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Response of Potato Productivity and Storability to some Potassium Levels and Foliar Spray with some Macro and Microelements

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ABSTRACT

Two field trials were conducted on potato plants cv. Spunta, in vegetable private farm at Al-Enaniya village, Sinbelawin district, Dakahlia Governoraten, during 2014/2015 and 2015/2016 seasons to study the effect of soil application of potassium levels (96, 72 and 48 kg K_2O/fed), either single and/or in combination with foliar spray of macro and micronutrients compound (N=25%, P=16%, K=12%, Zn=0.5%, Fe=0.5%, Mn=0.5%, Cu=0.3%) at different levels *i.e.,* 6, 4 and 2 g/L on plant growth, yield and its components, as well as chemical constituents and storability of tubers. In general, results showed that potato plants fertilized with potassium sulfate at the level of 96 kg K_2O/fed significantly increased plant stem length, number of leaves, leaf area and foliage plant fresh and dry weights as well as total yield, number of tubers/plant and tuber weight/plant, Moreover, this level of potassium significantly increased TSS, dry matter, specific gravity, Ascorbic acid (mg/g FW) and concentrations of macro and micronutrients (N, P, K, Fe, Zn, Mn, Cu). Also, potassium fertilization at of 96 kg K_2O/fed had the most interesting observation which enhancing storability during storage period. Foliar spray with macro and micro nutrients at a rate of 6 g/L resulted in an increases in the most vegetative growth parameters, yield and tubers quality traits. However, weight loss percentage of tubers was significantly reduced during storage period.The combined treatments of potassium levels and foliar spray with some macro and micronutrients were generally more effective on the most studied parameters than single ones. The best results were obtained by application 96 kg K_2O/fed with foliar spray of macro and micronutrients at the rate of 6 g/L. This treatment achieved increases in vegetative growth characters, total tubers yield (ton/fed), ascorbic acid (mg/g FW), TSS% of tuber, concentrations of N, P, K, micronutrients (Fe, Zn, Mn and Cu) in tubers and enhanced the tubers storability comparing with the other ones. Therefore, this treatment could be recommended for raising potato yield and improving tuber quality during storage period under similar conditions to this work.

Keywords: Potato, Potassium levels, *Solanum tuberosum L.*, Tuber production and Top dressing.

INTRODUCTION

Potato (*Solanum tuberosum*, L.) is a major world food crop. Potato is exceeded only by wheat, rice, and maize in world production for human consumption. In Egypt, it has been generally cultivated for both local consumption and export. Therefore, increasing potato yield and improving tuber quality are essential aims for both growers and consumers, but it usually depends on many factors especially that influence the plant growth throughout the growth period.

Potassium is involved in many processes within the plant as a catalyst. It plays a role in carbohydrate synthesis and translocation, enhances N uptake, and promotes protein synthesis (Marschner, 1995). Morever, Potassium is an essential plant nutrient that plays a very important role in plant growth and development. Its role is well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats, translocation of photosynthetic, enabling their ability to resist pests and diseases (Regmi *et al*, 2002).

Potato being a high nutrient mining crop it needs a higher amount of K for its economic tuber production (Regmi *et al*, 2002). In this regard, El- Sawy *et al.* (2000), Singh and Bansal (2000), Allison *et al.* (2001) and El-Hadidi and Mansour (2008) showed that the most vegetative parameters, yield and its components were significantly increased with increasing the applied K-levels from 48 to 96 kg K_2O/fed. Moreover, several investigators reported that potato plants growth, yield and storability were improved by potassium application (El-Sirafy *et al*., 2008; Mahmoud and Hafez, 2010; Kumar *et al*., 2010 and Abd El-Latif *et al*., 2011). Regarding to foliar spray with macro and micronutrients, the efficiency of fertilizers used in Egypt is low, either as a result of high pH of soil or high concentration of soil calcium carbonate. This problem could be solved by soil addition of great amounts of macro and micro-elements fertilizers or through foliar application (Abdel-Hadi *et al*, 1986). The positive effect of foliar application of macro and micronutrients on growth, yield and chemical constituents of different plants may be attributed to these elements which can be readily absorbed by the leaves as a result of foliar spraying application and not lost through fixation, decomposition or leaching under unfavorable soils conditions (Doeing, 1986). Several attempts were done on the application of micronutrients spray to correct deficiency symptoms and enhance the vegetative growth of potato which in turn reflects on increasing yield and its quality for facing local consumption and exportation (Stashauskaite *et al*., 1979; Medvedv *et al*., 1981; Rashid *et al*., 1989 and Taya *et al*., 1994). Several investigators indicated that spraying plants with macronutrients enhanced plant growth, stimulated dry matter accumulation and increased yield and quality as well as chemical composition (Marchand *et al*., 1999; Roemheld and El-Fouly, 1999; Ewais *et al*., 2010; Habib *et al*., 2011; Eleiwa *et al*., 2012; Salim *et al*., 2014 and Ghosh *et al*., 2017).

Therefore, the aim of the study was to investigate the effect of soil application of potassium levels and foliar spray with some macro and micronutrients levels in addition to their interactions on potato productivity and storability under the conditions of North Delta region, Dakahlia Governorate.

MATERIALS AND METHODS

A field experiment on potato plants cv. Spunta, in the vegetable private farm at Al-Enaniya village, Sinbelawin district, Dakahlia Governoraten, loam soil during two winter seasons (2014/2015 and 2015/2016) to study the effect of some potassium levels, either single and/or in combination with foliar spray of macro and micronutrients obtained from commercial compound called Estema green on plant growth, yield and its components, as well as chemical constituents and storability of tubers.

The experiment layout was split plot system in a randomized complete block design with three replicates. Potassium levels occupied the main plots which were subdivided to 4 sub plots each contained one of the foliar spray of macro and micronutrients (Stema green) rates. The plot area was 17.5 m^2 (1/240 feddan) which contained 5 ridges, each 5m long and 0.7m width. Each experiment included 12 treatments which were 3 levels of potassium and 4 rates of foliar spray macro micronutrients as follows:

a- soil potassium levels:

1- 96 kg K_2O_5/fed.
2- 72 kg K_2O_5/fed.
3- 48 kg K_2O_5/fed.

b- Foliar spray rates of macro and micronutrients:

1- Control treatment (water).
2- Foliar spray with 2 g/L.
3- Foliar spray with 4 g/L.
4- Foliar spray with 6 g/L.

In both growing seasons, foliar spray of macro and micronutrients as a Estema green compound (N=25%, P=16%, K=12%, Zn=0.5%, Fe=0.5%, Mn=0.5%, Cu=0.3%) and foliar spray at 45, 60 and 75 days after planting (DAP).

Tuber seeds were planted on 20th and 15th of October in the first and the second seasons, respectively. All treatments were fertilized with the recommendation rates of Nitrogen at 180 kg N/fed (ammonium nitrate, 33.5% N) was added at three equal doses after 3, 5 and 7 weeks from planting and Phosphorus at 75 kg P_2O_5/fed (Superphosphate 15.5% P_2O_5) was added once before planting. Potassium was added at different levels (96, 72, 48 kg K_2O/fed) as potassium sulphate (48% K_2O) after 7 weeks from planting date. The other cultural practices were applied according to the instructions laid down by the Ministry of Agriculture, Egypt.

Data recorded:

1- Growth parameters:

A random sample of three potato plants were taken from each plot after 70 and 90 DAP to estimate the plant stem length (cm), number of main stems/plant, number of leaves/plant, leaf area, foliage fresh and dry weights/plant (gm), number of tubers/plant and tubers weight/plant (gm).

2- Yield and its components:

At harvest time, yield of each plot was weighted in kg and converted to total yield (ton/fed).

Grading of tubers:

Tuber from each plot were size – graded to three classes according to tuber diameter, less than 30mm, from 30 to 60mm, and over than 60mm, then each grade was weighed separately and calculated as a percentage of the total yield.

3- Chemical analysis:

All chemical constituents were determined after harvest in the digested dry matter of tubers. Nitrogen were determined according to Prummel (1978), phosphorus and potassium were determined according to Jackson (1967), iron, zinc, manganese, cupper and ascorbic acid were determined according A.O.A.C (1990). Percentage of total soluble solids (TSS%) was determined by a hand refractometer.

4- Storability:

After curing, random samples (5 kg of marketable yield from each plot) were taken, stored in case of paper under normal room conditions. The percentage of weight loss was recorded at 60 days' intervals during the storage period (six months).

It was estimated using the following formula: -

$$\text{Weight loss (\%)} = \frac{\text{(weight before storage - weight after storage)}}{\text{Tuber weight before storage}} \times 100$$

Ascorbic acid (mg/g FW) was determined at the end of storage period

Data were subjected to the statistical analysis and means were compared using new L.S.D according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Results are presented under separate heading, include vegetative growth, tuber yield and its components, chemical composition of tuber, quality of tubers and storability. It is hoped that such sequence simplifies our presentation subject, since each part represents an identical stage of plant growth

1- Vegetative growth characters:

Results in Tables 1 and 2 showed that the highest values of stem length, number of main stems/plant, number of leaves/plant, leaf area, foliage dry and fresh weights/plant, number of tubers/plant and tuber weight of potato were obtained from plants fertilized with the high level of potassium sulphate (96 Kg K_2O/fed) followed by 72Kg K_2O/fed and 48Kg K_2O /fed in both seasons. Similar results were obtained by Mahmoud and Hafez (2010) who found that potato vegetative growth parameters *i.e.*, plant length, fresh and dry weight of leaves and shoots were gradually significantly increased by increasing the level of potassium application from 40, 80 up to 120kg K_2O/fed.

Also, Kumar *et al*. (2010) found that 100% of the recommended potassium fertilizer dose' recorded the best results in respect of plant height, leaf number per plant, number of days for bulb initiation (68.11 days) and number of days for bulb maturity (125.06 days) of onion plant.

Also, the results in Tables 1 and 2 indicate that high significant values of stem length, number of main stems/plant, number of leaves/plant, leaf area, foliage dry and fresh weights/plant, number of tubers/plant and tuber weight of potato were obtained from plants sprayed with macro and micronutrients at the different levels as compared with control (sprayed with water) gradual increases were recorded with increasing spray levels from 2g/l up to 6g/l in both seasons. Similar results were obtained by Dkhil *et al*. (2011) who showed that foliar fertilizer of potato had a significant effect on plant height, plant fresh and dry weight. Also Salim *et al*. (2014) found that the potato plants which received foliar application of 2000 ppm potassium nitrate and potassium silicate gave the highest values for plant length as compared with other treatments. Moreover, Ghosh *et al*. (2017) and Moinuddin *et al*. (2005) found that when the crop was fertilized by foliar application with micronutrient in combination with NPK enhanced most of the vegetative growth of potato (plant height, number of leaves per plant and number of branches per plant).

In the same tables, the interaction results indicated that the highest values of vegetative growth characters *i.e.,* stem length, number of main stems/plant, number of leaves/plant, leaf area, foliage dry and fresh weights/plant, number of tubers/plant and tuber weight were significantly obtained by using potassium at 96 kg K_2O/fed and spray with macro and micronutrients at 6g/L compared with the other interactions. Similar results were obtained by Ewais *et al.* (2010) when used K-fertilizer as 50% of the recommended rate used as soil application + 50% of that added as foliar application. Moreover, Eleiwa *et al.* (2012) found that the interaction between potassium levels and foliar nutritional compounds significantly affected number of leaves/plant.

Table 1. Vegetative growth characters of potato plants as affected by potassium levels, foliar spray with macro and micronutrients and their interactions during 2014/2015 (S1) and 2005/2006 (S2) winter seasons.

Characters / Treatments		Stem length (cm)				No. of main stems/plant				Number of leaves/plant				Leaf area/plant (m^2)				Foliage dry weight (gm)			
		70 day		90 day		70 day		90 day		70 day		90 day		70 day		90 day		70 day		90 day	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Potassium levels(K_2O):																					
96 kg/fed		66.72	72.60	70.36	75.65	1.34	1.38	1.61	1.74	26.22	31.71	27.16	32.74	0.30	0.31	0.34	0.36	19.38	24.99	24.79	29.03
72 kg/fed		62.25	68.88	65.33	71.91	1.29	1.34	1.50	1.63	22.64	29.55	23.58	30.58	0.27	0.29	0.31	0.34	14.60	20.66	20.01	24.70
48 kg/fed		58.31	65.44	70.36	68.39	1.24	1.28	1.38	1.48	20.14	26.46	21.08	27.49	0.24	0.27	0.28	0.32	11.89	11.47	17.30	15.51
LSD at 5%		2.68	1.43	3.18	1.39	0.06	0.05	0.08	0.12	2.83	2.04	2.31	1.85	0.009	0.004	0.007	0.005	1.24	1.13	1.19	1.08
Foliar spray macro and micronutrients.																					
Control		53.60	64.40	57.59	67.67	1.19	1.24	1.31	1.40	18.06	26.85	19.00	27.88	0.23	0.26	0.27	0.30	11.61	13.92	17.02	17.96
2 g/l		61.23	67.88	63.90	70.40	1.29	1.32	1.49	1.61	21.28	28.56	22.22	29.59	0.26	0.27	0.30	0.32	13.48	16.34	18.89	20.38
4 g/l		65.59	70.30	68.93	73.42	1.32	1.37	1.56	1.65	23.83	29.66	24.77	30.69	0.28	0.30	0.32	0.35	16.59	20.15	22.00	24.19
6 g/l		69.28	73.32	72.60	76.44	1.37	1.41	1.62	1.79	28.83	31.89	29.77	32.92	0.31	0.33	0.36	0.39	19.47	25.74	24.88	29.78
LSD at 5%		3.66	1.61	2.80	1.57	0.05	0.05	0.11	0.09	2.11	1.23	1.75	1.09	0.14	0.06	0.01	0.09	0.78	1.34	0.67	1.29
Interactions:K levels& Foliar spray																					
96 kg/fed	Control	57.97	65.82	63.44	68.66	1.25	1.30	1.39	1.49	19.72	28.85	20.66	29.88	0.26	0.28	0.29	0.32	16.59	19.99	22.00	24.03
	2 g/l	65.75	73.20	68.66	76.33	1.35	1.36	1.58	1.71	24.39	30.19	25.33	31.22	0.28	0.28	0.33	0.34	16.62	22.05	22.03	26.09
	4 g/l	70.23	74.42	73.23	77.51	1.37	1.41	1.68	1.77	27.06	30.63	28.00	31.66	0.32	0.32	0.36	0.37	20.94	25.92	26.35	29.96
	6 g/l	72.94	76.97	76.11	80.11	1.41	1.45	1.80	1.98	33.72	37.19	34.66	38.22	0.34	0.36	0.38	0.41	23.38	31.99	28.79	36.03
72 kg/fed	Control	53.27	64.54	56.66	67.94	1.17	1.24	1.30	1.39	17.72	26.52	18.66	27.55	0.24	0.26	0.27	0.30	11.10	14.78	16.51	18.82
	2 g/l	62.37	67.38	64.69	69.83	1.3	1.33	1.48	1.65	20.06	28.30	21.00	29.33	0.26	0.27	0.29	0.31	13.90	18.88	19.31	22.92
	4 g/l	64.83	69.86	68.00	73.00	1.32	1.37	1.58	1.69	24.06	31.73	25.00	32.76	0.27	0.31	0.32	0.35	14.69	20.35	20.10	24.39
	6 g/l	68.52	73.75	72.00	76.88	1.37	1.41	1.66	1.81	28.72	31.63	29.66	32.66	0.31	0.33	0.36	0.39	18.72	28.63	24.13	32.67
48 kg/fed	Control	49.56	62.84	52.66	66.41	1.14	1.19	1.26	1.34	16.72	25.19	17.66	26.22	0.21	0.25	0.24	0.29	7.16	7.00	12.57	11.04
	2 g/l	55.56	63.06	58.36	65.05	1.22	1.26	1.42	1.49	19.39	27.19	20.33	28.22	0.24	0.25	0.27	0.3	9.94	8.10	15.35	12.14
	4 g/l	61.72	66.63	65.55	69.76	1.28	1.33	1.43	1.51	20.39	26.63	21.33	27.66	0.24	0.29	0.29	0.34	14.15	14.17	19.56	18.21
	6 g/l	66.39	69.23	69.71	72.33	1.33	1.37	1.41	1.58	24.06	26.85	25.00	27.88	0.29	0.30	0.34	0.37	16.31	16.62	21.72	20.66
L.S.D. at 5%		6.34	4.85	4.86	2.72	0.09	0.09	0.19	0.16	3.46	2.13	3.62	2.06	0.02	0.08	0.04	0.12	1.45	2.32	1.36	1.91

Table 2. Vegetative growth characters of potato plants as affected by potassium levels, foliar spray with macro and micronutrients and their interactions during 2014/2015 (S1) and 2005/2006 (S2) winter seasons.

Characters / Treatments		Foliage Fresh Wight (gm /Plant)				Number of tubers / plant				Tubers weight / plant (gm)			
		70 day		90 day		70 day		90 day		70 day		90 day	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Potassium levels(K_2O):													
96 kg/fed		266.20	280.71	295.60	307.53	2.29	2.37	3.11	3.39	539.21	548.97	548.97	559.46
72 kg/fed		225.66	241.62	257.51	268.44	2.10	2.18	2.97	3.15	510.99	522.68	519.84	533.16
48 kg/fed		170.79	187.29	192.35	206.03	1.65	1.59	2.70	2.57	493.48	497.17	504.85	513.98
LSD at 5%		11.67	12.80	10.48	5.79	0.22	0.25	0.25	0.16	5.34	6.89	4.58	6.67
Foliar spray macro and micronutrients.													
Control		180.36	193.51	208.94	220.33	1.88	1.69	2.82	2.55	453.91	467.45	470.67	481.14
2 g/l		207.56	224.51	231.27	244.66	1.80	1.94	2.59	2.95	479.22	481.64	487.00	499.52
4 g/l		225.82	241.62	253.93	264.22	1.99	2.06	2.98	3.12	538.81	546.12	546.72	554.69
6 g/l		269.79	286.51	299.81	313.45	2.38	2.51	3.31	3.53	586.30	596.55	593.83	606.79
LSD at 5%		5.50	5.46	6.47	5.49	0.19	0.19	0.16	0.12	10.81	14.21	11.43	13.32
Interactions:K levels& Foliar spray													
96 kg/fed	Control	220.23	229.96	246.56	256.78	2.06	2.03	2.95	2.96	473.74	489.96	490.20	498.20
	2 g/l	252.44	269.62	280.16	296.44	2.14	2.20	2.93	3.26	493.44	502.74	500.97	513.00
	4 g/l	278.22	292.96	308.89	319.78	2.23	2.31	2.98	3.40	593.65	601.09	601.18	610.33
	6 g/l	313.94	330.29	346.79	357.11	2.73	2.94	3.58	3.93	596.00	602.09	603.53	616.33
72 kg/fed	Control	191.34	207.29	224.27	234.11	1.88	1.81	2.85	2.60	459.00	473.20	470.85	486.44
	2 g/l	213.32	225.62	241.45	252.44	1.85	2.15	2.46	3.16	485.83	496.42	494.36	508.31
	4 g/l	226.03	238.96	256.87	267.44	2.23	2.22	3.23	3.23	512.81	520.21	520.31	528.79
	6 g/l	271.96	294.62	307.47	319.76	2.45	2.55	3.35	3.63	586.33	600.88	593.86	609.12
48 kg/fed	Control	129.51	143.29	156	170.11	1.72	1.23	2.68	2.10	429.00	439.20	450.96	458.77
	2 g/l	156.94	178.29	172.21	185.11	1.40	1.47	2.38	2.43	458.39	445.76	465.66	477.25
	4 g/l	173.23	192.96	196.04	205.44	1.52	1.64	2.73	2.73	509.98	517.05	518.68	524.96
	6 g/l	223.47	234.62	245.17	263.48	1.97	2.03	3.01	3.03	576.57	586.70	584.10	594.94
L.S.D. at 5%		9.54	9.46	11.21	9.51	0.34	0.32	0.29	0.21	18.73	24.62	19.80	23.07

2- Yield and quality parameters:

Obtained results in Tables 3 and 4 indicated that the highest values of yield parameters (total yield, grading) and quality parameters (TSS, dry matter, specific gravity and ascorbic acid) were obtained from plants fertilized by potassium level of 96Kg K_2O/fed followed by 72Kg/fed in both seasons. The positive effect of K-levels in improving total yield and its components may be imputed to the fact that K-element is one of the most important element for potato plants.

Table 3. yield and components characters of potato plants as affected by potassium levels, foliar spray with macro and micronutrients and their interactions during 2014/2015 (S1) and 2005/2006 (S2) winter seasons.

Characters / Treatments		Total yield (ton/fed)		Grading					
				Tuber > 60 mm (%)		Tuber 30-60 mm (%)		Tuber < 30 mm (%)	
		S1	S2	S1	S2	S1	S2	S1	S2
Potassium levels(K_2O):									
96 kg/fed		10.46	11.14	55.12	56.75	40.92	40.95	8.60	9.23
72 kg/fed		9.27	10.06	54.84	56.47	40.64	40.67	8.32	8.95
48 kg/fed		9.36	9.73	53.96	55.59	39.76	39.79	7.44	8.07
LSD at 5%		0.37	0.23	0.12	0.065	0.107	0.18	0.12	0.09
Foliar spray macro and micronutrients.									
Control		7.78	8.55	53.11	54.74	38.91	38.94	6.59	7.22
2 g/l		8.40	9.22	54.29	55.92	40.09	40.12	7.77	8.40
4 g/l		10.64	11.13	54.95	56.58	40.75	40.78	8.43	9.06
6 g/l		11.96	12.34	56.20	57.83	42.00	42.03	9.68	10.31
LSD at 5%		0.12	0.27	0.18	0.16	0.13	0.16	0.074	0.052
Interactions:K levels& Foliar spray									
	Control	8.99	9.74	53.93	55.56	39.73	39.76	7.41	8.04
96	2 g/l	9.81	10.64	54.55	56.18	40.35	40.38	8.03	8.66
kg/fed	4 g/l	10.99	11.63	55.31	56.94	41.11	41.14	8.79	9.42
	6 g/l	12.06	12.54	56.69	58.32	42.49	42.52	10.17	10.8
	Control	7.23	8.30	53.63	55.26	39.43	39.46	7.11	7.74
72	2 g/l	7.51	8.58	54.34	55.97	40.14	40.17	7.82	8.45
kg/fed	4 g/l	10.41	10.98	54.96	56.59	40.76	40.79	8.44	9.07
	6 g/l	11.91	12.36	56.42	58.05	42.22	42.25	9.90	10.53
	Control	7.13	7.61	51.78	53.41	37.58	37.61	5.26	5.89
48	2 g/l	7.87	8.43	53.98	55.61	39.78	39.81	7.46	8.09
kg/fed	4 g/l	10.52	10.77	54.58	56.21	40.38	40.41	8.06	8.69
	6 g/l	11.91	12.11	55.50	57.13	41.30	41.33	8.98	9.61
L.S.D. at 5%		0.21	0.48	0.30	0.27	0.19	0.27	0.25	0.31

Table 4. yield and component characters of potato plants as affected by potassium levels, foliar spray with macro and micronutrients and their interactions during 2014/2015 (S1) and 2005/2006 (S2) winter seasons.

Characters / Treatments		Tss(%)		Dry matter (%)		specific gravity (%)		Ascorbic acid (mg/g F.Wt.)	
		S1	S2	S1	S2	S1	S2	S1	S2
Potassium levels(K_2O):									
96 kg/fed		3.79	4.91	21.95	22.65	1.36	1.12	19.95	21.39
72 kg/fed		3.70	5.00	20.90	21.60	1.24	1.09	19.52	20.87
48 kg/fed		3.50	4.75	20.44	21.14	1.18	1.05	19.14	20.36
LSD at 5%		0.67	0.64	0.34	0.29	0.06	0.03	0.16	0.11
Foliar spray macro and micronutrients.									
Control		3.22	5.00	20.26	20.96	1.11	1.05	17.43	18.57
2 g/l		3.55	4.77	20.58	21.28	1.21	1.07	18.81	20.08
4 g/l		3.72	4.88	21.11	21.81	1.27	1.09	20.21	21.63
6 g/l		4.16	4.88	22.43	23.13	1.44	1.14	21.69	23.22
LSD at 5%		0.33	0.23	0.57	0.43	0.06	0.01	0.11	0.17
Interactions:K levels& Foliar spray									
	Control	3.33	5.00	20.97	21.67	1.16	1.08	17.86	19.08
96	2 g/l	3.66	4.66	21.53	22.23	1.28	1.09	19.24	20.63
kg/fed	4 g/l	3.83	5.00	21.94	22.64	1.32	1.12	20.63	22.12
	6 g/l	4.33	5.00	23.35	24.05	1.67	1.19	22.06	23.75
	Control	3.33	5.00	20.05	20.75	1.11	1.05	17.44	18.57
72	2 g/l	3.66	5.00	20.28	20.98	1.23	1.06	18.72	20.07
kg/fed	4 g/l	3.66	5.00	20.86	21.56	1.27	1.10	20.22	21.66
	6 g/l	4.16	5.00	22.40	23.10	1.36	1.16	21.71	23.20
	Control	3.00	5.00	19.76	20.46	1.06	1.02	16.99	18.08
48	2 g/l	3.33	4.66	19.93	20.63	1.13	1.04	18.48	19.53
kg/fed	4 g/l	3.66	4.66	20.53	21.23	1.23	1.06	19.77	21.12
	6 g/l	4.00	4.66	21.55	22.25	1.30	1.09	21.31	22.72
L.S.D. at 5%		0.58	0.40	0.99	0.78	0.11	0.02	0.20	0.30

It is helps in producing stocky plants and healthy in appearance with thick leaves and larger tubers. In addition, it has an indispensable role in translocation of synthesized carbohydrates from plant leaves towards tubers. The obtained results are in accordance with those of Byiu and Ray (2002), Abdelgader *et al.* (2003) and Al-Moshileh and Errebi (2004), they noted that the total tuber yield and quality parameters were increased with increasing potassium application.

Regarding to the effect of foliar spray with macro and micronutrients on the previously mentioned characters, results in Tables 3 and 4 showed that the highest values were obtained from plants sprayed with macro and micronutrients at the rate of 6 g/L) in both seasons. Similar results were obtained by Gunadi (2009), Awad *et al*. (2010) and Ghosh *et al.* (2017).

Similarly, the interaction between potassium levels and foliar spray with macro and micronutrients had significant effect on yield and Its quality parameters, the best results were obtained from plants received potassium at the level of 96 kg K_2O/fed and sprayed with macro and micronutrientsat the rate of 6 g/L in both seasons. Similar results were obtained by Moinuddin *et al.* (2005).

3. Chemical composition:

Results in Tables (5) showed that the highest values of N%, P%, K%, Fe ppm, Zn ppm, Mn ppm and Cu ppm of potato tuber were obtained from plants fertilized with the highest level of potassium sulphate (96 Kg K_2O/fed) followed by 72 Kg K_2O/fed and 48 Kg K_2O/fed in both seasons. Similar results were obtained by Abd El-Latif *et al*. (2011) found that N content in tuber has increased significantly by adding 96 k_2O kg/fed., while, P content has increased when 72 K_2O kg/fed. was applied, at the same time as K content in tuber has increased by adding the high level of K fertilizers (120 K_2O kg/fed.). On the other hand, the lowest N, P and K contents were recorded when control (without addition of k fertilizers) in both seasons.

Table 5. Chemical characters of potato plants as affected by potassium levels, foliar spray with macro and micronutrients and their interactions during 2014/2015 (S1) and 2005/2006 (S2) winter seasons.

Characters		N%		P %		K %		Fe ppm		Zn ppm		Mn ppm		Cu ppm	
Treatments		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Potassium levels(K_2O):															
96 kg/fed		1.66	1.81	0.232	0.253	3.19	3.16	11.14	12.33	4.90	5.97	3.75	4.18	1.37	1.46
72 kg/fed		1.55	1.68	0.217	0.243	2.99	3.05	10.85	11.95	4.96	5.80	3.54	3.95	1.27	1.35
48 kg/fed		1.46	1.58	0.214	0.235	2.62	2.96	10.48	11.66	4.77	5.57	3.31	3.75	1.18	1.23
LSD at 5%		0.04	0.05	0.016	0.006	0.02	0.02	0.07	0.08	0.29	0.13	0.03	0.02	0.04	0.02
Foliar spray macro and micronutrients.															
Control		1.13	1.23	0.173	0.201	2.40	2.58	9.37	10.55	3.78	5.02	2.57	3.05	0.88	0.79
2 g/l		1.40	1.52	0.208	0.228	2.88	2.91	10.37	11.52	4.66	5.51	3.19	3.63	1.12	1.16
4 g/l		1.70	1.88	0.236	0.256	3.16	3.22	11.28	12.53	5.22	6.04	3.86	4.24	1.40	1.55
6 g/l		2.00	2.13	0.267	0.289	3.29	3.51	12.29	13.32	5.85	6.53	4.51	4.92	1.70	1.88
LSD at 5%		0.04	0.04	0.013	0.002	0.03	0.03	0.05	0.13	0.27	0.14	0.03	0.05	0.02	0.03
Interactions: K levels& Foliar spray															
	Control	1.22	1.32	0.190	0.211	2.50	2.69	9.69	10.86	3.25	5.26	2.78	3.25	0.97	0.90
96	2 g/l	1.49	1.68	0.219	0.236	3.08	3.03	10.69	11.97	4.87	5.67	3.42	3.83	1.22	1.28
kg/fed	4 g/l	1.81	2.00	0.244	0.265	3.53	3.32	11.41	12.84	5.42	6.22	4.08	4.46	1.50	1.68
	6 g/l	2.11	2.24	0.278	0.301	3.64	3.58	12.79	13.64	6.08	6.71	4.73	5.16	1.79	1.98
	Control	1.10	1.23	0.155	0.200	2.38	2.58	9.39	10.53	4.13	5.09	2.58	3.04	0.88	0.80
72	2 g/l	1.41	1.50	0.209	0.230	2.96	2.89	10.39	11.46	4.63	5.54	3.16	3.62	1.12	1.17
kg/fed	4 g/l	1.70	1.88	0.238	0.254	3.24	3.23	11.37	12.51	5.23	6.04	3.88	4.24	1.40	1.55
	6 g/l	2.00	2.11	0.268	0.289	3.40	3.50	12.27	13.30	5.85	6.52	4.53	4.91	1.70	1.88
	Control	1.06	1.14	0.175	0.193	2.31	2.46	9.02	10.26	3.97	4.72	2.35	2.88	0.79	0.66
48	2 g/l	1.29	1.39	0.198	0.219	2.61	2.81	10.05	11.13	4.49	5.33	3.00	3.44	1.04	1.05
kg/fed	4 g/l	1.60	1.77	0.228	0.249	2.73	3.10	11.06	12.23	5.03	5.86	3.63	4.02	1.30	1.43
	6 g/l	1.90	2.04	0.256	0.278	2.82	3.45	11.81	13.01	5.61	6.37	4.26	4.68	1.59	1.79
L.S.D. at 5%		0.07	0.07	0.023	0.004	0.06	0.05	0.10	0.23	0.47	0.24	0.06	0.07	0.04	0.05

Also, the results in Table (5) indicate that the highest values of N%, P%, K%, Fe ppm, Zn ppm, Mn ppm and Cu ppm of potato tuber using foliar spray with macro and micronutrients at the highest level (6 g/l). Similar results were obtained by Horvat *et al*. (2014) reported that the concentration of nitrogen, phosphorus, potassium and calcium in potato tuber significantly influenced by foliar fertilizers. Moreover, Ghosh *et al*. (2017) showed that foliar application with potassium significantly improved quality parameters (ascorbic acid, specific gravity and reducing sugar).

In the same tables, the interaction results indicated that the Chemical character's constituents (N, P, K, Fe, Zn, Mn, Cu) of potato tuber were significantly increased by using potassium at the level of 96 kg K_2O/fed and spray with macro and micronutrients at the rate of 6 g/L compared with the other interactions. Similar results were obtained by Salim *et al*. (2014) found that foliar spraying with potassium silicate or potassium nitrate had strong stimulating effect on mineral nutrients (N, P, K, Zn, Mn and Fe) and protein concentration of potato leaves in both seasons.

4. storability:

Results in Table 6 indicated that the highest values of weight loss % of potato tuber were obtained from plants fertilized with potassium sulphate at 48Kg K2O/fed, while the highest values of ascorbic acid (mg/g FW) were obtained with potassium fertilization at 96 kg K2O/fed. Similar results were obtained by Etman *et al.* (2002) reveal that application of K at two levels of 75 and 100 kg

K_2O/fed caused a significant decreased in percentage of total weight loss of sweet potato tuber roots compared with the other levels (25-50kg K_2O/fed). In addition, Imas and Bansal (1999) illustrated that applying K to potato significantly decreased weight losses from the tubers after harvest.

Regarding to the effect of foliar spray with macro and micro nutrients, data in Table 6 showed that the highest values of weight loss % were obtained when potato plants sprayed with the lowest level of foliar application while the highest values ascorbic acid of potato tubers were obtained from plants sprayed with macro and micronutrients at the rate of 6 g/L in both seasons. Similar results were obtained by El-Sawy *et al.* (2000), El-Sayed *et al.* (2007) and El-Sawy (2011).

On the other hand, the interaction between potassium levels and foliar spray with macro and micro nutrients had the significant effect on weight loss % and ascorbic acid (mg/g FW), the best results were obtained from plants received potassium at the level of 96 kg K_2O/fed and sprayed with macro and micronutrients at the rate of 6 g/L in both seasons. Similar results were obtained by El-Sawy (2011) found that application of potassium at 100 kg K_2O/fed and foliar of K at 0.5 % decreased weight loss (%) decay percentage and sprouting in both seasons.

Table 6. Storage characters of potato plants as affected by potassium levels, foliar spray with macro and micronutrients and their interactions during 2014/2015 (S1) and 2005/2006 (S2) winter seasons.

Characters / Treatments	Ascorbic acid mg/g FW		Weight loss %					
			60 days		120 days		180 days	
	S1	S2	S1	S2	S1	S2	S1	S2
Potassium levels(K_2O):								
96 kg/fed	8.18	8.82	1.08	1.28	7.89	8.08	22.91	23.10
72 kg/fed	7.99	8.61	1.18	1.38	7.98	8.18	23.00	23.20
48 kg/fed	7.80	8.44	1.27	1.46	8.07	8.27	23.09	23.29
LSD at 5%	0.07	0.11	0.07	0.02	0.07	0.03	0.039	0.054
Foliar spray macro and micronutrients.								
Control	7.14	7.74	1.45	1.66	9.64	9.85	24.66	24.87
2 g/l	7.68	8.31	1.20	1.38	8.50	8.68	23.52	23.70
4 g/l	8.29	8.91	1.09	1.28	7.43	7.62	22.45	22.64
6 g/l	8.85	9.54	0.97	1.17	6.35	6.55	21.37	21.57
LSD at 5%	0.09	0.10	0.017	0.09	0.03	0.08	0.04	0.02
Interactions:K levels& Foliar spray								
96 kg/fed Control	7.33	7.95	1.27	1.46	9.46	9.65	24.48	24.67
96 kg/fed 2 g/l	7.85	8.51	1.13	1.33	8.43	8.63	23.45	23.65
96 kg/fed 4 g/l	8.50	9.09	1.04	1.23	7.38	7.57	22.4	22.59
96 kg/fed 6 g/l	9.04	9.72	0.91	1.11	6.29	6.49	21.31	21.51
72 kg/fed Control	7.14	7.72	1.50	1.71	9.69	9.90	24.71	24.92
72 kg/fed 2 g/l	7.70	8.31	1.2	1.37	8.5	8.67	23.52	23.69
72 kg/fed 4 g/l	8.28	8.92	1.08	1.28	7.42	7.62	22.44	22.64
72 kg/fed 6 g/l	8.86	9.52	0.94	1.15	6.32	6.53	21.34	21.55
48 kg/fed Control	6.95	7.55	1.6	1.81	9.79	10	24.81	25.02
48 kg/fed 2 g/l	7.50	8.10	1.27	1.45	8.57	8.75	23.59	23.77
48 kg/fed 4 g/l	8.10	8.72	1.15	1.34	7.49	7.68	22.51	22.70
48 kg/fed 6 g/l	8.65	9.37	1.06	1.27	6.44	6.65	21.46	21.67
L.S.D. at 5%	0.16	0.17	0.06	0.04	0.02	0.06	0.018	0.04

CONCLUSION

In view of the obtained and discussed results, it was found that fertilization with potassium at 96 kg K_2O and foliar application of macro and micronutrients at 6 g/l gave high vegetative growth parameters and produced higher yield with high quality parameters under the conditions of this study.

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إستجابة البطاطس (إنتاجية وتخزين) لبعض مستويات البوتاسيوم والرش ببعض العناصر الكبرى والصغرى

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أجريت هذه الدراسة في قرية العنانية – مركز الســنبلاوين – محافظة الدقهلية خلال موسمي ٢٠١٥/٢٠١٤ و٢٠١٦/٢٠١٥.صممت التجربة بنظام القطع المنشقة مرة واحدة في ثلاث مكررات حيث خصصت القطع الرئيسية لمستويات من سلفات البوتاسيوم عند مستويات (٩٦كجم/فدان ،٧٢كجم/فدان و٤٨كجم/فدان) والقطع تحت الرئيسية لأربعة معاملات من الرش (الرش بالماء (الكنترول)، الرش بمركب ستماجرين (نيتروجين٢٥% - فوسفور١٦% - بوتاسيوم١٢ % - زنك٠.٥% - حديد ٠.٥% - منجنيز ٠.٥% - نحاس ٠.٣%) بثلاثة تركيزات ٢ جم/لتر، ٤ جم/لتر و ٦ جم/لتر) وقد تم الرش ثلاث مرات الأولى بعد ٤٥ يوم من الزراعة والثانية بعد ٦٠يوم من الزراعة والثالثة بعد ٧٠ يوم من الزراعة.أوضحت النتائج أن معاملات التسميد بسلفات البوتاسيوم عند مستوى ٩٦كجم/ فدان أدى للحصول علي زيادة في ارتفاع النباتات والوزن الطازج والجاف للنباتات وعدد الأوراق للنبات والمساحة الورقية للنبات وإعطاء أكبر إنتاج للمحصول ودرنات ذات أحجام جيدة وعدد درنات عالى بالنسبة لمتوسط كل نبات.وأوضحت النتائج أيضا أن الرش بتركيز ٦جم/ لتر من مركب ستيما جرين أدت الى زيادة في ارتفاع النباتات والوزن الطازج والجاف للنباتات وعدد الأوراق للنبات والمساحة الورقية للنبات وذلك بالمقارنة بالكنترل وإعطاء أكبر إنتاج للمحصول ودرنات ذات أحجام جيدة وعدد درنات عالى بالنسبة لمتوسط كل نبات هذا بالمقارنة مع الكنترول.وعموما كان تأثير التفاعل بين سلفات البوتاسيوم عند مستوى ٩٦كجم/ فدان كتسميد أرضي والرش بتركيز ٦جم/ لتر من مركب ستيما جرين واضحا على جميع الصفات المدروسة سواء كانت خضرية أو ثمرية أو فسيولوجية.