

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% K₂O potassium sulphate 50% K₂O and potassium citrate 38% k), levels (0, 60 and 120 kg K₂O/ fed for each source), phosphorus sources (calcium super phosphate 15.5 % P₂O₅, rock phosphate 30 % P₂O₅ and phosphoric acid 85% P₂O₅) and levels (0, 30 and 60 kg P₂O₅/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 K₂O/fed and phosphoric acid at 60 kg P₂O₅/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% K₂O), Potassium sulphate (50% K₂O) and Potassium citrate (38% k) and three levels (0, 60 and 120 kg K₂O /fed). The second experiment was 3 treatments of phosphorus fertilizers sources (calcium super phosphate (15.5 % P₂O₅), rock phosphate (30 % P₂O₅) and phosphoric acid (85 % P₂O₅) in three levels (0, 30 and 60 kg P₂O₅/fed). Each treatment was replicated three times; thus, the total numbers of every experiment was 27 experimental units.

The plot area was 10.5 m² 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 % P₂O₅) as 60 kg P₂O₅/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 % K₂O) 96 kg K₂O /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 ₂ O	0 kg/fed	0 kg/fed	0 kg/fed
60 unit K ₂ O	115kg/fed(302g/plot)	120 kg/fed(315g/plot)	157 kg/fed(414g/plot)
120 unit K ₂ O	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 ₂ O ₅	0 kg/fed	0 kg/fed	0 L/fed
30 unit P ₂ O ₅	193 kg/fed(508g/plot)	100 kg/fed(262g/plot)	35 L/fed(91ml/plot)
60 unit P ₂ O 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 K₂O /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 K₂O /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% P₂O₅ +52% K₂O. 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.

Char.	plant length (cm)		No. of stem/plant		Fresh weight of plant foliage (g/plant)		Dry matter of plant foliage (%)		
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	
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 ₂ O .fed ⁻¹	42.41	45.08	2.67	3.44	710.60	98.83	13.69	18.26	
60 kg K ₂ O .fed ⁻¹	43.22	44.55	3.06	3.44	722.69	97.72	13.91	18.06	
120 kg K ₂ O .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 P₂O₅/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 P₂O₅/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 obtained with adding phosphoric acid at the rate 60 kg P₂O₅/fed. compare with the other sources under any levels. This increase 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 (%)	
		1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
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 ₂ O ₅ .fed ⁻¹	43.67	45.27	2.78	3.39	96.41	99.95	18.24	18.91
	30 kg P ₂ O ₅ .fed ⁻¹	44.80	46.45	3.17	3.28	98.88	102.51	18.41	19.09
	60 kg P ₂ O 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 K₂O /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 K₂O /fed followed by 60 kg K₂O /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%		
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	
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 K₂O .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 K₂O .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 K₂O .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 K₂O/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 K₂SO₄ /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.	Leaves						Tubers						
	N%		P%		K%		N%		P%		K%		
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	
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 ₂ O 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 ₂ O 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 ₂ O 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 P₂O₅/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 P₂O₅/fed. And found that the highest mean values were obtained with adding phosphoric acid at the rate 60 kg P₂O₅/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 a 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 shows 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 K₂O /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 K₂O /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 K₂O/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)		
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	
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 ₂ O .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 ₂ O .fed ⁻¹	722.69	740.24	13.91	14.38	4.39	4.56	177.85	172.45	16.18	16.30	
120kg K ₂ O .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 P₂O₅/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 P₂O₅/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

P₂O₅/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.

Treat.	Char.	Tuber fresh weight (g/plant)		Tuber dry weight (%)		No. of tuber/plant		Average weight of tuber		Total yield (ton/fed)	
		1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
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 ₂ O 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 ₂ O 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 ₂ O 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 K₂O /fed.

Data in table 10 reveal that the average of all parameters were significantly increased with potassium mono phosphate at rate of 120 kg K₂O /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.	TSS %		Total sugar%		starch%		Vit C (mg/100g)		
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	
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 ₂ O .fed ⁻¹	5.46	3.86	1.75	1.93	18.84	19.29	11.60	10.03	
60 kg K ₂ O .fed ⁻¹	5.51	3.86	1.82	1.86	19.00	19.29	11.88	10.15	
120 kg K ₂ O .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 P₂O₅/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 P₂O₅/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 P₂O₅/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.	TSS %		Total sugar%		starch%		Vit C (mg/100g)		
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	
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 ₂ O ₅ .fed ⁻¹	5.13	4.61	1.44	1.49	17.68	18.05	12.02	10.25	
30 kg P ₂ O ₅ .fed ⁻¹	5.18	4.64	1.52	1.58	17.87	18.21	12.42	10.60	
60 kg P ₂ O 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 K₂O /fed in form of K-mono phosphate and 60 kg P₂O₅/fed in form of phosphoric acid is found to be the appropriate rates for optimum productivity of potato plants in loamy soil.

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إستجابة نباتات البطاطس للتسميد البوتاسي والفوسفاتي حسام محمد السعيد عبد النبي، السيد ابراهيم الجميلي و نهله أحمد رفعت قشطه قسم الخضار والزينة - كلية الزراعة - جامعة المنصورة- مصر.

نفذت تجربتان حقليتان في مزرعه خاصه بالمطرية محافظة الدقهلية خلال الموسمين ٢٠٠٩-٢٠١٠، ٢٠١٠-٢٠١١ وذلك لدراسة تأثير صور ومستويات التسميد البوتاسي والفوسفاتي على النمو الخضري، المحصول والتركيب الكيميائي للبطاطس صنف سيونتا. التجربة الاولى وهى تمثل كل التفاعلات الممكنه بين ٣ معاملات من صور التسميد البوتاسي (بوتاسيوم مونوفوسفات (٥٢% بو٢)، سلفات البوتاسيوم (٥٠% بو١) و سترات البوتاسيوم (٣٨% بو٣) في ٣ مستويات (٠، ٦٠، ١٢٠ كجم بو٢/أ). التجربة الثانيه عباره عن ٣ معاملات من صور التسميد الفوسفاتي (كالمسيوم سوبر فوسفات (١٥.٥% فو٢أ)، صخر الفوسفات (٣٠% فو٢أ) و فوسفوريك اسيد (٨٥% فو٢أ)) في ٣ مستويات (٠، ٣٠، ٦٠ كجم فو٢أ/ف). كل معاملة تم تكرارها ثلاث مرات وبذلك يكون عدد وحدات التجربه ٢٧ وحده لكل تجربه. تم تنفيذ كل تجربه في تصميم قطاعات كاملة العشوائية. وقد اظهرت نتائج التجربه ان:-

١. تأثير صور ومستويات التسميد البوتاسي:

اظهرت النتائج ان متوسطات كل من طول النبات (سم)، عدد الفروع/نبات، الوزن الجاف والطازج للنبات (جم)، النسبه المئوية للنيتروجين والفوسفور والبوتاسيوم فى الاوراق والدرنات، بالاضافه للمحصول مثل الوزن الطازج للدرنات (جم)، الوزن الجاف للدرنات (%)، عدد الدرناات/نبات، متوسط وزن الدرناات والمحصول الكلى (طن/ف) كذلك صفات الجوده للدرنات والتي تشمل المواد الصليه الكليه (%)، السكريات الكليه (%)، النشا (%)، فيتامين ج (مجم/١٠٠جم) فى الدرناات بعد ١١٠ يوم من الزراعه جميعها تأثرت بالزياده المعنويه نتيجة لزياده مستويات البوتاسيوم تحت جميع صور التسميد البوتاسي وسجلت اعلى القياسات عند اضافته البوتاسيوم مونو فوسفات عند المستوى ١٢٠ كجم بو٢/أ. ف.

٢. تأثير صور ومستويات التسميد الفوسفاتي:

أوضحت النتائج أن متوسطات كل من طول النبات (سم)، عدد الفروع/نبات، الوزن الجاف والطازج للنبات (جم)، النسبه المئوية للنيتروجين والفوسفور والبوتاسيوم فى الاوراق والدرنات، بالاضافه للمحصول مثل الوزن الطازج للدرنات (جم)، الوزن الجاف للدرنات (%)، عدد الدرناات/نبات، متوسط وزن الدرناات والمحصول الكلى (طن/ف) كذلك صفات الجوده للدرنات والتي تشمل المواد الصليه الكليه (%)، السكريات الكليه (%)، النشا (%)، فيتامين س (مجم/١٠٠جم) فى الدرناات بعد ١١٠ يوم من الزراعه كان تأثرت معنويا تحت جميع صور التسميد الفوسفاتي خلال كلا الموسمين. كما سجلت اعلى القياسات عند اضافته الفوسفوريك اسيد تحت المستوى ٦٠ كجم فو٢أ/ف مقارنة مع المعاملات الكنترول تحت التجربه.

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