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Effect of potassium fertilization levels and algae extract on growth, bulb yield and quality of onion (*Allium cepa* L.)

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ABSTRACT

A pot experiment was carried out to study the effect of potassium fertilizer at rates of 0, 30 and 60 kg K_2O fed^{-1} and algae extract foliar application at rates of 0, 0.5, 1.0 and 1.5 g l^{-1} and their interaction on the growth parameter and chemical composition of onion (*Allium cepa* L). Results indicated that, application of potassium fertilizer and foliar spray with algae extract alone or together gave significant positive effects on growth parameters. Data also showed that significant increases in nitrogen, phosphorous, potassium, iron, zinc and copper contents and uptake were found. It is quite clear from data that application of potassium fertilizer was markedly increased chl. a & b and carotene as compared with control (0 kg K_2O fed^{-1}). Data indicated that, the highest increments resulted from the application of potassium at rate of 60 kg K_2O fed^{-1}. In addition to that, foliar application of algal bio-extract resulted in marked positive effect on chl. a & b and carotene as compared with control treatment. Results also indicated that application of algal bio-extract at a rate of 1.5g l^{-1} gave the highest pigment contents as compared to the control one. Moreover, the interaction between 60 kg K_2 0/fed and 1.5 gl^{-1} of algae extract gave the highest significant pigment contents

Key words: Potassium, Algae extract, Growth parameter, Yield production, Chemical composition, Onion plants.

Introduction

Onion (*Allium cepa* L.) is a species of the *alliaceae* family of great economic importance and is the second most important vegetable crop in the world with a world production of about 55 million tones FAO (2006). In Egypt, it is the most important cash crop after rice. Increasing its yield with consequent economic return is the major concern of the farmers (Sliman *et al.*, 1999). Besides that, it is making a significant nutritional contribution to human diet. Onion also has medicinal and functional properties Lanzotti, (2006) and Rodriguez *et al*., (2009).

Its consumption is attributed to several factors, mainly heavy promotion that links flavor, health, and the popularity of onion-rich ethnic foods. It is a good source for carbohydrates, proteins, vitamin C , calcium and flavonoid in the human diet and flavonoid utilization has been related with a diminished danger of cancer, avert of cardiovascular ailment and diabetes and anti-bacterial, antiviral, anti-allergenic (Schippers, 2001; Slimestad, *et al*., 2007 and Sebastian 2007).

Potassium is macronutrient required by the plants for ideal development and yield. It is a basic part in physiological and biochemical process in plant (protein synthesis, ion absorption and transport, photosynthesis, respiration and resistance in plants against pests and diseases). (Pettigrew, 2008; Bukhsh *et al*., 2010; Marschner, 2012 and Saud, *et al*., 2013). Increasing yield and growth parameters (dry matter production-diameter and weight of bulbs); TSS and total chlorophyll contents of onion plants can be achieved by rising level of potassium. Potassium stiffens straw and thus reduces lodging. Moreover, all the root crops frequently respond to potassium application. However, Yadav *et al*., (2003) found that onion yield of bulb and fresh weight of bulbs markedly increased with application of 150 kg K_2O ha^{-1}as compared to other potassium levels. Increased bulb yield of garlic

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was obtained with application of 150 kg K_2O ha^{-1}. Moreover, considering economics of crops, balanced use of K_2O fertilizers at 150 kg ha-1 gave the optimum returns (Tiwari *et al.,* 2003). Abou El-Nasr and Ibrahim (2011) reported that the highest potassium fertilization at a rate of 75 kg K_2O fed^{-1} gave the tallest shoot, the highest number of leaves per plant and the highest fresh weight of shoots as well as the highest total yield. Also, the obtained results indicated that the root measurements expressed as root length, root diameter, root weight, TSS and carotenoids content, as well as leaves chemical composition (N, P and K concentrations) were increased with increasing potassium fertilization. Currently, there is increased advantage to use natural products such as algae in agriculture (Ramya, *et al*., 2010; Calvo *et al.*, 2014; Narasimha Rao and Reshmi Chatterjee, 2014; Dwivedi *et al*., 2014; Du Jardin, 2015 and Michalak *et al.*, 2016).

Positive influence of bio-stimulant treatment on yield parameters was observed. Overall increase in pigments content of leaves after bio-stimulants application agrees well with better total and commercial yields of treated vegetable cultivars in comparison with their controls. In addition, bio-stimulants improved antioxidant activity, vitamin C and higher pigment levels in leaves of vegetables compared to non-treated plants. Thus, the application of bio-stimulants considered as a good production strategy for obtaining high yields of nutritionally valuable vegetables with lower impact on the environment Sazetak, (2011). Bio-stimulants able to promote vegetative growth mineral nutrients uptake and improve the productivity of many plants Dwivedi *et al*., 2014 reported that seaweed extracts not only increase the vegetative growth of the plant but also triggers the early flowering, fruiting in crops and ultimately on seed yields.

The main objective of this study was to increase the yield and quality of onion through investigating the effect of different potassium fertilization rates and foliar application of bio-stimulants (Algae extract) as well as their interaction.

Materials and Methods

A pot experiment was carried out at the National Research Centre. Dokki, Cairo, Egypt to study the effect of potassium application and foliar feeding of algae extract on the growth parameter and chemical composition of onion (*Allium cepa* L.). Soil sample was taken before transplanting, air-dried, sieved by 2 mm sieve and analyzed. Some chemical and physical properties are present in table (1).The experiment contained 36 plastic pots having a diameter of 30 cm and length of 35 cm. each pot filed with 10 kg soil. Seedlings of onion plants were obtained from Vegetable Department, Ministry of Agriculture. Uniform onion seedlings cv. Giza 20 at 4 to 5 green true leaf stage were transplanted. The full amounts of phosphorus were applied at the time of final preparation. However, nitrogen fertilizer at 120 kg N fed^{-1}as ammonium sulfate (20.6%) was side dressed in two equal portions at 60 and 90 days after transplanting date. Potassium fertilizer was applied as potassium sulphate (46%) at three rates of 0, 30 and 60 kg K_2O fed^{-1}. Foliar spray of algae extract at rates of 0, 0.5, 1.0 and 1.5 g l^{-1} were conducted by hand sprayer three times after 15, 30 and 45 days after transplanting.

Table 1: Some characteristics of the investigated soil.

Physical properties				Chemical properties						
Sand	Silt	Clay	Texture	pH	EC	$CaCO_3$	OM	N	P	K
%					dSm^{-1}	%	%	(ppm)		
33.21	48.41	18.28	loamy	7.70	0.44	0.45	0.59	107	3.0	57

Preparation of Algae Extract

The used algae in the present study *Spirulina platensis* is a photosynthetic and multicellular blue green microalgae that grows in wide range fresh, marine and brackish water (Marrez *et al*., 2014). The fresh algae material (One kg) was cut into small pieces and weighted. The sample was extracted using blender. The blended material was filtered through a double layered of muslin cloth to remove debris and designated as 100% and different used concentrations in this study were prepared by adding tap water and refrigerated between 0 – 4ºC until use (Pise and Sabale, 2010). The source of algae fresh (Algal Biotechnology Unit, NRC, Egypt).The chemical characteristics of algae was

present in table (2).The experiment was led in a randomized complete block design with three replicates.

Table 2: Chemical composition of some macro- and micronutrients and growth hormone of blue green algae bio fertilizer used in the experiment study

Moisture%	Crude protein%	Macronutrients (%)						Micronutrients (ppm)			
		N	P	K	Na	Mg	Ca	Fe	Zn	Mn	Cu
4.77	58.25	11.2	1.65	0.88	0.22	0.01	0.33	1936	33	73	14

Growth hormone (%)					
Cytokinins	Betanin	Alginic	Zatin	Mannitol	Oligo saccharide
0.001	0.03	4.8	0.002	0.001	2.9

The experimental treatments were as follows:

T1: Control **T5:** 30 kg K fed^{-1} **T9:** 60 kg K fed^{-1}

T2: BGA 0.5 gL^{-1} **T6:** 30 kg K fed^{-1}+ BGA 0.5 gL^{-1} **T10:** 60 kg K fed^{-1}+ BGA 0.5 gL^{-1}

T3: BGA 1.0 gL^{-1} **T7:** 30 kg K fed^{-1}+ BGA 1.0 gL^{-1} **T11:** 60 kg K fed^{-1}+ BGA 1.0 gL^{-1}

T4: BGA 1.5 gL^{-1} **T8:** 30 kg K fed^{-1}+ BGA 1.5 gL^{-1} **T12:** 60 kg K fed^{-1}+ BGA 1.5 gL^{-1}

Recorded data

At maturity stage, the following data were taken: Plant height, fresh and dry matter of leaves and bulb g /plant, Plant height (cm**),** leaves number /plant, bulb diameter (cm) and total leave area (cm^2).

Chemical constituents

- Chlorophyll a, b and total carotenoids in leaves were determined using the method described by Lichtenthaler, (1987).
- Total carbohydrates content in bulb (percentage) in powdered dry matter of bulb determined colormetrically according to Herbert *et al.* (1971).
- Extraction of essential oil: bulb Hydro distillation for 3h according to Clevenger (1928).
- Total N, P K, Na and Ca in fresh and dry matter of leaves and bulb were determined according to the methods of the Cottenie *et al*. (1982). Iron, zinc and copper contents were determined using atomic absorption spectrophotometer (Cottenie *et al*., 1982).
- The physical and chemical properties of the soil were determined according to the method described by Page *et al*., (1982).

Statistical analysis

The means of data recorded were subjected to the analysis of variance according to Snedecor and Cochran, 1980. The least significant differences (LSD) at P=0.05 level was used to verify the differences among means of the treatments.

Results and Discussion

Effect of potassium and foliar spray of algal extract and their interaction on:

1- Growth and yield of onion plants

Data presented in table (3) indicated that both soil application of potassium and foliar spray with algae extract had significantly positive effects on growth and yield of onion. Soil application of 60 kg K_2O fed^{-1} showed the highest marked increments of bulb fresh and dry weights; leaves fresh and dry weights; bulb diameter; plant height; number of leaves and leaf area. The increments reached

to 48 and 37; 61 and 48; 11; 16; 19 and 97% over control (0.0 kg K_2O fed^{-1}), respectively. Concerning the effect of algae extract foliar application of 1.5 g l^{-1} markedly increased bulb fresh and dry weights; bulb diameter; number of leaves and leaf area. The increments reached to 65 and 74; 23; 36 and 77% over control (water spray). While, 1 g l^{-1} significantly increased leaves fresh and dry weights by 60 and 76%, respectively, and plant height by 17% over control. The combination between the two studied factors resulted in significant positive effects only in case of both fresh and dry weights of bulb and leaves. Combination between 60 kg potassium and 1.5 g l^{-1} algae extract gave the highest fresh and dry weights of bulb. While, 60 kg K_2O fed^{-1}.in combination with 1gl^{-1} algae extract showed the highest fresh and dry weights of leaves.

These results may be due to the role of potassium in metabolism and many processes needed to sustain and promote plant vegetative growth and development. Moreover, K plays a major role in many physiological and biochemical processes such as cell division, elongation, and metabolism of carbohydrates and protein compounds (Marschner, 1995). The obtained results are in a good accordance with those recorded Saud *et al*., (2013). Application of algal bio-extract gave the greatest value from plant height, number of leaves/plant, leaves fresh weight per plant, nick fresh weight/plant and leaves dry weight/plant. The positive effect of glutamine and arginine that plant growth regulators may produce their effects within the part in which they were synthesized. Steeve (2003) demonstrated that certain messengers called plant growth substances are generally like hormones in there action, controlled utilization of nutritional substances for a balanced coordinated development of plant body. Growth regulators are used as natural compounds that are applied directly to a target plant to alter its life processes or its structure in order to improve quality and productivity of plants in addition to facilitate harvesting. These results are in line with those obtained by Farooqi *et al*., (1996), Kim *et al*., (2001).

In addition, bio-stimulants improved antioxidant activity, vitamin C and higher pigment levels in leaves of vegetables as compared to non-treated plants. Thus, the application of bio-stimulants can be considered as a good production strategy for obtaining high yields of nutritionally valuable vegetables with lower impact on the environment Sazetak (2011). Algae extract foliar application was recommended for increasing the growth parameters (Pramanick *et al.,* 2013).

Table 3: Effect of potassium and blue green algae on growth parameters of onion plants

Treatment		Fresh matter (g $plant^{-1}$)		Dry matter (g $plant^{-1}$)		Bulb diameter (cm)	leaves height (cm)	leaves /plant	Total leave area (cm^2)
(K)	BGA	Bulb	Leaves	Bulb	Leaves				
0 K_2O (kg fed^{-1})	**0 g L^{-1}**	11.33	15.65	3.69	2.07	2.90	47.3	4.33	91.4
	0.5 g L^{-1}	10.29	17.86	4.70	3.51	3.39	54.7	4.33	118.3
	1.0 g L^{-1}	15.55	22.33	5.43	4.10	3.76	65.3	4.67	224.9
	1.5 g L^{-1}	19.53	22.56	6.17	4.28	3.96	63.0	6.00	246.4
30 K_2O (kg fed^{-1})	**0 g L^{-1}**	13.82	19.87	4.09	3.30	3.33	55.3	4.67	222.1
	0.5 g L^{-1}	18.88	25.49	5.63	4.00	3.87	64.3	5.00	309.4
	1.0 g L^{-1}	19.34	28.37	5.94	5.18	3.99	66.0	4.67	323.3
	1.5 g L^{-1}	22.25	30.66	6.87	5.44	4.00	64.0	6.00	374.6
60 K_2O (kg fed^{-1})	**0 g L^{-1}**	15.62	21.03	4.64	3.76	3.61	67.7	5.00	260.7
	0.5 g L^{-1}	21.17	29.12	6.23	4.38	3.77	65.7	5.67	307.8
	1.0 g L^{-1}	21.78	39.91	7.99	6.73	4.06	68.0	5.33	382.0
	1.5 g L^{-1}	25.44	35.88	8.55	5.80	4.11	66.3	7.00	394.7
Mean of K	**o kg fed^{-1}**	14.18	19.60	5.00	3.49	3.50	57.6	4.83	170.3
	30 kg fed^{-1}	18.57	26.10	5.63	4.48	3.80	62.4	5.09	307.4
	60 kg fed^{-1}	21.00	31.49	6.85	5.17	3.89	66.9	5.75	336.3
Mean of BGA	**0 g L^{-1}**	13.59	18.85	4.14	3.04	3.28	56.8	4.67	191.4
	0.5 g L^{-1}	16.78	24.16	5.52	3.96	3.68	61.6	5.00	245.2
	1.0 g L^{-1}	18.89	30.20	6.45	5.34	3.94	66.4	4.89	310.1
	1.5 g L^{-1}	22.41	29.70	7.20	5.17	4.02	64.4	6.33	338.6
LSD 0.05									
Potassium (K)		0.054	0.014	0.093	0.014	0.169	2.987	0.414	19.90
Blue green Algae (BGA)		0.121	0.045	0.179	0.035	0.151	4.927	0.380	22.97
(K * BGA)		0.209	0.079	0.310	0.031	N.S.	N.S.	N.S.	N.S.

2-Macronutrient contents and uptake of onion fresh bulb and leaves

Data presented in tables (4 & 5) showed that all studied macronutrients were significantly increased except N and Na measured in bulb. While, all studied macronutrients were significantly increased as a results of spraying onion plants with algae extract except Na-content, which showed significant decrement. The interaction between both studied factors showed marked effect on potassium measured in bulb. Combination between 60 kg K_2O fed^{-1} and 1.5g l^{-1} algae extract foliar spray showed the highest K content. On the other hand, combination between the aforementioned treatments showed marked increases in N, P and K contents in onion leaves. Application of algae can be stimulate the nutrients uptake by plant David *et al.,* (1994) and Adani *et al.,* (1998) reported that Potassium humate considers as organic potash fertilizers. It supplies high levels of soluble potassium in readily available forms. Combined with humic acid, potassium can be rapidly absorbed and incorporated into plant whether via soil or foliar application methods. Enhancement of plant growth using potassium humate were used for increasing nutrients uptake such as N, Ca, P, K, Mg, Fe, Zn and Cu enhancing photosynthesis, chlorophyll density and plant root respiration that resulted in greater plant growth and yield Chen and Aviad (1990).

Algae produced a beneficial effect on some vegetable crops (Abdel-Mawgoud *et al.,* 2010).They are natural bioactive materials rich in minerals, protein, lipids, carbohydrates, vitamins and microelements (Co, B, Mo, Zn, and Cu). In addition, seaweed fertilizer a unique combination of N, P, K, trace elements and simple sugar that are in dissolved forms that are easily absorbed through roots and leaves besides releasing trace elements bound to the soil (Chapman and Chapman, 1980) and it is safe to human, animals and the environment (Sathya *et al*., 2010).

Table 4: Effect of different rates of potassium fertilizers and foliar spray of algae extract on fresh bulb and leaves N, P, K, Na and Ca content (%) of onion plants

Treatment		N %		P %		K %		Na %		Ca %	
(K)	BGA	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves
0 K_2O (kg fed^{-1})	0 g L^{-1}	0.155	0.196	0.024	0.031	0.132	0.250	0.027	0.088	0.027	0.063
	0.5 g L^{-1}	0.193	0.271	0.035	0.037	0.192	0.305	0.019	0.068	0.045	0.099
	1.0 g L^{-1}	0.210	0.339	0.046	0.042	0.208	0.359	0.016	0.046	0.063	0.119
	1.5 g L^{-1}	0.272	0.412	0.049	0.051	0.229	0.403	0.013	0.039	0.066	0.152
30 K_2O (kg fed^{-1})	0 g L^{-1}	0.173	0.212	0.029	0.033	0.152	0.278	0.025	0.081	0.039	0.082
	0.5 g L^{-1}	0.204	0.274	0.036	0.038	0.197	0.327	0.019	0.065	0.048	0.111
	1.0 g L^{-1}	0.213	0.358	0.047	0.044	0.215	0.371	0.015	0.044	0.065	0.140
	1.5 g L^{-1}	0.286	0.496	0.051	0.056	0.237	0.413	0.011	0.035	0.072	0.156
60 K_2O (kg fed^{-1})	0 g L^{-1}	0.184	0.234	0.031	0.034	0.187	0.285	0.022	0.076	0.044	0.093
	0.5 g L^{-1}	0.204	0.328	0.043	0.041	0.201	0.341	0.019	0.055	0.055	0.116
	1.0 g L^{-1}	0.255	0.385	0.048	0.045	0.218	0.381	0.014	0.041	0.066	0.144
	1.5 g L^{-1}	0.307	0.601	0.068	0.067	0.308	0.551	0.010	0.032	0.093	0.193
Mean of K	o kg fed^{-1}	0.208	0.305	0.039	0.040	0.190	0.329	0.019	0.060	0.050	0.108
	30 kg fed^{-1}	0.219	0.335	0.041	0.043	0.200	0.347	0.018	0.056	0.056	0.122
	60 kg fed^{-1}	0.238	0.387	0.048	0.047	0.229	0.390	0.016	0.051	0.065	0.137
Mean of BGA	0 g L^{-1}	0.171	0.214	0.028	0.033	0.157	0.271	0.025	0.082	0.037	0.079
	0.5 g L^{-1}	0.200	0.291	0.038	0.039	0.197	0.324	0.019	0.063	0.049	0.109
	1.0 g L^{-1}	0.226	0.361	0.047	0.044	0.214	0.370	0.015	0.044	0.065	0.134
	1.5 g L^{-1}	0.288	0.503	0.056	0.058	0.258	0.456	0.011	0.035	0.077	0.167
LSD 0.05											
Potassium (K)		N.S.	0.018	0.007	0.002	0.015	0.029	N.S.	0.007	0.007	0.010
Blue green Algae (BGA)		0.030	0.021	0.008	0.002	0.017	0.034	0.003	0.008	0.008	0.011
(K * BGA)		N.S.	0.036	N.S.	0.004	0.013	0.058	N.S.	N.S.	N.S.	N.S.

Table 5: Effect of potassium and blue green algae on nutrient uptake (mg plant^{-1}) of bulb and leaves fresh of onion plants

Treatment		N		P		K		Na		Ca	
		Uptake (mg plant^{-1})									
(K)	BGA	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves
0 K_2O (kg fed^{-1})	0 g L^{-1}	17.56	30.7	2.72	4.9	14.96	39.1	3.06	13.8	3.06	9.9
	0.5 g L^{-1}	19.86	48.4	3.60	6.6	19.76	54.5	1.96	12.1	4.63	17.7
	1.0 g L^{-1}	32.50	75.7	7.15	9.4	32.34	80.2	2.49	10.3	9.80	26.6
	1.5 g L^{-1}	53.12	92.9	9.57	11.5	44.72	90.9	2.54	8.8	12.89	34.3
30 K_2O (kg fed^{-1})	0 g L^{-1}	23.91	42.1	4.01	6.6	21.01	55.2	3.46	16.1	5.39	16.3
	0.5 g L^{-1}	38.52	69.8	6.80	9.7	37.19	83.4	3.59	16.6	9.06	28.3
	1.0 g L^{-1}	41.19	101.3	9.09	12.5	41.58	105.3	2.90	12.5	12.57	39.7
	1.5 g L^{-1}	63.64	152.1	11.35	17.2	52.73	126.6	2.45	10.7	16.02	47.8
60 K_2O (kg fed^{-1})	0 g L^{-1}	28.74	49.2	4.84	7.2	29.21	59.9	3.44	16.0	6.87	19.6
	0.5 g L^{-1}	43.19	95.5	9.10	11.9	42.55	99.3	4.02	16.0	11.64	33.8
	1.0 g L^{-1}	55.54	153.7	10.45	18.0	47.48	152.1	3.05	16.4	14.37	57.5
	1.5 g L^{-1}	78.10	215.6	17.30	24.0	78.36	197.7	2.54	11.5	23.66	69.2
Mean of K	o kg fed^{-1}	30.76	61.93	5.76	8.10	27.95	66.18	2.51	11.25	7.60	22.13
	30 kg fed^{-1}	41.82	91.33	7.81	11.50	38.13	92.63	3.10	13.98	10.76	33.03
	60 kg fed^{-1}	51.39	128.5	10.42	15.28	49.40	127.2	3.26	14.98	14.14	45.03
Mean of BGA	0 g L^{-1}	23.40	40.67	3.86	6.23	21.73	51.40	3.32	15.30	5.11	15.27
	0.5 g L^{-1}	33.86	71.23	6.50	9.40	33.17	79.07	3.19	14.90	8.44	26.60
	1.0 g L^{-1}	43.08	110.2	8.90	13.30	40.47	112.5	2.81	13.07	12.25	41.27
	1.5 g L^{-1}	64.95	153.5	12.74	17.57	58.60	138.4	2.51	10.33	17.52	50.43
LSD 0.05											
Potassium (K)		0.76	1.82	0.15	0.22	0.71	1.77	0.05	0.23	0.20	0.63
Blue green Algae (BGA)		0.88	2.10	0.17	0.25	0.81	2.04	0.06	0.27	0.24	0.73
(K * BGA)		1.52	3.63	0.30	0.43	1.41	3.53	0.10	0.46	0.41	1.26

3- Concentration and uptake of macronutrient contents in onion, dry bulb and leaves.

Effect of potassium application and foliar spray of blue green algae extract and their interaction on macronutrient contents of onion dry bulb and leaves presented in tables 6 &7 Results indicated that concentration of the investigated macronutrient significantly increased due to of potassium application; however, concentration of Na was gradually decreased. Highest macronutrient contents were obtained by potassium added at a rate 60 kg K_2O fed^{-1}. However, similar trend was observed for foliar spray of bio-stimulators extract where, marked effects were recorded. The highest macronutrient contents were achieved by spraying onion plants with 1.5g l^{-1} algae extract.

Concerning the interaction effect, all studied macronutrient contents showed insignificant increments with an exception in case of N measured in onion bulb where, the increment was significant. The highest N content (2.53%) was recorded because of combination between the highest level of both studied factors (60kg K_2O fed^{-1} + 1.5g l^{-1} algae extract).

Considering the significance of both potassium fertilization and foliar application of algae extract on macronutrients uptake and their interaction, data showed that K fertilization treatments significantly increased the uptake of macronutrients. Addition of 60 kg K_2O fed^{-1} gave the highest uptake of macronutrients as compared with other K treatments. However, 1.5g l^{-1} algae extract as foliar feeding gave the highest nutrients uptake. Concerning the effect of interaction between the two studied factors, the combination between 60kg K_2O fed^{-1} and 1.5g l^{-1} algae extract gave the highest significant results.

Spirulina platensis is a rich source of potassium and contains considerable amounts of macro and micronutrients contents; hence, it increases uptake and accumulation of these elements in plants. This in turn explains the significant increase of vegetative growth and yield and its components as well as content of nitrogen, phosphorus and protein in leaves also leaf chlorophyll content for most crops especially, those grown under semi-arid and desert conditions (Marrez *et al.,* 2014).

The improvement effect of algae extract on plant growth may be ascribed to the hormone content, which has an energetic role in cell division and augment. This leads to increase the shoot growth, leaves number, and plant dry weight (Gollan and Wright 2006). It also contains macronutrients, which are very essential for growth, thereby enhancing the utilization of soil nutrients such as N P K (Chapman and Chapman, 1980; Attememe, 2009, Zodape *et al*., 2011). Such

enhancement in growth parameters resulting in greater root growth. Applying bio stimulators increased the response of different growth parameters particularly in Watermelon (Abdel-Mawgoud *et al.,* 2010).

Table 6: Effect of potassium and blue green algae on nutrient contents of bulb and leaves dry of onion plants

Treatment		N %		P %		K %		Na %		Ca %	
(K)	BGA	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves	Bulb	Leaves
0 K_2O (kg fed^{-1})	0 g L^{-1}	1.31	0.79	0.25	0.26	0.14	0.49	0.21	0.13	0.07	0.16
	0.5 g L^{-1}	1.66	1.33	0.28	0.29	0.14	0.56	0.20	0.11	0.10	0.21
	1.0 g L^{-1}	1.80	1.36	0.29	0.31	0.16	0.62	0.19	0.10	0.10	0.23
	1.5 g L^{-1}	1.83	1.41	0.32	0.32	0.17	0.67	0.19	0.10	0.11	0.25
30 K_2O (kg fed^{-1})	0 g L^{-1}	1.96	1.51	0.36	0.34	0.18	0.54	0.19	0.11	0.12	0.20
	0.5 g L^{-1}	1.99	1.70	0.37	0.35	0.18	0.58	0.18	0.11	0.13	0.23
	1.0 g L^{-1}	2.09	2.19	0.43	0.36	0.19	0.62	0.17	0.10	0.14	0.23
	1.5 g L^{-1}	2.16	2.34	0.44	0.37	0.20	0.76	0.16	0.09	0.16	0.26
60 K_2O (kg fed^{-1})	0 g L^{-1}	2.01	1.70	0.37	0.35	0.18	0.56	0.17	0.11	0.14	0.21
	0.5 g L^{-1}	2.05	1.82	0.38	0.35	0.19	0.61	0.17	0.10	0.14	0.23
	1.0 g L^{-1}	2.40	2.30	0.45	0.37	0.21	0.63	0.16	0.10	0.16	0.24
	1.5 g L^{-1}	2.53	2.37	0.54	0.37	0.24	0.83	0.15	0.08	0.16	0.28
Mean of K	o kg fed^{-1}	1.65	1.22	0.29	0.30	0.15	0.59	0.20	0.11	1.65	1.22
	30 kg fed^{-1}	2.05	1.94	0.40	0.36	0.19	0.63	0.18	0.10	2.05	1.94
	60 kg fed^{-1}	2.25	2.05	0.44	0.36	0.21	0.66	0.16	0.10	2.25	2.05
Mean of BGA	0 g L^{-1}	1.76	1.33	0.33	0.32	0.17	0.53	0.19	0.12	1.76	1.33
	0.5 g L^{-1}	1.90	1.62	0.34	0.33	0.17	0.58	0.18	0.11	1.90	1.62
	1.0 g L^{-1}	2.10	1.95	0.39	0.35	0.19	0.62	0.17	0.10	2.10	1.95
	1.5 g L^{-1}	2.17	2.04	0.43	0.35	0.20	0.75	0.17	0.09	2.17	2.04
LSD 0.05											
Potassium (K)		0.101	0.010	0.054	0.038	0.012	0.041	0.010	0.006	0.010	0.019
Blue green Algae (BGA)		0.116	0.153	0.062	N.S.	0.014	0.047	0.011	0.007	0.011	0.022
(K * BGA)		0.200	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 7: Effect of potassium and blue green algae on nutrient uptake (mg $plant^{-1}$) of bulb and leaves dry of onion plants

Treatment		N		P		K		Na		Ca	
		Uptake (mg $plant^{-1}$)									
(K)	BGA	Bulb	Leaves	Bulb	Leaves	Bulb	leaves	Bulb	leaves	Bulb	leaves
0 K_2O (kg fed^{-1})	0 g L^{-1}	48.3	16.4	9.2	5.4	5.2	10.1	7.8	2.69	2.6	3.3
	0.5 g L^{-1}	78.0	46.7	13.2	10.2	6.6	19.7	9.4	3.86	4.7	7.4
	1.0 g L^{-1}	97.7	55.8	15.8	12.7	8.7	25.4	10.3	4.10	5.4	9.4
	1.5 g L^{-1}	112.9	60.4	19.7	13.7	10.5	28.7	11.7	4.28	6.8	10.7
30 K_2O (kg fed^{-1})	0 g L^{-1}	80.2	49.8	14.7	11.2	7.4	17.8	7.8	3.63	4.9	6.6
	0.5 g L^{-1}	112.0	68.0	20.8	14.0	10.1	23.2	10.1	4.40	7.3	9.2
	1.0 g L^{-1}	124.2	113.4	25.5	18.7	11.3	32.1	10.1	5.18	8.3	11.9
	1.5 g L^{-1}	148.4	127.3	30.2	20.1	13.7	41.3	11.0	4.90	11.0	14.1
60 K_2O (kg fed^{-1})	0 g L^{-1}	93.3	63.9	17.2	13.2	8.4	21.1	7.9	4.14	6.5	7.9
	0.5 g L^{-1}	127.7	79.7	23.7	15.3	11.8	26.7	10.6	4.38	8.7	10.1
	1.0 g L^{-1}	191.8	154.8	36.0	24.9	16.8	42.4	12.8	6.73	12.8	16.2
	1.5 g L^{-1}	216.3	137.5	46.2	21.5	20.5	48.1	12.8	4.64	13.7	16.2
Mean of K	o kg fed^{-1}	84.2	44.8	14.5	10.5	7.8	21.0	9.8	3.7	4.9	7.7
	30 kg fed^{-1}	116.2	89.6	22.8	16.0	10.6	28.6	9.8	4.5	7.9	10.5
	60 kg fed^{-1}	157.3	109.0	30.8	18.7	14.4	34.6	11.0	5.0	10.4	12.6
Mean of BGA	0 g L^{-1}	73.9	43.4	13.7	9.9	7.0	16.3	7.8	3.5	4.7	5.9
	0.5 g L^{-1}	105.9	64.8	19.2	13.2	9.5	23.2	10.0	4.2	6.9	8.9
	1.0 g L^{-1}	137.9	108.0	25.8	18.8	12.3	33.3	11.1	5.3	8.8	12.5
	1.5 g L^{-1}	159.2	108.4	32.0	18.4	14.9	39.4	11.8	4.6	10.5	13.7
LSD 0.05											
Potassium (K)		1.24	0.88	0.25	0.17	0.12	0.30	0.11	0.06	0.09	0.12
Blue green Algae (BGA)		1.43	1.02	0.29	0.20	0.14	0.35	0.13	0.07	0.11	0.14
(K * BGA)		2.48	1.76	2.65	0.34	0.24	0.61	0.22	0.12	0.19	0.24

4- Photosynthesis pigments.

Effect of potassium application and foliar of algal extraction and their interaction on photosynthesis pigments are illustrated in table 8. It is quite clear from the data presented that application of potassium fertilizer was markedly increased chl. a & b and carotene as compared with control treatment (0 kg K_2O fed^{-1}). Data indicated that, the highest increments resulted from the application of potassium at rate of 60 kg K_2O fed^{-1}. In addition to that, foliar application of algal bio-extract resulted in marked positive effect on chl. a & b and carotene as compared with control treatment. Results also indicated that application of algal bio-extract at a rate of 1.5 g l^{-1} gave the highest pigment contents as compared to the control one. Moreover, the interaction between 60kg K_2O fed^{-1} and 1.5 g l^{-1} of algae extract gave the highest significant pigment contents. Algae extract being organic and biodegradable in nature was considered as an important source of nutrition for sustainable agriculture especially in the newly reclaimed soil. Chemical analysis of algae extract had a wide variety of plant growth regulators such as auxin and cytokinins in varying amounts, which stimulate root establishment, root elongation and promote vegetative growth of plants (Zhang & Ervin, 2004). Algae were early considered as an important group of microorganisms capable of fixing atmospheric nitrogen, as well as they cause significant increase in root growth, fresh and dry weights of roots, total biomass, yield component, photosynthetic pigments and growth promoting hormones (Ghalab & Salem, 2001). Raupp & Oltmanns, 2006 and Yassen *et al.,* 2007), reported that, algae extract might play a role through their content of cytokinins in delaying the aging of leaves by reducing the degradation of chlorophyll. In addition, alga extract as a bio-regulator affecting the balance between photosynthesis and respiration processes in plants. Enan *et al*., (2016) reported that the results of foliar application of alga extract at rate of 2.5 g l^{-1} or 3.5 g l^{-1} produced significantly higher values of photosynthetic pigments (chlorophyll a, b and carotenoids), vegetative growth traits of sugar beet plants i.e. root diameter, root and foliage fresh weight, root and shoot dry weight/plant.

Table 8: Effect of potassium and blue green algae on photosynthesis pigment in fresh leaves of onion plants

Treatment		Chl.a	Chl.b	Carotene	Total pigment
(K)	BGA	(µg/g f.w)			
0 K_2O (kg fed^{-1})	0 g L^{-1}	3.51	1.21	0.81	5.53
	0.5 g L^{-1}	4.17	1.71	1.06	6.94
	1.0 g L^{-1}	4.47	1.78	1.16	7.41
	1.5 g L^{-1}	5.33	1.86	2.69	9.88
30 K_2O (kg fed^{-1})	0 g L^{-1}	4.39	1.69	1.09	7.18
	0.5 g L^{-1}	5.38	1.90	1.53	8.82
	1.0 g L^{-1}	6.82	2.22	1.79	10.82
	1.5 g L^{-1}	9.09	2.75	3.36	15.20
60 K_2O (kg fed^{-1})	0 g L^{-1}	5.94	2.51	1.21	9.65
	0.5 g L^{-1}	6.83	2.84	1.55	11.22
	1.0 g L^{-1}	7.69	3.39	2.33	13.40
	1.5 g L^{-1}	9.48	4.33	3.44	17.25
Mean of K	o kg fed^{-1}	4.37	1.64	1.43	7.44
	30 kg fed^{-1}	6.42	2.14	1.94	10.50
	60 kg fed^{-1}	7.48	3.27	2.13	12.88
Mean of BGA	0 g L^{-1}	4.61	1.80	1.04	7.45
	0.5 g L^{-1}	5.46	2.15	1.38	9.00
	1.0 g L^{-1}	6.32	2.46	1.76	10.54
	1.5 g L^{-1}	7.97	2.98	3.16	14.11
LSD 0.05					
Potassium (K)		0.30	0.27	0.20	0.400
Blue green Algae (BGA)		0.36	0.28	0.28	0.462
(K * BGA)		0.54	0.55	0.41	0.801

5- Protein, oil and total soluble sugars.

Effect of potassium application and foliar of algal extraction and their interaction on protein, oil % and total soluble sugars are illustrated in table 9. Results showed that application of potassium, foliar of algae extract and their interaction had positive marked effect on onion quality. Data showed that protein measured in both bulb and leaves significantly increased due to applying potassium at rate of 60 kg K_2O fed^{-1} and foliar spray of 1.5 g/l algae extract either alone or in combination.

The effect of algal bio-extract on chemical constituents of onion bulb was significant on N %, protein % and dry matter %., TSS% and carbohydrate. Algal bio-extract was the most positive effect on N percentage, protein percentage and TSS percentage. Das *et al*., (2003) recorded that positive increment in protein contents due to arginine or glutamine application. In addition, Sood and Naggar (2003) suggested that, polyamine act as activated to RNA, protein synthesis the retarding effect of polyamines on leaf senescence was reflected in increasing the reserve metabolites as chlorophyll, protein and starch. Moreover, Chang *et al*., (2005) demonstrated that arginine is capable of efficiently delivering proteins into different plant tissues of onion in fully bioactive form. Moreover, the promotion effect of amino acid on total carbohydrates may due to their important role of biosynthesis of chlorophyll molecules, which in turn affected total carbohydrates content. Talaat *et al*., (2005), Attoa *et al*., (2000) and Abdel-Aziz *et al*., (2009).

Enan *et al*., (2016) indicated that foliar application of alga extract at rate of 2.5 g l^{-1} or 3.5 g l^{-1} produced significantly higher values of photosynthetic pigments (chlorophyll a, b and carotenoids). vegetative growth traits of sugar beet plants (root diameter, root and foliage fresh weight), (root and top dry weight/plant), extractable sugar %, quality index %, nitrogen, phosphorus, potassium, boron contents in leaves and root, top and sugar yields/fed, as well as the lowest content of sodium in roots in both seasons.

Table 9: Effect of potassium and blue green algae on protein (%), oil (%) and Total soluble sugar % (TSS) of onion plants

Treatment		Protein (%)		Oil (%)	Total soluble sugar % (TSS)
(K)	BGA	Bulb	leaves		
0 K_2O (kg fed^{-1})	0 g L^{-1}	8.17	4.93	5.31	11.81
	0.5 g L^{-1}	10.34	8.28	6.53	12.97
	1.0 g L^{-1}	11.27	8.49	7.35	13.00
	1.5 g L^{-1}	11.43	8.82	8.77	14.21
30 K_2O (kg fed^{-1})	0 g L^{-1}	12.22	9.44	6.09	12.35
	0.5 g L^{-1}	12.41	10.60	6.81	13.57
	1.0 g L^{-1}	13.07	13.71	8.33	14.81
	1.5 g L^{-1}	12.75	14.63	9.31	15.96
60 K_2O (kg fed^{-1})	0 g L^{-1}	12.58	10.60	7.92	14.90
	0.5 g L^{-1}	12.79	11.39	7.99	15.98
	1.0 g L^{-1}	15.03	14.38	9.26	16.80
	1.5 g L^{-1}	15.79	14.79	9.84	17.16
Mean of K	o kg fed^{-1}	10.30	7.63	6.99	13.00
	30 kg fed^{-1}	12.61	12.10	7.64	14.17
	60 kg fed^{-1}	14.05	12.79	8.75	16.21
Mean of BGA	0 g L^{-1}	10.99	8.32	6.44	13.02
	0.5 g L^{-1}	11.85	10.09	7.11	14.17
	1.0 g L^{-1}	13.12	12.19	8.31	14.87
	1.5 g L^{-1}	13.32	12.75	9.31	15.78
LSD 0.05					
Potassium (K)		0.65	0.89	0.29	0.51
Blue green Algae (BGA)		0.74	0.51	0.33	0.97
(K * BGA)		1.30	1.32	0.61	1.39

6- Micronutrient contents and uptake of onion, dry bulb and leaves.

Data presented in tables 10 &11 showed that application of potassium, bio stimulator and their interaction on concentration and uptake of micronutrients (Fe, Zn and Cu). Results observed that

significantly increment in Fe, Zn and Cu contents due to potassium added and foliar feeding with algae extract were obtained. Data also showed that interaction between the two studied factors (potassium & foliar with algae) showed a positive increases either in bulb or in leaves.

Table 10: Effect of potassium and blue green algae on micronutrient content (ppm) of bulb and leaves dry of onion plants

Treatment		Fe (ppm)		Zn (ppm)		Cu (ppm)	
(K)	**BGA**	**Bulb**	**Leaves**	**Bulb**	**Leaves**	**Bulb**	**Leaves**
0 K_2O (kg fed^{-1})	**0 g L^{-1}**	76	516	80	50	8.0	4.0
	0.5 g L^{-1}	308	878	200	70	16.0	12.0
	1.0 g L^{-1}	518	1382	300	84	18.0	14.0
	1.5 g L^{-1}	716	1676	420	100	20.0	16.0
30 K_2O (kg fed^{-1})	**0 g L^{-1}**	230	712	100	50	10.0	6.0
	0.5 g L^{-1}	346	1200	300	80	16.0	12.0
	1.0 g L^{-1}	520	1422	400	90	18.0	14.0
	1.5 g L^{-1}	836	1760	500	120	20.0	18.0
60 K_2O (kg fed^{-1})	**0 g L^{-1}**	254	858	100	50	12.0	10.0
	0.5 g L^{-1}	456	1224	300	80	16.0	12.0
	1.0 g L^{-1}	630	1632	400	90	18.0	16.0
	1.5 g L^{-1}	894	2378	920	150	22.0	18.0
Mean of K	**o kg fed^{-1}**	405	1113	250	76	15.5	11.5
	30 kg fed^{-1}	483	1274	325	85	16.0	12.5
	60 kg fed^{-1}	559	1523	430	93	17.0	14.0
Mean of BGA	**0 g L^{-1}**	187	695	93	50	10.0	6.7
	0.5 g L^{-1}	370	1101	267	77	16.0	12.0
	1.0 g L^{-1}	556	1479	367	88	18.0	14.7
	1.5 g L^{-1}	815	1938	613	123	20.7	17.3
LSD 0.05							
Potassium (K)		4.54	13.52	4.22	1.25	0.13	0.17
Blue green Algae (BGA)		5.24	15.62	4.87	1.44	0.15	0.20
(K * BGA)		9.08	27.04	8.44	2.49	0.25	0.35

Table 11: Effect of potassium and blue green algae on micronutrient uptake (mg $plant^{-1}$) of bulb and leaves dry of onion plants

Treatment		Fe (mg $plant^{-1}$)		Zn (mg $plant^{-1}$)		Cu (mg $plant^{-1}$)	
(K)	**BGA**	**Bulb**	**leaves**	**Bulb**	**leaves**	**Bulb**	**leaves**
0 K_2O (kg fed^{-1})	**0 g L^{-1}**	0.28	1.08	0.30	0.11	0.030	0.008
	0.5 g L^{-1}	1.46	3.11	0.95	0.25	0.076	0.043
	1.0 g L^{-1}	2.83	5.72	1.65	0.35	0.098	0.058
	1.5 g L^{-1}	4.45	7.24	2.62	0.43	0.124	0.069
30 K_2O (kg fed^{-1})	**0 g L^{-1}**	0.95	2.37	0.41	0.17	0.041	0.020
	0.5 g L^{-1}	1.96	4.84	1.71	0.32	0.091	0.049
	1.0 g L^{-1}	3.11	7.44	2.40	0.47	0.108	0.073
	1.5 g L^{-1}	5.79	9.66	3.47	0.66	0.138	0.099
60 K_2O (kg fed^{-1})	**0 g L^{-1}**	1.19	3.25	0.47	0.19	0.056	0.038
	0.5 g L^{-1}	2.86	5.41	1.89	0.36	0.100	0.053
	1.0 g L^{-1}	5.07	11.09	3.23	0.61	0.145	0.109
	1.5 g L^{-1}	7.70	13.92	7.95	0.88	0.189	0.106
Mean of K	**o kg fed^{-1}**	2.26	4.29	1.38	0.28	0.082	0.045
	30 kg fed^{-1}	2.95	6.08	2.00	0.41	0.094	0.060
	60 kg fed^{-1}	4.21	8.42	3.38	0.51	0.123	0.077
Mean of BGA	**0 g L^{-1}**	0.81	2.23	0.39	0.15	0.042	0.022
	0.5 g L^{-1}	2.09	4.45	1.51	0.31	0.089	0.048
	1.0 g L^{-1}	3.67	8.08	2.42	0.48	0.117	0.080
	1.5 g L^{-1}	5.98	10.27	4.68	0.66	0.151	0.091
LSD 0.05							
Potassium (K)		0.04	0.08	0.03	0.01	0.001	0.001
Blue green Algae (BGA)		0.05	0.10	0.04	0.01	0.001	0.001
(K * BGA)		0.09	0.17	0.07	0.01	0.002	0.002

Application of 60 kg K_2O fed^{-1} resulted in increasing micronutrient contents. Application of, foliar feeding at rate 1.5g/l algae extract gave the highest content of micronutrients. Results showed that interaction between the aforementioned treatments recorded the highest contents.

Iron, Zn and Cu uptake gradually increased either by K application or by foliar spray with algae extract in both bulb and leaves. Potassium applied with 60 kg K_2O fed^{-1} showed the highest significant increases. The increments reached to 86, 145 and 50% and 96, 82 and 71&as compared to control one (0.0 kg K_2O fed^{-1}.) for Fe, Zn and Cu in both bulb and leaves, respectively. On the other hand, the increases reached to 638, 1100 and 260% and 361, 340 and 314 over control treatment (0.0 g/l algae extract) for Fe, Zn and Cu in both bulb and leaves, respectively as a result of spraying onion plants with 1.5 g l^{-1} alga extract. However, interaction effects between the two studied factors were also significant. The highest calculated micronutrients uptake in both bulb and leaves was found, because of their interaction between 60 kg K_2O fed^{-1} and 1.5 g l^{-1} alga extract foliar spray, with an exception in case of Cu, where combination between 60 kg K_2O fed^{-1}. and 1.0 gl^{-1} alga extract foliar spray gave the highest leaves cu uptake.

Moreover, the superiority of onion plants by spraying seaweed extract these may be attributed the extract contains growth promoting hormones (IAA and IBA), cytokinins, trace elements (Fe, Cu, Zn, Co, Mo, Mn and Ni) as well as vitamins and amino acids (Zodape *et al*. 2011). Seaweed extracts improve nutrient uptake by roots (Crouch *et al*., 1990). In the same respect, seaweed extract has been shown to enhance plant defense against pest and diseases (Allen *et al*., 2001). However, yield increases in seaweed treated plants are thought to be associated with the hormonal substances present in the extracts especially cytokinins.

The beneficial effect of bio stimulator extract on chemical content of onion bulb might be due to their direct and indirect stimulatory and antioxidant protective effect.

Stimulator extract is rich in many essential minerals, i.e. Mg, Fe, Ca and K as well as many natural antioxidants (Morsi *et al*., 2008). The promoting effect of seaweed extract on chemical content of onion bulb might be to great contain high levels of organic matter, microelements, vitamins and fatty acids and rich in growth regulators such as auxin, cytokinins and gibberellins, also due to many components that may work synergistically at different concentrations (Shehata *et al.,* 2011).

Conclusion

Algae extract being organic and biodegradable in nature was considered as an important source of nutrition for sustainable agriculture especially in the newly reclaimed soil.

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