98	37.08	16.24	16.40
	2	9.30	9.83	18.38	18.80	28.07	29.42	33.84	36.11	15.87	15.99
	3	9.18	9.17	18.07	18.73	27.62	29.29	33.30	34.65	15.39	15.79
	4	8.66	8.67	17.26	18.08	26.91	28.84	32.68	33.67	14.62	15.02
45kg P_2O_5/fed	1	9.25	9.84	18.25	18.77	28.13	29.20	33.66	36.29	16.16	15.76
	2	9.04	9.51	17.97	18.44	27.61	29.10	33.24	34.90	15.68	15.43
	3	8.92	9.12	17.61	18.37	27.18	29.04	33.06	34.23	15.12	15.34
	4	8.71	8.76	17.31	18.13	26.94	28.91	32.81	33.80	14.77	15.11
LSD at 5%		0.20	0.19	00.21	00.11	00.32	00.24	00.14	00.23	00.30	0.23

app.= application & tr.= treatment & Meth.=method

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تأثير معدلات التسميد الفوسفاتي و طرق إضافة حمض الهيوميك علي الإنتاجية والجودة في البطاطا.

أسامة محمد سيف الدين ، عبدالبديع صالح عزت و عبد الله حلمي على المرسي
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نُفذت تجربتان حقليتان على محصول البطاطا (صنف بيورا جارد) فى المزرعة البحثية لمعهد بحوث البساتين بالبرامون- محافظة الدقهلية خلال موسمى الزراعة ٢٠٠٨ و ٢٠٠٩ م، لدراسة تأثير معدلات إضافة الفوسفور (١٥، ٣٠ و٤٥ كجم فو٢أ٥/فدان) كلٌ منها منفرداً أو مع بعض طرق إضافة حمض الهيوميك (كنترول "بدون أضافة"، الرش الورقي، معاملة الشتلات قبل الزراعة و الأضافة الأرضية)، على نمو ومحصول البطاطا ومكوناته وكذلك أيضاً المحتويات الكيماوية فى الجذور الدرنية ونسبة الفقد فى وزن الجذور الدرنية خلال فترة التخزين ونسبة التلف فى الجذور الدرنية فى نهاية فترة التخزين (٤ شهور) . وقد وزعت المعاملات فى قطع منشقة مرة واحدة فى ثلاثة مكررات.

ويمكن تلخيص النتائج المتحصل عليها فيما يلى :-

- بصفه عامة، أدت الزيادة فى معدل الفوسفور المضاف من ١٥ إلى ٤٥ كجم فو٢أ٥/فدان إلى حدوث زيادات ملموسة فى طول النبات، الوزن الجاف لعرش النبات، المساحة الورقية للنبات بالإضافة إلى زيادة الكلوروفيل والكاروتينات، وكذلك زيادة المحصول الكلى والمحصول التسويقى للفدان ومتوسط وزن وطول وقطر الجذر الدرنى وعلاوة على ذلك، أدت إضافة الفوسفور عند معدل ٤٥ كجم فو٢أ٥/فدان إلى زيادات معنوية فى نسبة عناصر النيتروجين والفوسفور والبوتاسيوم تركيزات الكربوهيدرات الكلية والسكريات الكلية، وقد أدت أيضاً إلى حدوث انخفاض معنوى فى نسبة نقص وزن الجذور الدرنية ونقص نسبة تلف الجذور الدرنية خلال وفى نهاية فترة التخزين.
- ومن ناحية أخرى أدت طرق إضافة حمض الهيوميك إلى حدوث زيادات معنوية فى كل الصفات المدروسة فى كلا موسمى الدراسة. وقد أدت الإضافة الأرضية لحمض الهيوميك إلى زيادة فى صفات النو الخضرى والصبغات النباتية وكذلك المحصول الكلى والتسويقى وجودة الجذور الدرنية، كما أدت إلى زيادة المحتويات الكيماوية للجذور الدرنية، وبجانب ذلك أدت إلى انخفاض نسبة نقص وزن ونسب تلف الجذور الدرنية عند نهاية فترة التخزينً.
- التفاعلات بين معدلات إضافة الفوسفور وطرق إضافة حمض الهيوميك كانت بصفة عامة أكثر تأثيرا من الإضافة المنفردة لكل منهما. وكانت أفضل النتائج بإضافة الفوسفور بمعدل ٣٠ كجم فو٢أ٥/فدان مع طريقة الإضافة الأرضية لحمض الهيوميك، حيث حققت هذه المعاملة زيادة فى صفات النو الخضرى والصبغات النباتية وكذلك المحصول الكلى والتسويقى وجودة الجذور الدرنية، كما أدت إلى زيادة المحتويات الكيماوية للجذور الدرنية، بالإضافة إلى تحسين القدرة التخزينية للجذور الدرنية للبطاطا وتقليل نسبة تلفها فى نهاية فترة التخزين مقارن مع المعاملات الأخرى.

وبناءً على ماتقدم، يمكن التوصية باستخدام ٣٠ كجم فوسفور للفدان مع الإضافة الأرضية لحمض الهيوميك لرفع إنتاجية البطاطا وتحسين جودة الجذور الدرنية وقابليتها للتخزين، علاوة على ذلك تقليل الفوسفور المستخدم بنسب تصل إلى ٣٣.٣% والذى من شأنه خفض تكاليف الانتاج والتلوث البيئى، تحت الظروف المشابهة لظروف هذه الدراسة.

قام بتحكيم البحث

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