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Comparative Studies of Application Both Mineral and Bio-potassium Fertilizers on the Growth, Yield and Quality of Potato Plant

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Abstract: Two field experiments were conducted during the two successive winter seasons of 2006 and 2007 at the experimental station of the Agriculture Research Center (ARC), Kafr El–Zayat, El–Gharbia Governorate, Egypt to study the response of potato plant (*Solanum tuberosum L.*) cv. Valor to mineral and bio-potassium fertilizers and its effect on the growth, yield and quality of tubers. The experiment included 16 treatments representing the interaction of four mineral–K fertilizer treatments (45, 90, 135 and 180 kg K_2O /fed.) with four bio-potassium fertilizer treatments [control, 2, 3 and 4 L. /fed.].(Fed. = 0.4 ha.). Results showed that increasing of potassium sulphate levels as mineral potassium fertilizer increased the vegetative growth characters of potato plants, i.e., plant length, leaf number/plant, and leaf area/plant as well as fresh and dry weight of whole plant. Application of potassein as a bio-potassium fertilizer improved plant growth characters compared with untreated plants. Using of potassein at the level of 3 L./fed. gave the highest values of vegetative growth characters. Moreover, increasing of mineral potassium fertilizer up to 180 kg K_2O /fed were gradually increased the potato tubers yield. Likewise, tubers number/plant and marketable tubers percentage as well as tubers quality expressed as specific gravity, starch %, protein % and dry matter % showed positive responses to increasing mineral-K levels, and the highest values with the highest level of mineral-k (180 kg K_2O /fed.). While, the lowest values were recorded with the lowest level (45 kg K_2O /fed.) in both seasons. Interaction between mineral and bio-K fertilizers had a positive effect on the productivity of potato plants. The highest value of yield was recorded with potato plants which received potassein as bio-K fertilizer at the level (3 L. /fed.) combined with potassium sulphate as mineral–K fertilizer at the level (90 kg K_2O /fed.) in both seasons. Likewise, tubers quality and N, P contents in the tubers showed the same trend of the yield of potato plants in both seasons. While, K content in the tubers was increased with the highest mineral-K level (180 kg K_2O /fed.) a long with the highest bio-K level (4 L. / fed.) in both seasons.

Key words: Potato; (*Solanum tuberosum L.*); mineral-K fertilizer; bio-K fertilizer, vegetative growth, yield and quality.

INTRODUCTION

Potato (*Solanum tuberosum L.*) is the fourth important crop in the world after wheat, maize and rice. It is considered as one of the most important vegetable crops grown in Egypt, where it grows under different environmental conditions[1,2]. Potato plays an important role in the economy of the country as a food as well as a cash crop; much foreign exchange can be earned by exporting potatoes to other countries[2,3].

Potato crop needs high levels of fertilizers. Among the nutrients usually used for potato fertilization, K is a nutrient taken up in the greatest quantity by the potato plant[4,5]. Potassium is a plant nutrient with diverse roles to play in plant metabolism and required in large amounts by most crops. It interacts with many other plant constituents to affect yield and quality. Potassium has many functions in plant; it is involved in the transport of sugars around the plant and it helps control the water status of the plant tissues[6].

Potassium promotes vegetative growth[7,8,9,5]. Growth and development of tubers were affected by potassium application and the response was better at higher rates of potassium[7,10,11,3]. Potato tuber quality such as specific gravity, starch content and dry matter as well as marketable tubers percentage showed a positive response to increasing of K fertilizer[12,13,3,8,14,5]. Many investigators such as[15,16,3,14,5] indicated that K increased N, P and K uptake in potato plant.

Bio-fertilizers application affected plant growth of potatoes[17,18,19,20,21,22] and total yield of plant[23,21] as well as physical and chemical properties[24,23,25,26,21]. Moreover, applying bio-fertilizer to the soil or inoculated with tuber, increased the percentage of nutrients in potato leaves, dry matter content, total carbohydrates, specific gravity and total yield per plant[27,28,22].

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The aim of this investigation is to study the effect of mineral and bio-potassium fertilizer treatments as well as their interaction on the growth, yield and tubers quality.

MATERIAL AND METHODS

Two field experiments were carried out during the two successive winter seasons of 2006 and 2007, respectively in clay loam soil at the Agriculture Research Centre (ARC) at Kafr El-Zayat, El-Gharbia Governorate, Egypt. The physical and chemical properties of the experimental soil are shown in Table (1). Each experiment contained 16 treatments, which were the simple combination between 4 levels of mineral potassium fertilizer, i.e., 45, 90, 135 and 180 k_2o kg/fed. in the form of potassium sulphate (48% K_2O) as soil dressing and four levels of bio-potassium fertilizer commercially called potassein i.e., control, 2, 3 and 4 L./fed. as foliar spraying. The mineral potassium fertilizer was added at two equal doses, the first dose was added after four weeks from seed tubers planting and the second one's was two weeks later. Potassein is a liquid foliar bio-fertilizer contains 30% K_2O and active microorganisms hydrolyzing insoluble potassium into soluble one, provided from Ministry of Agriculture, Egypt. Potassein treatments were sprayed two times, the first was applied after three weeks from full tubers emergence and the second one's was sprayed after 15 days from the first one.

Table 1: Physical and chemical analysis of the experimental soil during the seasons of 2006 and 2007.

A. Physical properties	2006	2007
Soil texture	Clay loam	Clay loam
Clay (%)	47.60	46.20
Silt (%)	29.20	28.50
Fine sand (%)	20.30	21.60
Coarse sand (%)	2.90	3.70
B. Chemical analysis		
Available K mg/100 g soil	0.41	0.50
Available P mg/100 g soil	5.90	5.82
Total N mg/100 g soil	150.60	146.40
Cl^- (meq/L.)	1.85	1.80
CO_3^{--}(meq/L.)	5.14	4.62
$Na_2CO_3^{--}$(meq/L.)	3.72	2.82
$Ca_2CO_3^{--}$(meq/L.)	1.74	1.70
SO_4^{--}(ppm)	80.50	95.50
Organic matter (%)	1.82	1.76
EC (mmhos/cm/25°C)	2.15	2.19
pH	8.1	8.3
Fe^{++}(ppm)	17.90	17.30
Zn^{++}(ppm)	1.10	1.14
Mn^{++}(ppm)	5.50	5.74
Cu^{++}(ppm)	4.45	3.71

The experimental design was split plot design with three replicates. Whereas, the four different levels of mineral potassium fertilizers were laid out in main plots while four levels of bio-potassium were distributed randomly in the sub-plots. Each sub–plot area was 14.06 m^2 consisted of three ridges each was 0.75 m in width and 6.25 m long. Seed tubers cv. Valor were planted on one side at 25 cm a part. Potato seed tubers were planted on 5^{th} of October and 7^{th} in 2006 and 2007, respectively. Harvest date was done at 110 days after planting (DAP) in both seasons. The normal agricultural practices took place, whenever it was necessary according to the recommendations of the Egyptian Ministry of Agriculture. Six plants were taken randomly from each sub-plot as a representative sample at 100 days after planting of seed tubers and the following criteria's were recorded:-

1- Vegetative Growth Characters: i.e., plant length (cm), main stems number /plant, leaves number /plant, leaf area /plant (cm^2), fresh and dry weight of whole plant (g /plant) whereas, leaf area /plant was determined as described by[29].

Tubers Yield: i.e., tubers number /plant, yield /plant (g /plant), total tubers yield (ton /fed.) and marketable tubers percentage.

Tubers Quality: i.e., specific gravity, starch %, dry matter and protein %. Tubers specific gravity was calculated from samples weights measured in air and water.

4- Tubers Chemical Content: i.e., N, P and K were determined as percentage on basis of dry weight. Nitrogen, phosphorus and potassium were determined as described by[30,31,32], for the previous respective. Starch % was calculated according to the method as described by[33]. Protein % was determined according to[34].

Statistical Analysis: All the obtained data were statistically analyzed according to[35].

RESULTS AND DISCUSSION

A. Vegetative Growth Characters:

1- Effect of Mineral - k fertilizer: Data in Table (2) show that vegetative growth characters of potato plants were significantly affected by different levels of mineral–K fertilizer whereas, plant length, leaves number /plant, leaf area /plant, fresh and dry weight of whole plant were slow gradually increased by increasing levels of potassium sulphate.

The highest values of the above mentioned growth characters were obtained with the highest level of K fertilizer (180 kg K_2O /fed.). On the other hand, the lowest values were obtained with the lowest level of mineral-k fertilizer (45 kg K_2O /fed.). These findings

Table 2: Effect of mineral-k fertilizer on the vegetative growth characters of potato plant during the two successive seasons of 2006 and 2007.

Mineral potassium fertilizer (kg/fed.)	Plant Length (cm)	Main Stems No/Plant	Leaves No. /Plant	Leaf area/ Plant (cm^2)	Whole Plant Fresh Weight (g)	Whole Plant dry Weight (g)
			A. First season			
45	45.6	3.5	27.4	1484.0	156.0	10.3
90	47.0	3.6	29.9	1609.2	178.1	11.3
135	47.8	3.5	30.3	1678.5	193.5	11.5
180	48.3	3.5	31.4	1681.2	198.7	12.1
L.S. D. at 5% Level	0.5	N.S.	0.5	22.7	2.1	0.1
			B. Second Season			
45	45.3	3.5	27.1	1479.1	182.0	11.8
90	47.9	3.6	29.8	1625.1	194.0	12.1
135	48.7	3.5	30.5	1658.6	202.5	12.3
180	49.0	3.5	31.7	1662.4	203.2	12.4
L.S. D. at 5% Level	1.0	N.S.	0.6	17.5	3.5	0.1

were significant and true in both experimental seasons except that main stems number /plant. The statistical analysis of the obtained data reveals that the differences within various potassium levels were great enough to reach the significant level of 5%.

It could be concluded that increasing of mineral-K fertilizer levels promoted the vegetative growth characters which in turn increased plant length, leaves number /plant, leaf area /plant, fresh and dry weight of whole plant.

These results are in agreement with those reported by[7,36,11,3,8,14]. Moreover,[5] indicated that potassium fertilizer had positive effect on vegetative growth parameters. There were linear relationships between the rate of K application and each of these parameters.

2- Effect of Bio-K fertilizer: Data in Table (3) indicate that application of potassein as bio-K fertilizer improved plant growth characters as expressed by plant length, leaf number /plant, leaf area /plant, fresh and dry weight of whole plant compared with untreated plants (control). Whereas, the above mentioned plant growth characters were increased with increasing potassein levels up to 3 L. /fed. It means that the highest values of the above mentioned vegetative growth characters were recorded with the potassein at the level of 3 L. /fed and these increases were highly significant compared with untreated plants (control) in both seasons. These findings were true in both seasons, except the main stems number/ plant in the second season.

The potassium enhanced the elements absorption which caused an enhancement in plant growth, it might be due to the effect of nutrients mobilizing microorganisms which help in availability of metals and increased levels of extractable minerals[37]. In addition to, potassium is highly mobile nutrient within the plant and it is needed for the correct functioning of many enzymes in the plant[6]. Another possible explanation, the improvement in vegetative growth characters of potato plants as a result of using of bio-fertilizer treatments may be due to applying bio-fertilizer increases micro-organisms living in the soil and these microorganisms working on the organic matter in the soil to convent organic form of nutrients such as N to mineral–N[17]. Also, bio-fertilizers play a fundamental role in converting P and K fixed form to be soluble ready for plant nutrition making the uptake of nutrients by plants more easy[27].

3- Effect of the Interaction Between Mineral and Bio-k fertilizers: Data presented in Table (4) show that vegetative growth parameters of potato plants were significantly responded to the interaction between mineral and bio-K fertilizers. Whereas, addition of potassium sulphate as a mineral-k at the level of 90 kg K_2O /fed. with potassein as bio-K-fertilizer at the level of 3L./fed. resulted in the highest values of plant length, leaves number/ plant, leaf area/plant, fresh and dry weight of whole plant. On the other hand, the lowest values of the above mentioned plant growth characters were recorded with that plants which supplied with potassium sulphate at the level of 45 kg K_2O /fed. combined with potassein at the level of 2 L./fed. The above mentioned findings were true in both experimental seasons. Significant differences were detected among these interaction treatments in both seasons.

B. Yield and Quality.

1. Effect of Mineral-K fertilizer: Data of Table (5) demonstrate that yield of potato plants was significantly influenced by different mineral–K fertilizer levels. Increasing of potassium sulphate up to 180 kg K_2O

Table 3: Effect of bio– k fertilizer on the vegetative growth characters of potato plant during the two successive seasons of 2006 and 2007.

Bio potassium fertilizer treatment	Plant Length (cm)	Main Stems No/Plant	Leaves No. /Plant	Leaf area/ Plant (cm^2)	Whole Plant Fresh Weight (g)	Whole Plant dry Weight (g)
		A. First season				
Control	46.5	3.5	27.6	1553.0	169.9	10.9
2L./Fed.	47.5	3.5	31.3	1632.2	184.2	11.6
3L./Fed.	48.6	3.6	32.0	1660.2	200.6	11.8
4L./Fed.	46.2	3.5	28.1	1607.5	171.6	11.0
L.S. D. at 5% Level	0.6	0.1	0.7	42.0	3.5	0.2
		B. Second Season				
Control	46.3	3.5	27.9	1582.7	180.9	11.6
2L./Fed.	48.9	3.5	31.0	1613.6	203.7	12.1
3L./Fed.	49.0	3.5	32.0	1642.2	209.9	12.6
4L./Fed.	46.6	3.5	28.3	1586.7	187.1	12.3
L.S. D. at 5% Level	0.5	N.S.	0.6	15.7	3.7	0.1

Table 4: Effect of mineral and bio-potassium fertilizers on the vegetative growth characters of potato plant during the two successive seasons of 2006 and 2007.

				A. first season			
Mineral potassium fertilizer (kg/fed.)	Bio- potassium fertilizer	Plant Length (cm)	Main Stems No/Plant	Leaves No. /Plant	Leaf area/ Plant (cm^2)	Whole Plant Fresh Weight (g)	Whole Plant dry Weight (g)
45	Control	44.0	3.0	22.5	1279.1	123.3	8.4
	2L./Fed.	43.5	3.5	26.0	1377.2	145.7	10.1
	3L./Fed.	46.0	3.7	30.0	1543.5	173.2	11.0
	4L./Fed.	49.0	3.8	31.0	1736.3	181.6	11.8
90	Control	43.0	3.5	24.0	1330.4	133.1	10.0
	2L./Fed.	45.0	3.5	29.0	1537.7	178.3	11.3
	3L./Fed.	52.5	3.8	38.5	1905.8	225.8	12.8
	4L./Fed.	47.5	3.5	28.0	1663.1	175.3	11.1
135	Control	46.3	3.6	28.3	1707.3	184.2	11.0
	2L./Fed.	51.0	3.5	35.5	1855.9	212.6	12.5
	3L./Fed.	49.0	3.5	30.5	1613.1	204.2	11.9
	4L./Fed.	45.0	3.4	27.0	1537.5	173.1	10.6
180	Control	52.5	3.7	35.7	1895.0	239.0	14.1
	2L./Fed.	50.5	3.4	34.5	1758.1	200.4	12.5
	3L./Fed.	47.0	3.4	29.0	1578.6	199.1	11.5
	4L./Fed.	43.3	3.4	26.5	1493.2	156.4	10.5
L.S.D at 5% level		1.1	0.1	1.3	84.0	7.0	0.4

Table 4: Cont'd.

Mineral potassium fertilizer (kg/fed.)	Bio-potassium fertilizer	Plant Length (cm)	Main Stems No/Plant	Leaves No. /Plant	Leaf area/ Plant (cm^2)	Whole Plant Fresh Weight (g)	Whole Plant dry Weight (g)
B. Second season							
45	Control	41.5	3.2	21.4	1326.8	135.6	9.2
	2L./Fed.	43.0	3.5	26.0	1359.2	172.9	10.6
	3L./Fed.	46.5	3.6	30.0	1494.3	190.1	12.6
	4L./Fed.	50.0	3.9	31.0	1736.0	229.5	14.7
90	Control	42.3	3.5	25.5	1456.9	163.3	10.2
	2L./Fed.	49.0	3.5	28.0	1640.8	184.7	11.3
	3L./Fed.	52.0	3.7	36.5	1787.5	246.8	14.1
	4L./Fed.	48.3	3.5	29.0	1615.3	181.0	12.7
135	Control	49.0	3.6	27.5	1672.5	186.7	13.0
	2L./Fed.	52.5	3.5	36.2	1753.9	235.1	13.6
	3L./Fed.	49.0	3.4	32.0	1653.9	218.0	11.6
	4L./Fed.	44.4	3.4	26.5	1554.0	170.1	11.0
180	Control	52.5	3.9	37.0	1874.8	258.1	14.0
	2L./Fed.	51.0	3.5	33.8	1700.5	222.0	12.8
	3L./Fed.	48.5	3.3	29.5	1632.9	184.9	12.0
	4L./Fed.	43.8	3.4	26.6	1441.4	167.8	10.7
L.S.D at 5% level		0.9	0.2	1.2	31.3	7.3	0.2

Table 5: Effect of mineral–k fertilizer on the yield and quality as well as chemical constituents of potato plant during the two successive seasons of 2006 and 2007.

Treatments Mineral-k fertilizer (kg/fed.)	Tubers No./Plant	Yield/Plant (g)	Yield (ton/fed.)	Marketable tubers%	Specific gravity (g/cm^3)	Starch %	Protein %	N %	P %	K %	Dry matter %
A. First season											
45	7.6	513.8	11.150	93.3	1.0634	1.4956	16.661	2.666	0.722	3.625	15.783
90	8.0	534.0	11.587	94.2	1.0671	11.2421	17.077	2.732	0.744	3.637	16.470
135	8.2	548.3	11.898	94.3	1.0721	12.2341	17.446	2.791	0.771	3.649	16.717
180	8.4	554.6	12.035	94.8	1.0735	12.5012	17.599	2.816	0.777	3.704	16.942
L.S. D. at 5% Level	0.4	6.8	0.148	0.3	0.0071	1.4088	0.051	0.008	0.017	0.005	0.080
B. Second Season											
45	7.5	505.1	10.961	95.3	1.0455	6.9339	17.266	2.763	0.809	3.721	16.433
90	8.5	546.7	11.862	96.3	1.0683	11.4744	17.681	2.829	0.840	3.738	16.814
135	8.8	594.1	12.891	96.8	1.0690	11.6154	18.055	2.889	0.870	3.751	17.292
180	8.9	615.6	13.359	97.2	1.0765	13.0968	18.214	2.914	0.873	3.806	17.467
L.S. D. at 5% Level	0.4	8.8	0.191	0.4	0.0054	1.0845	0.051	0.008	0.011	0.005	0.207

/fed. increased the yield/plant which in turn reflected on the total tubers yield as ton/fed. in both seasons. Whereas, the highest values of total tubers yield amounted 12.035 and 13.359 ton/fed. for the first and second seasons, respectively were obtained with that plants received 180 k_2o kg/fed. On the other hand, the lowest values were recorded with the lowest K level (45 kg K_2O /fed.) and it was 11.150 and 10.961 ton/fed. respectively, Tubers number/plant and marketable tubers percentage were also affected by different mineral–K fertilizer levels and showed the same trend of yield as mentioned above. Concerning, tubers quality expressed as specific gravity and percentages of starch, protein and dry matter showed positive responses to different mineral–K levels, where the highest values of them were recorded with the highest mineral–K level (180 kg K_2O /fed.).

While, the lowest values were recorded with the lowest level (45 kg K_2O /fed.) in both seasons. Similarly, N, P and K contents in tubers were increased with increasing mineral–k levels up to 180 kg K_2O /fed. in both seasons. Finally, there were linear relationships between the different mineral fertilizer levels and the productivity of potato plants and tubers quality. These results were held good in both seasons. Significant differences were detected between mineral-K treatments on the productivity of potato plants, tubers quality and nutritional elements of tubers in both seasons.

It could be concluded that increasing productivity of potato plants as a result of increasing potassium sulphate levels (mineral–K) may be due to potassium increased the average tuber weight and tubers number/plant which in turn increased the total tuber yield (ton/fed.) and marketable tubers percentage. This effect might be due to that potassium plays an important role in the transport of assimilates and nutrients[6,36,38].

[39] indicated that with adequate K nutrition two thirds of the labeled photosynthesis passed within one day into the tubers when after flowering intensive growth of tubers set in. With insufficient K supply only half of the photosynthesis was translocated to the tubers during the same period. Similar trend of results were reported by[13,40,41,3,8,14,9].

Improvement of tubers quality characters expressed as specific gravity, Starch %, protein %, and dry matter % as affected by potassium nutrition may be attributed to potassium had a positive effect on translocation of assimilates[36,38].

In addition,[42] indicated that potassium is involved in the activation of the enzyme starch synthesis, which is responsible of the synthesis of starch. Moreover,[6] demonstrated that potassium has many functions in plants. It is needed for the correct functioning of many enzymes in the plant, it is involved in the transport of sugars around the plant and it helps control the water status of the plant tissues. Potassium had an effect on tuber dry matter content. Also, the observed improvement in the tubers quality characters as affected by increasing of mineral-k levels may be attributed to the positive effect of potassium on translocation of assimilates[39,36,38]. These findings were supported by previous investigators such as[43,3,14,5].

2- Effect of Bio-K fertilizer: Data in Table (6) show that the productivity of potato plants was enhanced by using the potassein as bio-K fertilizer. Whereas, the yield of potato plants were gradually increased with increasing potassein levels up to 3 L/fed. It means that, the highest yield value was detected with that plants received potassein at the level (3 L./fed).These increment in the productivity of potato plants as a result of using the potassein fertilizer at the level (3 L/fed) was highly significant in both seasons.

Likewise, tubers number/ plant and marketable tubers % showed the same trend of yield in both seasons. Moreover, quality of potato tubers expressed as specific gravity, starch %, protein % and dry matter % positively responded to potassein levels and showed the same trend of yield as mentioned before. Whereas, the highest values of potato tubers quality were observed with potassein at the level of 3 L/feddan.

The positive effect of bio-K fertilizer on the yield, tubers quality parameters and nutritional constituents is an expected result for its effect on improving plant growth and dry matter production. These results are in agreement with those reported by[21] who reported that bio-fertilizer application improved plant growth and dry matter production which in turn reflected on increased total yield production of potato plants.

Moreover,[27,28] demonstrated that applying bio-fertilizer to the soil or inoculated with tuber, increased the percentage of nutrients in potato leaves, dry matter content, total carbohydrates, specific gravity and total yield. Also,[22] indicated that bio-fertilizer play a fundamental role in converting P and K fixed form to be soluble ready for plant nutrition making the uptake of nutrients by plants more easy. Similar results were found by[44] who found that combination of both bio-fertilizer and growth regulator gave the highest total potato tubers yield. The obtained results are in affinity with those reported by[23,45,21,27,28].

Reducing the yield of potato plants, tubers quality as well as nutritional elements (N and P) and dry matter % with using the highest potassein level (4 L./fed.) may be due to reducing the vegetative growth characters (Table 3) as a result of direct contact of the highest level of potassein on the surface of vegetative growth of plants may be referred to some toxicity which consequently reflected on reducing the parameters of potato yield, tubers quality and dry matter production. Another explanation is that, if a potato plant takes up excess potassium; one outcome is a lower dry matter content in the tuber. This because the extra potassium is translocated to tuber, where it causes the water content to be raised[6].

3- Effect of the Interaction Between Mineral and Bio-k fertilizers: Data of Table (7) indicate that the interaction within mineral-k fertilizer and the bio-k fertilizer caused a significant effect on the total tubers yield, physical and chemical properties of potatoes. Whereas, the highest value of total tubers yield as ton/fed. was recorded with potato plants which supplied with bio-K fertilizer at the level of 3 L./fed. combined with potassium sulphate at the level of 90 k_2o kg/fed. in both seasons which it was 13.606 and 15.064 ton/fed. for the first and second seasons, respectively. On the other hand, the lowest value was recorded with plants received potassein at the level of 2 L. /fed. along with potassium sulphate at the level of 45 k_2o

Table 6: Effect of bio–k fertilizer on the yield and quality as well as chemical constituents of potato plant during the two successive seasons of 2006 and 2007.

Treatments Bio-k fertilizer	Tubers No./Plant	Yield/Plant (g)	Yield (ton/fed.)	Marketable tubers%	Specific gravity (g/cm^3)	Starch %	Protein %	N %	P %	K %	Dry matter %
A. First season											
Control	7.4	476.4	10.339	92.8	1.0597	9.7706	16.958	2.713	0.737	3.599	15.320
2L./Fed.	8.3	551.3	11.963	94.5	1.0682	11.4561	17.275	2.764	0.781	3.622	17.117
3L./Fed.	8.4	577.5	12.532	96.0	1.0783	13.4651	17.441	2.791	0.786	3.670	17.333
4L./Fed.	8.2	545.4	11.836	93.3	1.0698	11.7813	17.108	2.737	0.710	3.725	16.142
L.S. D. at 5% Level	0.2	4.4	0.095	0.4	0.0054	1.0849	0.057	0.009	0.008	0.009	0.290
B. Second Season											
Control	8.0	502.7	10.908	95.1	1.0563	9.0805	17.574	2.812	0.834	3.697	16.333
2L./Fed.	8.4	591.4	12.834	96.7	1.0711	12.0284	17.869	2.859	0.867	3.728	17.392
3L./Fed.	8.7	635.1	13.783	97.6	1.0753	12.8612	18.047	2.888	0.875	3.767	17.467
4L./Fed.	8.6	532.2	11.548	96.2	1.0566	9.1502	17.727	2.836	0.817	3.823	16.813
L.S. D. at 5% Level	0.2	11.9	0.258	0.4	0.0037	0.7289	0.057	0.009	0.010	0.009	0.133

Table 7: Effect of mineral and bio-potassium fertilizers on the yield and quality as well as chemical constituents of potato plant during the two successive seasons of 2006 and 2007.

Treatments Mineral-K (kg/fed.)	Bio-K	Tubers No./Plant	Yield/Plant (g)	Yield (ton/fed.)	Marketable tubers%	Specific gravity (g/cm^3)	Starch %	Protein %	N %	P %	K %	Dry matter %
A-first season												
45	Control	5.5	344.3	7.471	87.9	1.0333	4.5003	15.500	2.480	0.585	3.560	12.733
	2L./Fed.	6.5	487.4	10.577	90.9	1.0497	7.7651	16.025	2.564	0.657	3.592	15.333
	3L./Fed.	8.0	604.5	13.118	96.3	1.0825	14.3012	17.063	2.730	0.762	3.661	16.933
	4L./Fed.	10.5	619.1	13.434	98.0	1.0881	15.4160	18.056	2.889	0.883	3.688	18.133
90	Control	6.5	417.3	9.054	90.8	1.0336	4.5666	15.775	2.524	0.600	3.577	14.012
	2L./Fed.	7.5	555.1	12.046	93.3	1.0503	7.8911	16.650	2.664	0.757	3.609	16.400
	3L./Fed.	9.0	627.0	13.606	97.6	1.0977	17.3204	18.450	2.952	0.879	3.663	18.533
	4L./Fed.	9.0	536.5	11.641	94.9	1.0870	15.1904	17.341	2.789	0.740	3.697	16.933
135	Control	7.5	540.4	11.727	93.9	1.0706	11.9322	17.513	2.802	0.834	3.593	15.400
	2L./Fed.	9.8	593.0	12.869	97.0	1.0894	15.6747	18.369	2.939	0.869	3.615	19.333
	3L./Fed.	8.5	540.1	11.720	95.2	1.0690	11.6071	17.250	2.670	0.760	3.673	17.067
	4L./Fed.	7.0	519.6	11.275	91.1	1.0595	9.7225	16.650	2.664	0.613	3.716	15.067
180	Control	10.0	603.8	13.102	98.5	1.1015	18.0835	19.044	3.047	0.918	3.665	19.133
	2L./Fed.	9.2	569.5	12.359	96.8	1.0835	14.4936	18.056	2.889	0.843	3.671	17.400
	3L./Fed.	8.0	538.5	11.686	94.7	1.0641	10.6317	17.000	2.720	0.743	3.682	16.800
	4L./Fed.	6.3	506.6	10.992	89.2	1.0448	6.7962	16.294	2.607	0.603	3.799	14.433
L.S.D at 5% level		0.4	8.8	0.190	0.9	0.0109	2.1697	0.114	0.018	0.016	0.019	0.580

Table 7: Cont'd.

Treatments Mineral-K (kg/fed.)	Bio-K	Tubers No./Plant	Yield/Plant (g)	Yield (ton/fed.)	Marketable tubers%	Specific gravity (g/cm^3)	Starch %	Protein %	N %	P %	K %	Dry matter %
B. Second season												
45	Control	5.5	337.4	7.321	89.4	1.0229	2.4366	16.106	2.577	0.682	3.655	13.933
	2L./Fed.	7.2	473.5	10.276	95.1	1.0443	6.6967	16.631	2.661	0.731	3.691	16.000
	3L./Fed.	7.5	549.3	11.920	97.6	1.0513	8.0835	17.656	2.825	0.843	3.751	17.467
	4L./Fed.	10.5	660.2	14.236	99.0	1.0635	10.5188	18.669	2.987	0.981	3.787	18.333
90	Control	7.0	421.7	9.150	94.0	1.0290	3.6443	16.375	2.620	0.715	3.678	14.733
	2L./Fed.	7.5	564.9	12.258	96.1	1.0509	8.0172	17.250	2.670	0.825	3.718	17.000
	3L./Fed.	10.5	694.2	15.064	98.7	1.1300	23.7570	19.094	3.055	0.976	3.762	18.400
	4L./Fed.	9.0	505.9	10.977	96.3	1.0633	10.4790	18.006	2.881	0.842	3.793	17.123
135	Control	8.5	566.2	12.287	97.8	1.0602	9.8685	18.188	2.910	0.940	3.691	16.933
	2L./Fed.	10.0	670.0	14.538	98.0	1.1044	18.6608	18.938	3.030	0.970	3.725	18.567
	3L./Fed.	8.5	652.6	14.160	96.3	1.0607	9.9614	17.844	2.855	0.841	3.771	17.600
	4L./Fed.	8.0	487.5	10.580	95.2	1.0507	7.9708	17.250	2.760	0.730	3.815	16.067
180	Control	11.2	685.4	14.874	99.0	1.1130	20.3728	19.625	3.140	0.999	3.762	19.733
	2L./Fed.	9.0	657.4	14.266	97.7	1.0847	14.7391	18.665	2.985	0.940	3.778	18.000
	3L./Fed.	8.1	644.5	13.986	97.8	1.0591	9.6429	17.594	2.815	0.839	3.784	16.400
	4L./Fed.	7.5	475.1	10.309	94.3	1.0490	7.6323	16.981	2.717	0.713	3.898	15.733
L.S.D at 5% level		0.4	23.7	0.515	0.8	0.0073	1.4578	0.114	0.018	0.019	0.019	0.266

kg/fed. in both seasons and it was 10.577 and 10.276 ton/fed. for the first and second season, respectively. Moreover, tubers number/plant, marketable tubers % and tubers quality expressed as specific gravity, starch %, protein % and dry matter % as well as N and P% in tubers were also affected by the interaction treatments and showed the same trend of total tubers yield as mentioned before. While, the highest K content in tubers was recorded with the highest level of potassium sulphate (180 kg K_2O /fed.) combined with the potassein at the level of 4 L. /fed. Theses findings were true in both seasons.

It could be concluded that using potassein as bio-K fertilizer had a beneficial effect in reducing the amount of mineral fertilizers added for potato production.

Conclusion: It could be concluded that application of potassium sulphate (48 % K_2O) at the level of 90 kg K_2O /fed. as mineral-k fertilizer combined with potassein (30 % K_2O) at the level of 3 L./fed. as bio-k fertilizer gave the highest values of vegetative growth characters, total tubers yield (ton/fed.), tubers quality and marketable tubers percentage.

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