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YIELD AND QUALITY OF POTATO CROP AS AFFECTED BY THE APPLICATION RATE OF POTASSIUM AND COMPOST IN SANDY SOIL

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ABSTRACT

During 2004 and 2005 seasons, this study tested the effects of different rates of potassium and organic manure (compost) on the yield and quality of potato. Compost was used as organic manure at 5 and 10 ton/ fed., whereas, potassium was applied in the form of potassium sulfate (52% k_20) at five rates, i.e, 0,40,80,120 and160 kg k_20 per fed. The results showed that the increasing K rate increased fresh and dry weight of haulm of potato plant. Plants received the highest K rate recorded the highest number of tuber per m^2 , tuber weight and yield compared with plants treated with low K rate.. The highest tuber yield was obtained with application of 160 kg K_2O/fed.. Dry matter accumulation, and starch increased significantly with increasing levels of potassium levels. Applying compost at 10 ton per fed. increased both vegetative growth and yield of potato crop. In addition, the interaction between k and compost caused increasing in vegetative growth, yield and improving in quality of potato tuber. Plants applied with 160 kg K_2O / fed. combined with 10 ton compost /fed. produced the highest yield with best quality.

Keywords: Potato (*Solanum tuberosum L.)* Compost, Potassium, Yield and Quality

INTRODUCTION

Potato crop (*Solanum tuberosum* L.) receives high levels of fertilizers. Among the nutrients usually used for potato fertilization, K is of great importance since it is the nutrient taken up in the greatest quantity by the potato plant (**Perrenoud, 1993**). Due to the high requirements for K and organic manure in sandy soil, potato growers pay a great deal of attention to K fertilization in such type of soils in Egypt.

The effect of K on plant height is not consistent. **Mazullah *et al* (1990)** reported no significant effect of K on plant height of potato crop, while **Khandakhar *et al* (2004)** found positive effect for k application on the same parameter. Other growth parameters such as leaf area index, crop growth rate and tuber bulking rate were increased significantly with

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increasing level of potassium (**Saha *et al* 2001**).

Potassium promotes high potato tuber yield (**Westermann *et al* 1994b**) of good quality (**Westermann *et al* 1994a**). Insufficient K can result in reduced yields and tuber sizes (**McDole, 1978; McDole *et al* 1978 and Satyanarayana & Arora, 1985**). On K responsive soils, significant tuber yield response to K fertilization was recorded by various researches (**McDole *et al* 1978; Sharma & Arora, 1987; Chapman *et al* 1992; Tindall and Westermann, 1994**). On the other hand, the lowest values for growth parameters, yield and potato grades were recorded from crops which received low K rate (**Saha *et al* 2001**).

Tuber quality parameters such as dry matter, starch content and specific gravity were affected by K fertilization (**Schippers, 1968; McDole, 1978; Champman *et al* 1992; Westermann *et al* 1994a and b; Saha *et al* 2001**). **Deka and Dutta (2000)** mentioned that potassium fertilizer application marginally increased the uptake of nitrogen, phosphorus, potassium (**Lalitha *et al* 2000**). Potassium loosing in sandy soils can be reduced by applying compost manure, which has been reported to improve moisture and holding capacity of the soil as well as decrease the loosing of other chemicals by leaching (**McBurnie and Mitchell, 1993**).

Compost is more acceptable as a fertilizer than manure because weed seeds have been killed, animal pathogenic and obnoxious smells are not present, also decreases in bulk density, particle density and increased water content. (**A grower's Guide, 1995**). Amending the soil with compost increased vegetative growth and shoot weight more than final tuber yield (**Gent *et al* 1998 and Abou-Hussein *et al* 2002a**). In addition, adding compost to sandy soil increased tuber quality, nutrient content in leaves and tuber yield (**Abou-Hussein *et al* 2002b**).

The interaction effect of K and organic manure has been reported by **Singh and Brar (1985)** who concluded that applying K and FYM (Farmyard manure) to the soil increased potassium concentration in the leaves of potato crop. However, application of high rates of P and K increased the available P_2O_5, K_2O contents, dry matter, starch in potato tubers (**Malysher, 1979**).

This study aimed to determine the most efficient rates of K and compost fertilizers to maximize yield and quality of potato tuber in sandy soil.

MATERIAL AND METHODS

This study was performed at Taba Farm, Monofia governorate, during the two successive seasons of 2004 and 2005. The seed tuber of the cv Nicola was spread over the floor in diffused light condition for two weeks for sprouting. In the two seasons, the whole seed tubers were planted, in the first week of January at distance of 15 cm between plants and 75 cm between rows making plant density of 3.8 plants per m^2. Split plot design with three replicates was followed. The main plots were devoted for compost, whereas the levels of K fertilizer were assigned randomly in the sub-plots. Each experimental unit area was 16 m^2.

The texture of the soil was sandy with traces N, 0.44 % P and 100 ppm K. The analysis of compost is shown in Table (1).

Compost was used as an organic manure at two levels, namely 5 and 10 ton.

Table 1. The analyses of the compost used.

Moisture	pH	EC	C	O.M	C/N	Macro Elements (%)					Micro Elements (ppm)		
		ds/m	%		Ratio								
						N	P	K	Ca	Mg	Fe	Mn	Zn
24.00	8.30	2.50	26.00	47.00	15.87	1.64	0.68	1.52	0.16	0.91	1022.00	111.00	30.00

per feddan, meanwhile, potassium was applied in the form of potassium sulfate (52% K_2O) at five levels, i.e, 0, 40, 80, 120 and160 kg K_2O per feddan. Compost and 25% of K rate were added in the middle of the row at 50 cm depth during preparation then the soil was irrigated. The remaining amount of potassium was added as side dressing in two equal doses after 45 and 55 days from planting. Other agricultural practices other than the experimental treatments for potato production were performed as recommended by the Ministry of Agriculture in Egypt.

A random sample of ten plants was taken from each plot 75 days after planting (DAP) for the determinations of the vegetative growth, i.e., plant height, and haulm fresh and dry weights. Each experimental plot was harvested individually after 120 days from planting and average tuber weight, average tuber number m^2 and total yield (ton/fed.) were recorded.

Plant leaf samples were collected at 75 days after planting by collecting the fourth fully expanded leaves and analyzed for total N, P and K content. At least 33 to 42 leaves were collected from each experimental unit. Total nitrogen and potassium contents were determined according to the procedure described by **FAO Soils Bulletin (1980),** Phosphorus was determined by the method described by **Chapman and Pratt (1961).**

A random sample of 20 tubers were selected from each experimental unit then washed, dried and cut into small pieces, which were mixed and grounded for the determination of starch in tubers. Tuber specific gravity was calculated from samples weights measured in air and water. Dry matter content was determined at 65°C for 72 hours. Starch was determined according to the method of Luff-Schoorl that proceeds by the acid hydrolysis of starch and titration by sodium thiosulphate (**A.O.AC.1975**)

All data were statically analyzed according to **Snedecor and Cochran, (1990)**

RESULTUS

Vegetative growth

Potassium fertilizer had positive effect on most parameters of vegetative growth (Fig. 1). The highest value was recorded with the plants that received 160 K_2O compared with other treatments. There were linear relationships between the rate of K application and each of these parameters. Only in the first season that plant height did not show a clear trend. Meanwhile, dry matter content in leaves had the same trend with increasing levels of potassium fertilizer.

Increasing levels of compost from 5 to 10 ton per fed caused increment in vegetative growth of plants, i.e., plant height, fresh and dry weights (Table 2). The highest values of these parameters were recorded with the application of 10 ton per feddan. Adding compost to the soil had positive effect on dry mattre content in the leaves whereas the highest value were recorded with plants that received 10 ton compost per feddan compared to 5 ton treatment.

It is clear that applying compost with different levels of potassium fertilizers had positive effect on vegetative growth (Table 3). Increasing rate of potassium fertilizers from 0 to 160 K_2O and compost from 5 to10 ton fed. resulted in a positive effect on haulm fresh and dry weights.

Table 2. The effect of the compost treatments on growth, quality, yield and mineral contents of potato plant in 2004-2005 seasons.

Treatments	Vegetative growth					Yield and quality						Mineral content in leaves (%)		
Compost (ton /fed)	Plant height (cm)	Haulm FW (g/plant)	Haulm DW (g/plant)	Leaf DW (%)	No. of tubers m^2	Yield g/plant	Avg. tuber wt (g)	Total yield (Ton/fed.)	DM (%)	Specific gravity	Starch (%)	N	P	K
First Season														
5	57.73	374.48	42.56	11.34	32.26	1040.40	119.11	16.17	25.53	1.05	65.46	3.90	0.37	6.42
10	64.33	482.56	59.98	12.41	35.67	1160.36	120.14	18.03	27.47	1.07	71.96	4.31	0.51	7.27
L.S.D	4.84	79.25	12.77	0.78	2.50	87.96	0.76	1.37	1.42	0.01	4.77	0.30	0.11	0.63
Second season														
5	59.07	345.76	37.76	10.89	33.23	972.12	108.01	15.11	26.73	1.04	65.66	4.70	0.37	6.94
10	63.67	471.00	57.08	11.17	36.11	1130.42	115.33	17.57	29.07	1.08	71.02	5.07	0.49	7.80
L.S.D	5.91	91.83	14.16	0.88	1.06	116.07	5.37	1.80	1.71	0.03	3.93	0.27	0.09	0.63

Table 3. The effect of interaction ok K and compost treatments on growth, quality, yield and mineral contents of potato plant in 2004-2005 seasons.

Treatments		Vegetative growth				Yield and quality							Mineral content in leaves (%)		
Compost (ton /fed)	K_2O (kg/fed)	Plant height (cm)	Haulm FW (g / plant)	Haulm DW (g / plant)	DW Leaves (%)	No. of tubers m^2	Yield g/plant	Avg. tuber wt (g)	Total yield (Ton/fed.)	DM (%)	specific gravity	Starch (%)	N	P	K
							First season								
5	0	54.00	350.00	36.87	10.53	29.60	900.30	112.54	13.99	24.77	1.02	60.30	3.69	0.26	4.70
	40	56.33	366.50	40.20	10.97	31.45	1000.50	117.70	15.55	25.20	1.03	63.50	3.78	0.36	6.21
	80	57.66	375.30	43.23	11.52	32.56	1050.30	119.35	16.32	25.50	1.05	65.30	3.96	0.37	6.50
	120	63.00	380.30	44.60	11.73	33.30	1100.60	122.28	17.10	26.00	1.06	68.30	3.97	0.42	7.00
	160	57.66	400.30	47.90	11.97	34.41	1150.30	123.68	17.87	26.20	1.07	69.90	4.08	0.43	7.68
10	0	61.00	430.70	52.00	12.07	33.67	970.30	106.62	15.08	26.50	1.04	65.30	4.10	0.48	5.50
	40	64.00	460.60	56.80	12.33	35.15	1145.60	120.58	17.80	27.50	1.06	70.00	4.13	0.50	6.37
	80	61.33	480.60	59.30	12.34	35.89	1190.30	122.71	18.50	27.60	1.07	72.60	4.19	0.52	7.30
	120	66.33	510.30	63.30	12.40	36.63	1225.30	123.76	19.04	27.63	1.09	75.60	4.33	0.54	8.19
	160	69.00	530.60	68.50	12.91	37.00	1270.30	127.03	19.74	28.10	1.09	76.30	4.80	0.54	9.00
L.S.D		0.76	7.05	1.22	0.10	0.37	24.32	1.46	0.38	0.13	0.005	0.95	0.05	0.01	0.29
							Second season								
5	0	50.00	292.00	29.80	10.21	30.71	860.30	103.65	13.37	25.76	1.01	61.50	4.49	0.30	5.50
	40	55.33	320.30	35.60	11.11	31.45	880.30	103.56	13.68	26.20	1.03	64.80	4.58	0.33	6.91
	80	59.67	350.60	38.60	11.01	32.93	960.00	107.87	14.92	26.50	1.05	65.80	4.76	0.39	6.95
	120	59.67	375.60	41.30	11.00	35.15	1050.00	110.53	16.32	27.50	1.06	67.90	4.77	0.39	7.03
	160	62.00	390.30	43.50	11.15	35.89	1110.00	114.43	17.25	27.70	1.07	68.30	4.88	0.43	8.30
10	0	62.33	433.50	50.30	11.60	33.30	900.80	100.09	14.00	28.00	1.07	67.80	4.90	0.43	6.80
	40	62.67	450.30	54.20	12.04	34.41	1030.10	110.76	16.01	29.00	1.07	69.50	4.93	0.44	7.58
	80	62.67	460.30	55.30	12.01	36.26	1160.10	118.38	18.03	29.10	1.08	70.30	4.99	0.46	7.82
	120	68.67	490.32	60.30	12.30	38.11	1260.90	122.42	19.59	29.38	1.09	72.90	5.13	0.51	7.89
	160	70.67	520.60	65.30	12.54	38.48	1300.20	125.02	20.21	29.85	1.09	74.60	5.41	0.60	8.90
L.S.D		1.00	8.56	1.28	0.08	0.26	31.89	1.79	0.50	0.17	0.004	0.62	0.04	0.01	0.20

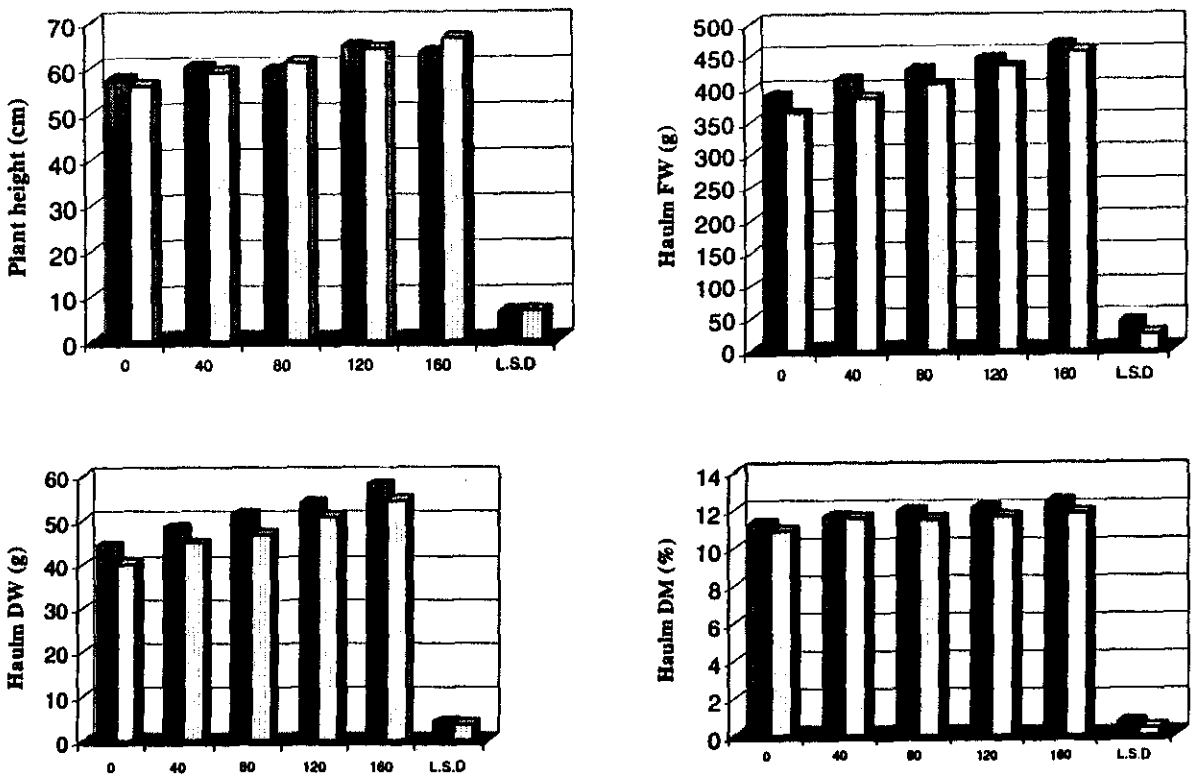

Fig. 1 The effect of K level on growth and mineral contents of potato plant in the first and second seasons.

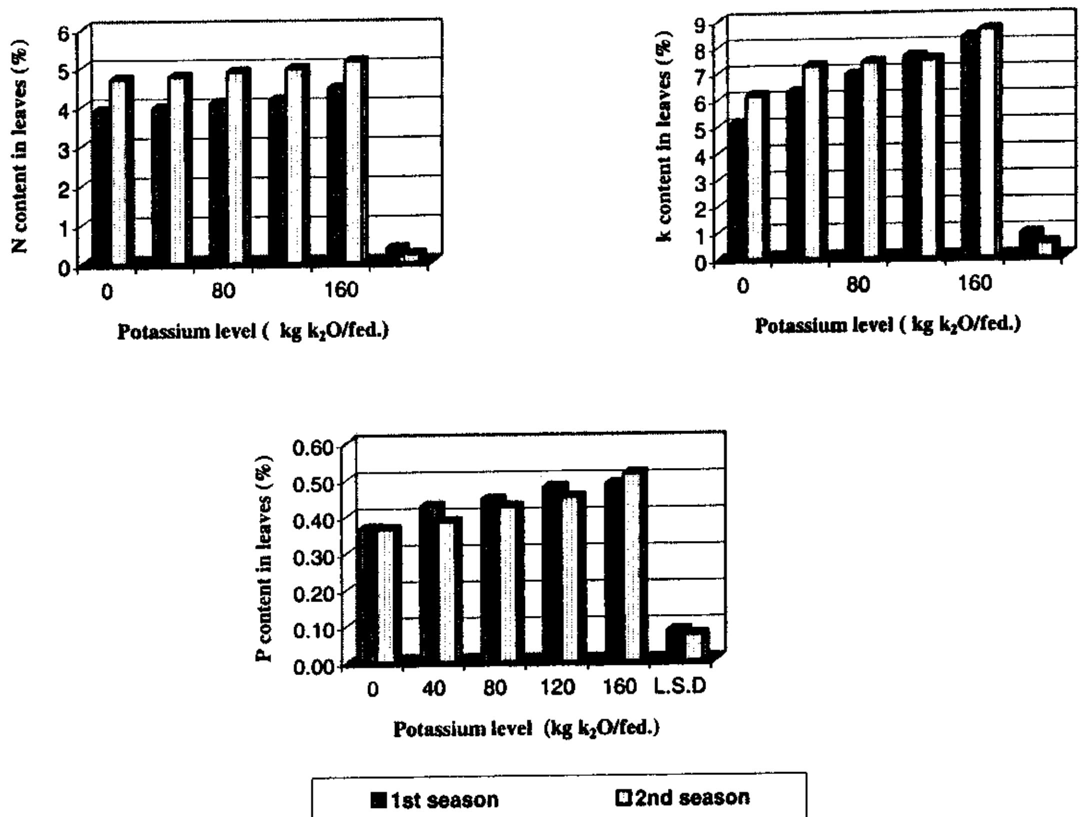

Fig. 1. Cont. The effects of K level on growth and mineral contents of potato plant in the first and second seasons.

The highest vegetative parameters were recorded with plants that received 160 K_2O with 10 ton compost per feddan in both seasons. Whereas, the lowest value was obtained with treatment of 5 ton compost without addition of K_2O. Dry matter content in leaves increased with increasing rate of potassium fertilizer and compost and the effect was significant among treatments.

Yield and quality

Potassium played an important role on yield and quality. Increasing rate of the potassium fertilizer to 160 K_2O had positive effect on number of tuber per m^2 and tuber weight per plant, which were reflected positively on increasing the total yield in both seasons (Fig. 2). Quality of tubers expressed as dry matter content, specific gravity and starch content showed a positive response to potassium fertilizer, where the highest values were recorded with the highest K rate. There were linear relationships between the rate of K application and these parameters.

Increasing rate of compost from 5 to 10 ton per feddan improved the yield and quality as shown in Table (2). The higher rate of compost (10 ton fed.) gave better results concerning number of tubers and tuber weight per plant, which resulted in higher tuber yield. Increasing compost to the sandy soil improved the quality of tuber expressed as dry matter content, specific gravity and starch content in both seasons.

Yield and quality responded positively to the interactive effect of K and compost (Table 3). The highest level of K (160 K_2O) with 10 ton of compost per feddan recorded the best results for number of tuber and average tuber weight, which were reflected positively on the total yield.

Mineral content in leaves

Increasing rate of potassium caused significant increments in N, P and K content in potato leaves in both seasons. Plants that received 160 K_2O had the highest K content.

Increasing rate of compost to 10 ton per feddan had positive effects on N, P and K contents in the leaves. Plants that received the highest rate of compost (10 ton per feddan) recorded the highest values.

The interaction of compost and K fertilizers on nutrient contents in potato leaves is shown in Table (3). The plants which received 160 K_2O and 10 ton compost gave the highest values of N,P and K in potato leaves compared with other treatments.

DISCUSSION

Potato crop is a heavy remover of soil potassium, so application of potassium fertilizer is very important in sandy soil for improving yield and quality of potato tuber. In this study increasing the rate of potassium fertilizer enhanced vegetative growth expressed as plant height, haulm fresh and dry weights. This increment may be due to increasing other growth parameters such as leaf area index, crop growth rate as reported by **Saha *et al* (2001). Marschner, (1995)** reported that increasing K enhances N uptake and this may explain the increment in vegetative growth.

Potassium increased the average tuber weight and number of tubers per m^2, resulting in high total yield. This effect

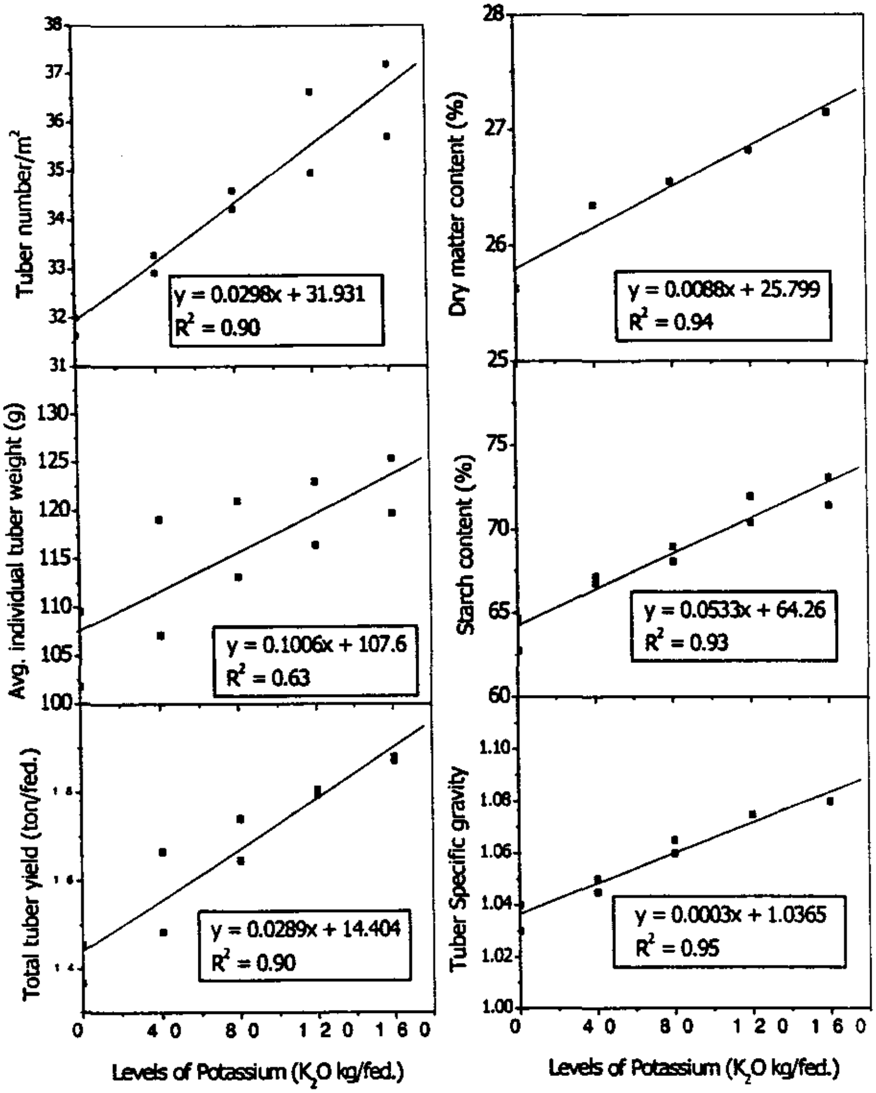

Fig. 2. The effect of K level on yield and quality of potato plant in the first and second season. (Average of two seasons)

might be due to the fact that potassium plays an important role in the transport of assimilates and nutrients (**Mengel, 1997**). It was added that potassium promotes phloem transport of photosynthates (mainly sucrose and aminoacids) to the physiological sinks the tubers. In adition, **Marschner (1995)** reported that potassium has a crucial role in the energy status of the plant, translocation and storage of assimilates and maintenance of tissue water relations. Other workers found significant tuber yield response to K fertilization (**Westermann *et al* 1994a; Panique *et al* 1997; Saha *et al* 2001; Gusev *et al* 1999 and Khandakhar *et al* 2004**).

Application of high rates of compost and K increased the available P_2O_5 and K_2O contents and dry matter and starch in potato tubers. These results agree with the findings of **Malysher (1979)**.

The observed improvement in the tuber quality parameters (percentage of dry matter and starch content) as affected by potassium nutrition can be explained on the basis of the positive effect of on translocation of assimilates (**Mengel, 1997 and Marschner, 1995**). According to **Singh and Trehan (1998)**, potassium is involved in the activation of the enzyme starch syntheses, which is responsible of the synthesis of starch, and this can explain the previous findings in this study.

In this study, increasing compost application to the soil increased plant growth expressed as plant height, haulm fresh and dry weights and increased average tuber weight and number of tuber per m^2, which were reflected on total yield. This effect might be due to the increase of the availability of nutrients in the soil (**Malysher, 1979**). This increase may promot haulm growth, which improves the photosynthesis leading to high rates of assimilation. This is translated in the form of higher tuber weight, tuber number and total yield. Similar results have been found by **Gurung *et al* (1996) and Abou-Hussein *et al* (2002a).**

The observed incrment in the percentage of N, P and K in the leaves due to application of compost can be explained on the basis of increasing the availability of nutrients in the soil (**Malysher, 1979**). This can also explain the increment in the specific gravity, total carbohydrates and starch in tubers. Similar results were found by **Singh & Brar (1985); Vokal *et al* (1986); Sharma & Arora (1987); Paula *et al* (1989) and Abou-Hussein *et al* (2002)**. In addition, the increment of the concentration of K in leaves in responses to the high rate of potassium could be due to the high mobility of K nutrient in the plant as supported by the findings of **Clarkson and Hanson, (1980)**.

The interaction between k fertilizer and compost caused an increment in most parameters such as vegetative growth, yield and enhance the content of nutrients in leaves of potato crop. This effect may be attributed to the enhancement of soil characters by organic matter application such as reducing K leaching (**McBurnie and Mitchell, 1993**), increasing K moblity (**Clarkson and Hanson, 1980**) and ehancemnt of soil water holding capacity (**McBurnie and Mitchell, 1993**). In addition K is a key factor in regulating plant water status (**Marschner, 1995**), which reflects on plant growth hence yield.

It could be concluded that potassium application at rate of 160 K_2O combined with 10 ton compost per feddan enhance tuber yield and quality in sandy soil.

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تأثر محصول جودة و البطاطس بإضافة البوتاسيوم والكمبوست فى الأراضي الرملية

[٣٩]

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أجريت هـذه الدراسـة فـى موسـمي ٢٠٠٤-٢٠٠٥ لدراسـة تـأثير مسـتويات مختلفة من البوتاسيوم والكومبوست عل كل من محصول وجودة البطاطس. حيث أضيف الكمبوست بمعدل ٥ و ١٠ طن للفدان بينما تم إضافة البوتاسيوم بمعدلات صـفر، ٤٠، ٨٠، ١٢٠ و ١٦٠ كجم K_20 فى صورة سلفات بوتاسيوم ٥٢ %. وقـد أوضـحت النتائج ان المستوى العالى مـن البوتاسـيوم أدي الى زيـادة معنويـة فـى المجمـوع الخضرى والجاف للنبـات و زيـادة عـدد الدرنات للمتر المربـع كمـا أن اضـافة البوتاسيوم أدى الى زيادة معنوية فى المـادة الجافة والنشا فـى الـدرنا ت والمحصـول الكلى. وإضافة البوتاسيوم أدي الى زيـادة محتوى الأوراق من البوتاسـيوم كمـا ان إضافة الكومبوست عند معدل ١٠ طن للفدان أدي الى زيادة مـن المجمـوع الخضـري والمحصول .كم ان إضافة البوتاسيوم مـع الكومبوست أدى الـى زيـادة المحصـول وتحسين جودة محصول البطاطس وكانـت افضل معاملة هى اضافة البوتاسيوم بمعدل ١٦٠ كجم K_20 مع الكومبوست بمعدل ١٠ طن/فدان.

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