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RESPONSE OF POTATO PLANTS TO POTASSIUM AND PHOSPHORUS FERTILIZATION

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ABSTRACT

Two separate experiments were carried out in a private farm in El-Matria; Dakahlia Governorate, Egypt during two successive seasons 2009/2010 and 2010/2011 to study the effect of potassium sources (potassium mono phosphate 52% K_2O potassium sulphate 50% K_2O and potassium citrate 38% k), levels (0, 60 and 120 kg K_2O/ fed for each source), phosphorus sources (calcium super phosphate 15.5 % P_2O_5, rock phosphate 30 % P_2O_5 and phosphoric acid 85% P_2O_5) and levels (0, 30 and 60 kg P_2O_5/fed for each source) on vegetative growth, tuber yield and chemical constituents of potato (*Solanum tuberosum* L.) "Spunta". Treatments were arranged in randomized complete block design in three replicates. The obtained results indicated that both potassium mono phosphate at 120 kg K_2O/fed and phosphoric acid at 60 kg P_2O_5/fed gave the highest values of vegetative growth parameters, tuber yield and its quality in both seasons as compared with other treatments and the differences were significant.

Keywords: K-fertilization, P-fertilization, forms, levels, potato plants

INTRODUCTION

Potato (*Solanum tuberosum* L.) as a member of the family solanaceae is one of the most important food crops all over the world including Egypt. It ranks the first export and the second vegetable crop in energy. Potato require high amounts of potassium and phosphorus fertilizers for optimum growth, production and tuber quality (Al-Moshileh and Errebi, 2004).

Potassium is one of essential nutrients required for plant growth and reproduction. It is classified as a macronutrient as nitrogen and phosphorus. It plays a vital role in photosynthesis, carbohydrate transport, protein formation, control of ionic balance, regulation of plant stomata and water use activation of plant enzymes (Munson *et al.*, 1985). According to Abd El-Aal-Faten *et al.*, (2008) studied the addition of K at 90 units/fed and resulted in the best values of plant growth, average number of shoots, leaves number as well as fresh and dry weight and gave heaviest tuber yield as well as number and size of tuber per plant and raised, the concentration of the nutrient elemental in tubers yield tissues.

The presence of phosphorus in the soil encourages plant growth because it is an essential nutrient. Practically, phosphorus is a major building block of DND molecules (Pant and Reddy, 2003). The Potato crop has traditionally been regarded as having a large requirement for phosphorus with the results that substantial applications of phosphate fertilizer are frequently made in anticipation of significant economic yield responses. Numerous studies have been found the relationships between P availability and yield

(Jenkins and Ali, 2000). In addition, (Hinsinger, 2001) reported that the two forms of phosphorus in soil are organic and inorganic. Organic phosphorus is the most stable form of phosphorus in the soil. While inorganic phosphorus is not stable. Therefore, inorganic phosphorus is readily absorbed and used by plant if it is not fixed.

The main objective of the present study is to evaluate the effect of different forms of potassium and phosphorus fertilizer with different levels on potato growth, chemical composition and yield.

MATERIALS AND METHODS

Two field experiments were carried out in a private farm in El-Matria,Dakahlia Governorate, Egypt during the two successive seasons of 2009/2010 and 2010/2011 to study the effect of sources and levels of potassium and phosphorus on vegetative growth , yield and chemical constituents of potato (*Solanum tuberosum* L) c.v spunta cultivar.

The treatments were arranged in a randomized complete block design. The first experiment was the simple possible combination between 3 sources of potassium fertilizers (Potassium mono phosphate (52% K_2O), Potassium sulphate (50% K_2O) and Potassium citrate (38% k) and three levels (0, 60 and 120 kg K_2O /fed). The second experiment was 3 treatments of phosphorus fertilizers sources (calcium super phosphate (15.5 % P_2O_5), rock phosphate (30 % P_2O_5) and phosphoric acid (85 % P_2O_5) in three levels (0, 30 and 60 kg P_2O_5/fed). Each treatment was replicated three times; thus, the total numbers of every experiment was 27 experimental units.

The plot area was 10.5 m^2 which contained 3 rows, 5m long and 0.7m wide.

Soil samples were taken at random from the experiment field area at a depth of 15 and 30 cm from soil surface before soil preparation to estimate the physical and chemical properties of the soil according to the method described by Jackson (1967) and corresponding data are presented in Table 1.

The land prepared for cultivation and the tuber pieces which treated with disinfectant fungal were planted on 22th and 25th January (2009/2010 and 2010/2011), respectively at equal distance and depth.

The rates of phosphoric acid fertilization were added to the surface soil in a foliar way twice one after 30 days and the other 15 days later. The other sources of P and K fertilization were applied twice at the same times of phosphoric acid addition as soil fertilization.

Ammonium nitrate (33.5%) 120 kg N/fed and Ca-super phosphate (15.5 % P_2O_5) as 60 kg P_2O_5/fed were added two times one before the second irrigation (30 days after sowing) and the other before the third irrigation(45 days after sowing) in potassium experiment Ammonium nitrate (33.5 %) 120 kg N /fed and potassium sulphate (48 % K_2O) 96 kg K_2O /fed were added two times one before the second irrigation and the other before the third irrigation in phosphate experiment..

Table 1: Some physico-chemical properties of the experimental soil during both seasons of 2009-2010 and 2010-2011.

Soil characters		2009-2010	2010-2011
Mechanical analysis (%)	Coarse sand	3.4	2.9
	Fine sand	43.6	44.8
	Silt	38.2	38.5
	Clay	14.8	13.8
	OM%	1.86	2.05
	Texture class	Loam	Loam
EC $dS.m^{-1}$(1:5)		0.79	0.83
pH (paste)		8.97	8.82
Anions (meq/100soil)	CO_3	n.d	n.d
	HCO_3	0.52	0.75
	Cl	1.18	1.28
	SO_4	0.78	0.90
	Ca	0.83	0.95
	Mg	0.63	0.80
	Na	0.81	0.93
	K	0.21	0.25
Micro nutrients (ppm)	Fe	2.17	2.21
	Mn	1.45	1.54
	Zn	0.88	0.84
	Cu	0.80	0.81
Available (ppm)	N	38	41
	P	30	36
	K	564	576

Table 2: Amount of fertilizers added for potassium experiment:

Ferti kg/fed / units	K- mono phosphate	K- sulphate	K-citrate
0 unit K_2O	0 kg/fed	0 kg/fed	0 kg/fed
60 unit K_2O	115kg/fed(302g/plot)	120 kg/fed(315g/plot)	157 kg/fed(414g/plot)
120 unit K_2O	230 kg/fed(605g/plot)	240 kg/fed(630g/plot)	314 kg/fed(828g/plot)

Table 3: Amount of fertilizer added for the phosphorus experiment:

Ferti kg/fed / Units	Calcium super phosphate	Rock phosphate	Phosphoric acid
0 unit P_2O_5	0 kg/fed	0 kg/fed	0 L/fed
30 unit P_2O_5	193 kg/fed(508g/plot)	100 kg/fed(262g/plot)	35 L/fed(91ml/plot)
60 unit P_2O_5	386 kg/fed(1016g/plot)	200 kg/fed(525g/plot)	70 L/fed(185ml/plot)

At harvesting time (110 days after planting), the plants were randomly taken from each plot to determine the following characters:

plant length (cm), number of stem/plant, fresh weight (g/plant)and dry weight(%) of plant foliage, tuber fresh weight (g/plant)and tuber dry weight (%), No. of tuber/plant, average weight of TSS,Vit C, tuber and total yield (ton/fed.). Then, the dried plant samples were thoroughly ground and stored for chemical analysis.

Plant Analysis:

The oven dried material of plants were ground and wet digested by a sulfuric-per chloric acids mixture as described by Peterburgski (1968). Total N, P and K% ,total sugar and starch were determined in the digested plant materials using the methods described by Pregle 1945, Jackson 1967, and Black 1965, respectively.

The obtained data were subjected to statistical analysis as factorial experiment in a randomized complete block design with three replicates in the both growing seasons according to Gomez and Gomez, (1984). Average means were compared statistically using LSD at 5%.

RESULTS AND DISCUSSION

1. Vegetative growth:

Data of vegetative growth parameters, i.e., plant length (cm), number of stem/plant, fresh weight (g/plant) and dry weight (%) of plant foliage after 110 days from planting as influenced by K and P sources and levels are present in Tables 4 and 5.

1.1. Effect of K sources and levels:

Concerning the effect of potassium fertilization sources, Table 4 reveal that the mean values of plant length (cm), fresh weight (g/plant) and dry weight (%) of plant foliage after 110 days from planting significantly affected with different sources of application except number of stem/plant had in significant effect and the highest mean values were recorded with using K-mono phosphate.

Data present in Table 4 show significantly effect by using different levels of K-application and indicated that the highest mean value of plant length (cm), number of stem/plant, fresh weight(g/plant) of plant and dry weight % of plant foliage after 110 days obtained from 120 kg K_2O /fed during both seasons.

Obtained data in Table 4 indicate that the average of all parameters were significantly increased with K-mono phosphate at rate 120 kg K_2O /fed. Compare with the other sources under any levels except No. of stem/plant in the 2nd season.

The increments in plant growth characters because of using two sources of potassium fertilization at the high level may be due to the increments in plant growth characters because of using K- mono phosphate treatment at high level may be due to the effect of phosphorus and potassium on potato plant growth. As it contains about 34% P_2O_5 +52% K_2O. This means the superiority happened as a results of direct and indirect effect to this elements on potato plants growth. Phosphorus play an important roles in a positive impact on growth of plants, it is the second elements of the three major elements (N, P and K). Phosphorus enters in the composition of the proteins nucleus. It is also an important element in respiration process. Also it play an important role in carbohydrate exchange as turning starch in to sugar and fat assimilation.

The role of such macro nutrients in the physiological process and cell division and elongation which indirect affect tissue formation and consequently vegetative growth of plant. These results are in good accordance with those obtained by (Malakouti *et al.*, 2005 and Yildirim *et al.*, 2009 El-Sirafy *et al.*, (2008a).

Table 4: Effect of K sources and levels and interaction effect on vegetative growth parameters after 110 days from planting during seasons of 2010 and 2011.

Treat. \ Char.		plant length (cm)		No. of stem/plant		Fresh weight of plant foliage (g/plant)		Dry matter of plant foliage (%)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of K-fertilization									
K-mono phosphate		47.54	48.85	2.83	3.25	724.40	106.96	15.24	19.52
K-sulphate		41.76	44.17	3.22	3.67	724.11	98.01	13.53	18.35
K-citrate		40.51	42.14	3.28	3.89	706.99	93.30	13.07	17.19
LSD at 5%		0.64	0.72	N.S	N.S	7.27	2.27	0.12	0.19
B: Effect of levels of K-fertilization									
0 kg K_2O .fed^{-1}		42.41	45.08	2.67	3.44	710.60	98.83	13.69	18.26
60 kg K_2O .fed^{-1}		43.22	44.55	3.06	3.44	722.69	97.72	13.91	18.06
120 kg K_2O .fed^{-1}		44.18	45.11	3.61	3.94	722.21	100.80	14.24	18.60
LSD at 5%		0.86	0.90	0.34	0.40	3.86	0.91	0.04	0.08
C: Interaction effect									
K-mono phosphate	0	46.07	47.12	2.50	3.25	716.27	102.84	14.80	18.89
	60	47.00	48.90	2.67	3.17	725.73	104.93	15.14	19.39
	120	49.57	49.95	3.33	3.33	731.20	111.73	15.78	20.08
K-sulphate	0	41.23	46.14	2.83	3.50	715.63	101.82	13.30	18.80
	60	41.77	43.19	3.00	3.67	726.23	95.54	13.54	17.86
	120	42.27	43.19	3.83	3.83	730.47	96.68	13.76	18.38
K-citrate	0	39.93	42.66	2.67	3.50	699.90	93.18	12.97	17.31
	60	40.90	41.56	3.50	3.50	716.10	92.70	13.04	16.93
	120	40.70	42.20	3.67	4.67	704.97	94.00	13.19	17.34
LSD at 5%		1.24	1.77	0.57	N.S	6.68	1.57	0.07	0.13

1.2 Effect of P sources and levels:

Concerning the effect of phosphorus fertilization sources, Table 5 reveal that the mean values of plant length (cm), number of stem/plant, fresh weight (g/plant) and dry weight (%) of plant foliage after 110 days from planting tended to significantly affected with different phosphorus sources except with number of stem/plant had no significant effect and the highest mean values were recorded with using phosphoric acid.

Data present in Table 5 indicate that the average of all parameters were significantly affect by using different levels of p-application and indicate that the highest mean values of plant length (cm),No.of stem, fresh weight of plant(g/plant)and dry weight of foliage% after110 days obtained from 60 kg P_2O_5/fed during both season obtained data in table 5 indicate that the average of all parameters after 110 days from plant were significantly increased with phosphoric acid at rate 60 kg P_2O_5/fed compared with other sources under any levels except No.of stem in the 2nd season.

The highest mean values of parameters under study were obtain with adding phosphoric acid at the rate 60 kg P_2O_5/fed. compare with the other sources under any levels. This increases might be due to that phosphoric acid as the best solubility and the best source of P-fertilization which had 85%P.

Generally, the role of phosphorus in plant growth are investigated by many workers (Hinsinger, 2001; Pant and Reddy, 2003 and Shafeek *et al.*, 2004). All of them agreed that, the presence of phosphorus in the soil encourages plant growth and development

Table 5: Effect of P source, levels and interaction effect on vegetative growth parameters after 110 days from planting during seasons of 2010 and 2011.

Treat. \ Char.		plant length (cm)		No. of stem/plant		Fresh weight of plant foliage (g/plant)		Dry matter of plant foliage (%)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of P-fertilization									
Ca-super phosphate		43.96	45.57	3.28	3.72	96.57	100.11	18.46	19.13
Rock-phosphate		43.11	44.69	2.94	3.39	95.77	99.28	18.25	18.92
Phosphoric acid		46.60	48.31	3.50	3.72	102.96	106.73	19.26	19.97
LSD at 5%		0.41	0.45	N.S	N.S	1.68	1.76	0.07	0.06
B: Effect of levels of P-fertilization									
0 kg P_2O_5 .fed^{-1}		43.67	45.27	2.78	3.39	96.41	99.95	18.24	18.91
30 kg P_2O_5 .fed^{-1}		44.80	46.45	3.17	3.28	98.88	102.51	18.41	19.09
60 kg P_2O_5 .fed^{-1}		45.20	46.86	3.78	4.17	100.00	103.67	19.32	20.02
LSD at 5%		0.67	0.70	0.34	0.37	1.67	1.75	0.06	0.07
C: Interaction effect									
Ca-super phosphate	0	43.23	44.82	2.67	3.83	94.77	98.23	18.16	18.82
	30	43.83	45.45	3.33	3.17	96.47	100.00	18.22	18.89
	60	44.80	46.44	3.83	4.17	98.47	102.08	19.00	19.69
Rock-phosphate	0	42.20	43.75	2.33	2.83	94.00	97.45	17.77	18.42
	30	43.87	45.48	2.67	3.00	96.80	100.36	17.95	18.61
	60	43.27	44.85	3.83	4.33	96.50	100.05	19.03	19.73
Phosphoric acid	0	45.57	47.24	3.33	3.50	100.47	104.16	18.80	19.49
	30	46.70	48.41	3.50	3.67	103.37	107.16	19.07	19.77
	60	47.53	49.28	3.67	4.00	105.03	108.87	19.92	20.65
LSD at 5%		0.97	1.56	0.97	N.S	2.51	3.74	0.11	0.11

2. Chemical constituents of leaves and tuber:

N, P and K percentages in leaves and tubers as affected by K and P sources and levels after 110 days from planting during seasons 2010 and 2011 are presents in Tables 6 and 7.

2.1. N, P and K% in leaves and tubers :

2.1.1. Effect of K sources and levels:

Regarding to the effect of adding potassium-sources, Table 6 show that the mean values of N, P and K percentages in leaves and tubers after 110 days from planting were significantly affected with different sources of potassium-fertilization k-mono phosphate gave the highest values of all measured parameters after 110 days in leaves and tubers and the differences were significant.

Concerning the effect of potassium fertilizers levels on N, P and K concentration in leaves and tubers after 110 days from planting , data in the same table show clearly that addition of 120 kg K_2O /fed gave the highest values of all estimated elements during both season except K% in the first season

It is evident from the data in Table 6 that, K-sources and levels had a significant effects on N, P and K percentages in leaves and tubers after 110 days from planting. As for the effect of K-sources and levels ,the highest mean values of N, P and K percentages in leaves and tubers were recorded with adding of K-mono phosphate at the rate 120 kg K_2O /fed followed by 60 kg K_2O /fed from the same sources.

Table 6: Effect of K sources, levels and interaction effect on N, P and K in leaves and tubers after 110 days from planting in during season 2010and 2011 .

Char. / Treat.		Leaves						Tubers					
		N%		P%		K%		N%		P%		K%	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of K-fertilization													
K-mono phosphate		1.86	1.57	0.286	0.271	2.81	2.57	0.80	0.68	0.146	0.138	1.77	1.62
K-sulphate		1.65	1.43	0.250	0.223	2.75	2.47	0.71	0.62	0.128	0.114	1.73	1.56
K-citrate		1.58	1.35	0.223	0.209	2.70	2.36	0.68	0.58	0.114	0.107	1.70	1.49
LSD at 5%		0.02	0.05	0.011	0.007	0.05	0.03	0.01	0.02	0.007	0.004	0.03	0.02
B: Effect of levels of K-fertilization													
0 kg K_2O .fed^{-1}		1.66	1.43	0.240	0.233	2.67	2.46	0.71	0.62	0.123	0.119	1.68	1.55
60 kg K_2O .fed^{-1}		1.70	1.45	0.275	0.228	2.71	2.42	0.73	0.62	0.140	0.116	1.71	1.52
120 kg K_2O .fed^{-1}		1.74	1.46	0.244	0.238	2.89	2.51	0.75	0.63	0.124	0.121	1.82	1.58
LSD at 5%		0.03	0.03	0.012	0.004	0.02	0.03	0.01	0.01	0.007	0.004	0.02	0.02
C: Interaction effect													
K-mono phosphate	0	1.78	1.49	0.281	0.265	2.74	2.52	0.77	0.64	0.143	0.135	1.73	1.58
	60	1.85	1.57	0.292	0.268	2.79	2.53	0.80	0.68	0.149	0.137	1.76	1.60
	120	1.96	1.62	0.284	0.277	2.91	2.64	0.84	0.70	0.145	0.141	1.84	1.66
K-sulphate	0	1.62	1.47	0.225	0.232	2.65	2.48	0.70	0.63	0.115	0.118	1.67	1.56
	60	1.64	1.41	0.294	0.212	2.70	2.39	0.71	0.61	0.150	0.108	1.70	1.51
	120	1.68	1.41	0.231	0.226	2.89	2.55	0.72	0.61	0.118	0.115	1.82	1.61
K-citrate	0	1.56	1.35	0.215	0.214	2.61	2.41	0.67	0.58	0.110	0.109	1.64	1.52
	60	1.59	1.36	0.238	0.204	2.64	2.33	0.69	0.58	0.122	0.104	1.66	1.47
	120	1.59	1.35	0.217	0.210	2.85	2.35	0.68	0.58	0.111	0.107	1.80	1.48
LSD at 5%		0.05	0.05	0.021	0.007	0.04	0.05	0.02	0.02	0.013	0.007	0.03	0.03

Comparing with the other sources under any levels, the mean values of N, P and K percentages in leaves and tubers were decreased during both seasons. This result may be due to the increase of enzymatic activities which affect absorption of mineral nutrients by plant and in turn increase its concentration in plant parts. This positive effect may be related to the main important role of K in plant. In this concern, Tawfik (2001) indicated that application of K-rates (60 and 120 kg K_2O/fed) increased leaf K-concentration. Also, Al-Moshileh and Errebi (2004) point out that tuber K-content increased significantly with K-rates (0, 150, 300, 450 and 600 kg K_2SO_4 /ha).

2.1.2. Effect of P sources and levels:

With regard to the effect of adding phosphorus sources, Table 7 show that the mean values of N, P and K percentages in leaves and tubers after 110 days from planting were significantly affected with different sources of phosphorus application. Phosphoric acid equipped the first order and gave the highest values of N,P and K concentrations in leaves and tubers and differences were significant.

Table 7: Effect of P sources, levels and interaction effect on N, P and K in leaves and tubers after 110 days from planting during seasons of 2010 and 2011 .

Char. / Treat.		Leaves						Tubers					
		N%		P%		K%		N%		P%		K%	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of K-fertilization													
Ca-super phosphate		1.74	1.50	0.245	0.248	2.41	2.27	0.75	0.64	0.125	0.126	1.52	1.43
Rock-phosphate		1.71	1.46	0.253	0.236	2.31	2.15	0.74	0.63	0.129	0.120	1.45	1.35
Phosphoric acid		1.84	1.57	0.278	0.265	2.48	2.26	0.79	0.68	0.142	0.135	1.56	1.42
LSD at 5%		0.05	0.04	0.003	0.004	0.02	0.06	0.02	0.02	0.003	0.004	0.01	0.04
B: Effect of levels of K-fertilization													
0 kg P_2O_5 .fed^{-1}		1.72	1.46	0.245	0.244	2.31	2.10	0.74	0.63	0.125	0.124	1.46	1.33
30 kg P_2O_5 .fed^{-1}		1.77	1.51	0.266	0.250	2.39	2.21	0.76	0.65	0.136	0.127	1.51	1.39
60 kg P_2O_5 .fed^{-1}		1.80	1.56	0.266	0.255	2.49	2.36	0.77	0.67	0.136	0.130	1.57	1.48
LSD at 5%		0.03	0.04	0.003	0.003	0.04	0.04	0.01	0.02	0.003	0.003	0.02	0.02
C: Interaction effect													
Ca-super phosphate	0	1.69	1.44	0.223	0.246	2.30	2.11	0.73	0.62	0.114	0.125	1.45	1.33
	30	1.74	1.50	0.254	0.246	2.41	2.12	0.75	0.65	0.130	0.125	1.52	1.33
	60	1.78	1.55	0.259	0.251	2.51	2.58	0.77	0.67	0.132	0.128	1.58	1.63
Rock-phosphate	0	1.66	1.40	0.244	0.232	2.24	2.04	0.72	0.60	0.124	0.118	1.41	1.29
	30	1.74	1.48	0.266	0.239	2.31	2.29	0.75	0.63	0.135	0.122	1.45	1.44
	60	1.73	1.52	0.251	0.236	2.37	2.11	0.74	0.65	0.128	0.120	1.50	1.33
Phosphoric acid	0	1.79	1.55	0.268	0.253	2.40	2.16	0.77	0.67	0.137	0.129	1.51	1.36
	30	1.84	1.56	0.278	0.264	2.46	2.23	0.79	0.67	0.142	0.135	1.55	1.40
	60	1.89	1.62	0.288	0.277	2.58	2.38	0.81	0.70	0.147	0.141	1.62	1.50
LSD at 5%		0.05	0.06	0.004	0.006	0.06	0.06	0.02	0.03	0.005	0.006	0.04	0.04

As for the effect of P-levels in the same Table, found a significant effect on N, P and K percentages in leaves and tubers after 110 days by increasing levels P-levels up to 60 kg P_2O_5/fed.

With respect to the effect of P-sources and levels in forms of Ca-super phosphate, Rock-phosphate and Phosphoric acid, data in Table 7 reveal that there were significant differences between the average values of N, P and K percentages in leaves and tubers after 110 days from planting due to adding P-sources under any level. Comparing with the untreated plants, N, P and K percentages in leaves and tubers were increased with increasing the levels from 0 up to 60 kg P_2O_5/fed. And found that the highest mean values were obtained with adding phosphoric acid at the rate 60 kg P_2O_5/fed during both seasons. The favorable effect of phosphorus fertilization on minerals content of potato leaves may be due to the direct effect of phosphorus form in increasing photosynthesis rate which increased carbohydrate concentration in the plant leaves , subsequently activated

elements absorption by the roots which reflected on the increment in N, P and K percentages in the leaves and tubers. These results are in accordance with those of Shabana (2004), Turan *et al.*, (2007), Magda and Asmaa (2009) and Gad-Nadia and Kandil-Hala (2010).

3. Yield and its components :

Table 8 and 9 present the response of yield and its components of potato plants, i.e., tuber fresh weight (g/plant), tuber dry weight (%), No. of tuber/plant, average weight of tuber and total yield (ton/fed) after 110 days from planting as affected by K and P sources and levels.

3.1. Effect of K sources and levels:

Data in Table 8 show that application of potassium fertilization sources gave significant effects on the mean values of tuber fresh weight (g/plant), tuber dry weight (%),and total yield (ton/fed) and had in significant effect on No. of tuber/plant and average weight of tuber. Potassium mono phosphate was superior more than other treatments. As for the effect of potassium levels, table 8 show significant effects on tuber fresh weight (g/plant),tuber dry weight percentage and total yield (ton/fed) after 110 days from planting by increasing potassium levels up to 120 kg K_2O /fed.

Listed data present in Table 8 indicate the tuber fresh weight (g/plant), tuber dry weight (%), No. of tuber/plant and total yield (ton/fed) after 110 days from planting affected significantly by adding K-source and levels during both seasons. The highest mean values of obtained parameters were with K-mono phosphate as K-source at rate of 120 kg K_2O /fed comparing with other sources under any level. This effect was true during both seasons. This trend was obtained by Anwar (1998) who reported that the number of tubers/plant significantly increased with increasing K fertilizer level. Also, Asmaa and Magda (2010) found that the total tuber yield was gradually and significantly increased with increasing the level of potassium application. Also, they concluded that the nutritive values of potato tubers were significantly affected by potassium application from (40, 80 up to 120 kg K_2O/fed.).

Table 8: Effect of K source, levels and interaction effect on tuber fresh weight (g), tuber dry weight (%), number of tuber/plant, average weight of tuber and total yield (ton/fed) after 110 days from planting during seasons 2010 and 2011.

Char. / Treat.		Tuber fresh weight (g/plant)		Tuber dry weight (%)		No. of tuber/plant		Average weight of tuber		Total yield (ton/fed)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of K-fertilization											
K-mono phosphate		724.40	745.99	15.24	15.70	4.39	4.50	190.21	193.11	17.78	17.84
K-sulphate		724.11	745.52	13.53	14.27	3.83	4.44	196.88	179.88	15.76	16.28
K-citrate		706.99	731.20	13.07	13.64	4.50	4.78	160.43	155.84	15.11	15.36
LSD at 5%		7.27	7.38	0.12	0.14	N.S	N.S	N.S	N.S	0.23	0.47
B: Effect of levels of K-fertilization											
0 kg K_2O .fed^{-1}		710.60	735.28	13.69	14.47	3.61	4.19	203.41	191.49	15.81	16.27
60 kg K_2O .fed^{-1}		722.69	740.24	13.91	14.38	4.39	4.56	177.85	172.45	16.18	16.30
120kg K_2O .fed^{-1}		722.21	746.00	14.24	14.62	4.72	4.94	166.26	164.70	16.66	16.74
LSD at 5%		3.86	3.92	0.04	0.04	N.S	N.S	N.S	N.S	0.26	0.31
C: Interaction effect											
K-mono phosphate	0	716.27	737.91	14.80	15.22	3.50	3.75	212.07	205.15	17.00	16.93
	60	725.73	744.34	15.14	15.57	4.67	4.17	182.24	203.13	17.67	17.84
	120	731.20	753.02	15.78	16.14	5.00	5.33	176.33	175.06	18.69	18.45
K-sulphate	0	715.63	739.07	13.30	14.66	3.33	4.33	223.17	203.95	15.50	16.74
	60	726.23	744.33	13.54	13.95	3.83	4.50	195.16	166.91	15.69	16.07
	120	730.47	753.16	13.76	14.21	4.33	4.50	172.30	168.79	16.08	16.02
K-citrate	0	699.90	729.74	12.97	13.78	4.00	4.33	174.98	169.94	14.93	15.34
	60	716.10	732.05	13.04	13.62	4.67	5.00	156.16	147.33	15.18	15.01
	120	704.97	731.81	13.19	13.53	4.83	5.00	150.15	150.25	15.22	15.76
LSD at 5%		6.68	6.80	0.07	0.06	0.12	0.09	N.S	N.S	0.46	0.52

3.2. Effect of P sources and levels:

It is clear from data present in Table 9 that; adding phosphorus sources (Ca-super phosphate, Rock-phosphate and Phosphoric acid) gave significantly higher magnitudes of tuber fresh weight (g/plant), tuber dry weight (%) and total yield (ton/fed) after 110 days from planting. Adding phosphorus sources as phosphoric acid was the one typeserior for increasing aforementioned traits followed by Ca-super phosphate and finally the Rock-phosphate. As for No. of tuber/plant and average weight of tuber had in significant effect. This trend were true during both seasons.

As for the effect of P-levels data in the same Table, revealed that the parameters under investigation were significantly increased with increasing the levels up to 60 kg P_2O_5/fed. except with the average weight of tuber during both seasons and No. of tuber/plant in the 2nd season had in significant effect.

With regard to the effect of phosphorus -sources and levels as Ca-super phosphate, Rock-phosphate and Phosphoric acid under levels 0, 30 and 60 kg P_2O_5/fed. data in Table 9 reveal that there were a significant differences between the average values of tuber fresh weight (g/plant), tuber dry weight (%) and total yield (ton/fed) after 110 days from planting during both seasons. The highest mean values for the previously mentioned traits were found to be associated with adding Phosphoric acid at rate of 60 kg

P_2O_5/fed. compared with other treatments had a major effect on the productivity of potato plant, hence increased total yield and its components. It may be attributed to the enhancement of phosphorus of the plant growth and it consequently reflected on the tuber yield. Many investigators obtained a similar trend of results (Gupta, *et al.*, 1999 and Ghoname and Shafeek 2004).

Table 9: Effect of P source ,levels and interaction effect on tuber fresh weight (g), tuber dry weight (%), number of tuber/plant, average weight of tuber and total yield (ton/fed) after 110 days from planting during seasons 2010and 2011.

Char. / Treat.		Tuber fresh weight (g/plant)		Tuber dry weight (%)		No. of tuber/plant		Average weight of tuber		Total yield (ton/fed)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of P-fertilization											
Ca-super phosphate		714.82	735.97	14.11	14.62	4.83	4.72	153.34	157.34	16.58	16.30
Rock-phosphate		705.46	726.62	13.90	14.41	4.61	5.33	155.63	137.93	16.33	15.99
Phosphoric acid		723.58	746.30	14.87	16.01	4.56	5.00	160.14	149.92	17.59	17.04
LSD at 5%		1.88	1.99	0.11	0.12	N.S	N.S	N.S	N.S	0.01	0.01
B: Effect of levels of P-fertilization											
0 kg P_2O_5 .fed^{-1}		709.60	731.83	14.08	14.60	3.89	4.44	182.86	164.92	16.38	15.96
30 kg P_2O_5 .fed^{-1}		713.15	734.63	14.23	14.75	4.67	5.06	153.40	146.39	16.90	16.44
60 kg P_2O_5 .fed^{-1}		721.11	742.44	14.56	15.70	5.44	5.56	132.85	133.88	17.22	16.92
LSD at 5%		2.62	2.66	0.05	0.06	1.06	N.S	N.S	N.S	0.04	0.04
C: Interaction effect											
Ca-super phosphate	0	711.50	732.85	13.95	14.46	3.67	4.17	193.87	175.74	16.14	15.78
	30	714.35	735.98	13.99	14.50	5.00	4.67	142.91	157.60	16.58	16.32
	60	718.43	739.09	14.38	14.91	5.83	5.33	123.23	138.67	17.03	16.80
Rock-phosphate	0	697.03	717.93	13.68	14.18	3.83	4.50	181.99	159.54	15.88	15.34
	30	701.93	723.00	13.80	14.31	4.67	5.67	150.31	127.51	16.52	16.10
	60	717.43	738.94	14.22	14.74	5.33	5.83	134.60	126.75	16.58	16.52
Phosphoric acid	0	720.27	744.70	14.61	15.15	4.17	4.67	172.73	159.46	17.13	16.77
	30	723.00	744.92	14.90	15.45	4.33	4.83	166.97	154.06	17.60	16.90
	60	727.47	749.28	15.08	15.64	5.17	5.50	140.17	136.23	18.05	17.44
LSD at 5%		4.54	4.61	0.09	0.10	N.S	N.S	N.S	N.S	0.07	0.07

4.Tuber quality:

Data of tuber quality, i.e., TSS %, total sugar%, starch% and Vit C (mg/100g) of tuber after 110 days from planting as influenced by K and P sources and levels are present in Tables 10 and 11.

4.1. Effect of K sources and levels:

It appeared from the data at Table 10 that with adding K-monophosphate as K-sources gave the highest

mean values of TSS %, total sugar%, starch% and Vit C (mg/100 g) of tuber after 110 days from planting during both seasons.

As shown in Table 10, there are significant differences among mean values of TSS %, total sugar%, starch% and Vit C (mg/100g) of tuber after 110 days from planting as affected by increasing K-fertilization levels up to 120 kg K_2O /fed.

Data in table 10 reveal that the average of all parameters were significantly increased with potassium mono phosphate at rate of 120 kg K_2O /fed comparing with the other sources and levels after 110 days from planting during both seasons. The higher yield and physical quality in case of using the high level of potassium sources may be attributed to the role of potassium in translocation of produced photosynthetic assimilates and its accumulation in storage tubers and in turn increase the tuber weight, which consequently affect positively on yield. Also, such increases are connected with the increase in vegetative growth which correlated greatly with the productivity of the plants. In this connection, (AbdEl-Aal, Faten *et al.*, 2005, Malakouti *et al.*, 2005 and Yildirim *et al.*, 2009).

Table 10: Effect of K sources, levels and interaction effect on TSS %, total sugar%, starch% and VC (mg/100g) after 110 days from planting during seasons 2010and 2011.

Char. / Treat.		TSS %		Total sugar%		starch%		Vit C (mg/100g)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of K-fertilization									
K-mono phosphate		5.58	3.91	1.97	2.01	19.25	19.57	13.05	11.00
K-sulphate		5.53	3.89	1.88	1.98	19.08	19.43	11.56	10.04
K-citrate		5.48	3.85	1.80	1.88	18.89	19.23	11.09	9.48
LSD at 5%		0.01	0.01	0.04	0.03	0.03	0.04	0.17	0.35
B: Effect of levels of K-fertilization									
0 kg K_2O .fed^{-1}		5.46	3.86	1.75	1.93	18.84	19.29	11.60	10.03
60 kg K_2O .fed^{-1}		5.51	3.86	1.82	1.86	19.00	19.29	11.88	10.15
120 kg K_2O .fed^{-1}		5.62	3.92	2.08	2.07	19.38	19.62	12.22	10.23
LSD at 5%		0.01	0.01	0.03	0.04	0.03	0.06	0.19	0.23
C: Interaction effect									
K-mono phosphate	0	5.52	3.86	1.83	1.89	19.05	19.30	12.48	10.44
	60	5.57	3.91	1.92	1.97	19.22	19.54	12.97	11.00
	120	5.65	3.96	2.16	2.14	19.48	19.79	13.71	11.38
K-sulphate	0	5.46	3.88	1.76	2.00	18.84	19.40	11.38	10.33
	60	5.52	3.85	1.82	1.88	19.02	19.27	11.52	9.91
	120	5.62	3.93	2.06	2.05	19.38	19.63	11.80	9.88
K-citrate	0	5.40	3.84	1.67	1.88	18.64	19.18	10.96	9.46
	60	5.44	3.81	1.71	1.74	18.76	19.06	11.17	9.53
	120	5.59	3.89	2.02	2.03	19.28	19.45	11.14	9.44
LSD at 5%		0.02	0.02	0.04	0.06	0.06	0.11	0.33	0.38

4.2. Effect of P sources and levels:

Listed data present in Table 11 indicate the TSS %, total sugar%, starch% and Vit C (mg/100g) of tuber after 110 days from planting were significantly affected with adding different phosphorus fertilizer during both seasons and the highest values were recorded with using phosphoric acid.

The same Table shows significant increment of TSS %, total sugar %, starch % and Vit C (mg/100g) after 110 days in both season with increasing p-fertilizer level up to 60 kg P_2O_5/fed.

It could be observed that application of P-fertilization sources and rates in Table 11 show that, adding P-sources as Ca-super phosphate, Rock-phosphate and Phosphoric acid at levels of 30 and 60 kg P_2O_5/fed. significantly increased of TSS %, total sugar%, starch% and Vit C (mg/100g)

of tuber after 110 days from planting than the untreated plants. Adding Phosphoric acid at rate of 60 kg P_2O_5/fed gave the highest mean values during both seasons. These data are in agreement with those obtained by Moustafa *et al.*, (2005), these found that, available phosphorus supplementation significantly improved the processing quality characteristics in tomato fruits i.e. total soluble solids, vitamin "C", color, titrable acidity.

Table 11: Effect of P sources , levels and interaction effect on T.S.S %, total sugar%, starch% and Vit.C (mg/100g) after 110 days from planting during seasons 2010and 2011.

Char. / Treat.		TSS %		Total sugar%		starch%		Vit C (mg/100g)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
A: Effect of sources of P-fertilization									
Ca-super phosphate		5.19	4.65	1.51	1.55	17.91	18.25	12.17	10.50
Rock-phosphate		5.12	4.60	1.44	1.51	17.64	18.02	11.99	10.26
Phosphoric acid		5.28	4.71	1.59	1.68	18.19	18.56	12.91	11.04
LSD at 5%		0.01	0.01	0.05	0.05	0.04	0.05	0.33	0.26
B: Effect of levels of P-fertilization									
0 kg P_2O_5 .fed^{-1}		5.13	4.61	1.44	1.49	17.68	18.05	12.02	10.25
30 kg P_2O_5 .fed^{-1}		5.18-	4.64	1.52	1.58	17.87	18.21	12.42	10.60
60 kg P_2O_5 .fed^{-1}		5.28	4.71	1.59	1.66	18.20	18.57	12.62	10.95
LSD at 5%		0.01	0.01	0.02	0.03	0.03	0.04	0.21	0.25
C: Interaction effect									
Ca-super phosphate	0	5.10	4.60	1.42	1.47	17.59	17.98	11.85	10.12
	30	5.18	4.63	1.52	1.47	17.85	18.17	12.17	10.51
	60	5.30	4.72	1.60	1.53	18.29	18.61	12.50	10.86
Rock-phosphate	0	5.07	4.58	1.38	1.63	17.49	17.88	11.66	9.79
	30	5.11	4.60	1.46	1.44	17.64	17.99	12.17	10.35
	60	5.16	4.64	1.49	1.50	17.80	18.19	12.13	10.65
Phosphoric acid	0	5.21	4.66	1.53	1.60	17.96	18.30	12.57	10.84
	30	5.25	4.69	1.58	1.57	18.12	18.47	12.92	10.93
	60	5.37	4.78	1.67	1.70	18.50	18.90	13.25	11.33
LSD at 5%		0.01	0.02	0.03	0.05	0.05	0.07	0.36	0.39

CONCLUSION

The positive perspective of this study emphasized the importance of potassium and phosphorus fertilization for potato. It is obvious that yield and its components of the potato variety spunta can be improved with the application of K and P fertilizers. Hence, application of 120 kg K_2O /fed in form of K-mono phosphate and 60 kg P_2O_5/fed in form of phosphoric acid is found to be the appropriate rates for optimum productivity of potato plants in loamy soil.

REFERENCES

Abd El-Aal- Faten, S.; A. M. Shaheen and A. Rizk-Fatma (2008). The effect of foliar application of Ga_3 and
soil dressing of NPK at different levels on the plant productivity of potatoes (*Solanum tuberosum* L.). Res. J. Agric. & Biol. Sci., 4(5): 384-391.

Abd El-Aal, Faten S.; M. R. Shafeek; A. A. Ahmed and A. M. Shaheen (2005). Response of growth and yield of onion plants to potassium fertilizer and humic acid. J. Agric. Sci. Mansoura Univ., 30 (1): 441 - 452.

Al-Moshileh, A. M. and M. A. Errebi (2004). Effect of various potassium sulfate rates on growth, yield and quality of potato grown under sandy soil and arid conditions. IPI regional workshop on Potassium and Fertigation development in West Asia and North Africa, Rabat, Morocco 24-28 November.(C F computer search)

Anwar, R. S. (1998). Response of potato crop to phosphorus and potassium fertilization under sandy soil conditions. M. Sc. Thesis, Fac. Agric. Zagazig Univ.

Asmaa, R. M. and M. H. Magda (2010). Increasing productivity of potato plants (*solanum tuberosum* L.) By using potassium fertilizer and humic acid application, Inter. J. Academic Res., 2. 83-88. .(C F computer search)

Black, C. A. (1965). Methods of soil analysis. Part 2. Amer. Soci. of Agric. [NC] Publisher, Madison, Wisconsin. .(C F computer search)

El-Sirafy Z. M.; A. Khadra-Abbady, A. M . El-Ghamry and R. A. El-Dissoky (2008a). Agro economic Evaluation of Conventional and Controlled Release Potassium Fertilizers for Potato Crop. Australian Journal of Basic and Applied Sciences, 2(4): 1092-1103.

Gad-Nadia and Kandil-Hala (2010). Influence of cobalt on phosphorus uptake, growth and yield of tomato. Agriculture and Biology Journal of North America ISSN, 1(5): 1069-1075.

Ghoname, A. A. and M. R. Shafeek (2004). Growth and productivity of sweet pepper (*Capsicum annum*, L.) Grown in plastic house as affected by organic, mineral and bio-N-fertilizer. Pakistan Journal of Agronomy, 4(4): 369-372.
.(C F computer search)

Gomez, K. A. and A. A. Gomez (1984). "Statistical Procedures for Agricultural Research". John Wiley and Sons, Inc., New York.pp:680. .(C F computer search)

Gupta, R. P., V. P. Sharma, D. K. Singh and K. J. Srivastava (1999). Effect of organic manures and inorganic fertilizers on growth, yield and quality of onion variety Agrifound Dark Red. News Letter, National Horticultural Research and Development Foundation, 19(2/3): 7-11.

Hinsinger, P. (2001). Bioavailability of soil inorganic P in the rhizosphere as affected by root-induced chemical changes: a review. Plant and soil, 237(2) 173-195 Dec 2001.

Jackson, M. L. (1967). "Soil chemical analysis advanced course" Puble. By the auther, Dept. of Soils, Univ. of Wise., Madison 6, Wishensin, U S A

Jenkins, P. D. and H. Ali (2000). Phosphorus supply and progeny tuber numbers in potato crops. Ann. App. Biol., 136: 41–46.

Magda-Hafez, M. and R. Asmaa-Mahmoud (2009). Effect of the Natural and Chemical Phosphorus Fertilization as Individually And/or Mixed on the Productivity of Eggplant. Res. J. Agric. & Biol. Sci., 5(4): 344-348.

Malakouti, M. J.; A. A. Shahabi and K. Bazargan (2005). Potassium in Iranian agric. Sana Publication Co., Ministry of Jihade-Agri., Tehran, Iran pp 294.

.(C F computer search)

Moustafa Cke, A.H.N., Taehyun, Schofield and Gopinadhan Pailyzin (2005). Effect of phosphorus fertilizer supplementation on processing quality and functional food ingredients in tomato. Agricultural and Food Chemistry, 519: 742-751.

Munson, R.; W. D. Bishop, W. L. Nelson, B. G. Ellis, E. C. Sample, D. A. Hot, M. E. Summer and L. S. Murphy (1985). "Potassium in Agriculture", America. Soci. Agron., Crop Sci. Soc. America, Soil Sci. Soc. America, Madison, Wisconsin, USA. .(C F computer search)

Pant, H. K. and K. R. Reddy (2003). Potential internal loading of phosphorus in a wetlands constructed in agricultural land water research, 37: 965-972.

Peterburgski, A. V. (1968). "Hand Book of Agronomic Chemistry". Kolas publishing House, Moscow, (in Russian), pp. 29-86.(C.F computer search)

Pregle, E. (1945). "Quantitative organic micro-analysis" 4th Ed. J. Chudrial, London. .(C F computer search)

Shabana, A. E. A. (2004). Effect of some biological treatments on tomatoes under saline condition. Ph.D. Thesis, Fac. Agric. Mans. Univ., Egypt.

Shafeek, M. R., S. Faten, Abd El-Al and Aisha, H. Ali (2004). The productivity of broad bean plant as affected by chemical and/or natural phosphorus with different bio-fertilizer. J. Agric. Sci. Mansoura Univ. 29(5): 2727-2740.

Tawfik, A. A. (2001). Potassium and Calcium nutrition improves potato production in drip-irrigated sandy soil. Fifth Triennial Congress of the African Potato Association, 28 May-2 June 2000, Kampala, Uganda. African Crop Sci. J., 9(1):147-155.

Turan, M.; N. Ataoglu and F. Sahin (2007). Effects of Bacillus F5 -3 on growth of tomato (*Lycopersicon esculentum*) plants and availability of phosphorus in soil. Plant soil and environ., 53(2): 58-64.

Yildirim, E.; H. Karlidag and M. Turan (2009). Mitigation of a salt stress in strawberry by Foliar K, Ca and Mg nutrient supply. Plant, Soil and Environment, 55 (5): 213 -221.

إستجابة نباتات البطاطس للتسميد البوتاسي والفوسفاتي

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نفذت تجرتان حقليتان فى مزرعه خاصه بالمطرية محافظة الدقهلية خلال الموسمين ٢٠٠٩-٢٠١٠ ، ٢٠١٠- ٢٠١١ وذلك لدراسه تأثير صور ومستويات التسميد البوتاسى والفوسفاتى على النمو الخضرى، المحصول والتركيب الكيميائى للبطاطس صنف سبونتا.

التجربه الاولى وهى تمثل كل التفاعلات الممكنه بين ٣ معاملات من صور التسميد البوتاسى (بوتاسيوم مونوفوسفات (٥٢% بو٢أ)، سلفات البوتاسيوم (٥٠% بو٢أ) و سترات البوتاسيوم (٣٨% بو2أ) فى ٣ مستويات (٠، ٦٠ و ١٢٠ كجم بو٢أ/ ف). التجربه الثانيه عباره عن ٣ معاملات من صور التسميد الفوسفاتى (كالسيوم سوبر فوسفات (١٥,٥% فو٢أ٥)، صخر الفوسفات (٣٠% فو٢أ٥) و فوسفوريك اسيد (٨٥% فو٢أ٥)) فى ٣ مستويات (٠، ٣٠ و ٦٠ كجم فو٢أ٥/ف). كل معامله تم تكرارها ثلاث مرات وبذلك يكون عدد وحدات التجربه ٢٧ وحده لكل تجربه.تم تنفيذ كل تجربة في تصميم قطاعات كاملة العشوائية.

وقد اظهرت نتائج التجربه ان:-

١. **تاثير صور ومستويات التسميد البوتاسى:**

اظهرت النتائج ان متوسطات كل من طول النبات (سم)، عدد الفروع/نبات، الوزن الجاف والطازج للنبات (جم)، النسبه المئويه للنيتروجين والفوسفور والبوتاسيوم فى الاوراق والدرنات، بالاضافه للمحصول مثل الوزن الطازج للدرنات (جم)، الوزن الجاف للدرنات (%)، عدد الدرنات/نبات، متوسط وزن الدرنات والمحصول الكلى (طن/ف) كذلك صفات الجوده للدرنات والتى تشمل المواد الصلبه الكليه (%)، السكريات الكليه (%)، النشا (%)، فيتامين ج (مجم/١٠٠جم) فى الدرنات بعد ١١٠ يوم من الزراعه جميعها تاثرت بالزياده المعنويه نتيجه لزياده مستويات البوتاسيوم تحت جميع صور التسميد البوتاسى وسجلت اعلى القياسات عند اضافه البوتاسيوم مونو فوسفات عند المستوى ١٢٠ كجم بو٢أ/ ف.

٢. **تأثير صور ومستويات التسميد الفوسفاتى:**

أوضحت النتائج أن متوسطات كل من طول النبات (سم)، عدد الفروع/نبات، الوزن الجاف والطازج للنبات (جم)، النسبه المئويه للنيتروجين والفوسفور والبوتاسيوم فى الاوراق والدرنات، بالاضافه للمحصول مثل الوزن الطازج للدرنات (جم)، الوزن الجاف للدرنات (%)، عدد الدرنات/نبات، متوسط وزن الدرنات والمحصول الكلى (طن/ف) كذلك صفات الجوده للدرنات والتى تشمل المواد الصلبه الكليه (%)، السكريات الكليه (%)، النشا (%)، فيتامين س (مجم/١٠٠جم) فى الدرنات بعد ١١٠ يوم من الزراعه كان تأثرت معنويا تحت جميع صور التسميد الفوسفاتى خلال كلا الموسمين. كما سجلت اعلى القياسات عند اضافه الفوسفوريك اسيد تحت المستوى ٦٠ كجم فو٢أ٥/ف مقارنه مع المعاملات الكنترول تحت التجربه.

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