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Productivity and Quality of Kohlrabi Grown in a Newly Reclaimed Sandy Soil Using Organic and Mineral-N Fertilizer Regimes with or without Spraying of *Spirulina platensis* Extract

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THE current study aimed to investigate the influence of organic manure and/or mineral N-fertilizer with or without *Spirulina platensis* alga cells extract on growth, yield and quality of kohlrabi knobs. Field experiments were carried out on Kohlrabi (*Brassica oleracea var. gongylodes*) cv. White Vienna at the Experimental Farm of the Environmental Studies and Research Institute, El-Sadat City University, Egypt, during the winter seasons of 2015/2016 and 2016/2017 under drip irrigation systems. The obtained results showed that using 50% mineral-N + 50% organic-N combined with spirulina extract improved plant growth, yield and knob quality compared to other N-fertilizer regimes. Therefore, this treatment gave the best growth and increased total yield with the best knob quality as compared with no added. The highest content of nitrate in knobs (473.85 mg kg^{-1} DW) was recorded by using 100% mineral-N treatment (as an average in both seasons). Whereas, adding 100% organic-N recorded the lowest content of nitrate in knobs (83.45 mg kg^{-1} DW) as an average of both seasons. It is worthy to mention that nitrate concentration in tested kohlrabi knobs is still in the safe border for human consumption.

Keywords: Biostimulants, Drip irrigation, Algae extract, Vermicompost, Nitrate content.

Introduction

Kohlrabi (*Brassica oleraceae var. gongylodes*) is an edible plant belongs to *Brassicaceae* family. Kohlrabi is considered as a cole crop with enlarged stem (knob) as an edible portion. Because of the high contents of knobs in vitamin C, potassium and antioxidant substances, enormous nutritional and medicinal values have been highlighted (Dhaliwal, 2017). It is widely cultivated in European and American countries, having a short growing season with high exportability. However, no available data about cultivation and consumption of this valuable vegetable in Egypt even a very limited area was cultivated randomly.

Using of inorganic fertilizers for growing vegetables is still a great manner in commercial and subsistence farming (Magdoff and Weil, 2004). Those fertilizers are recorded to be involved crossly into human, animal food as well in environmental systems. Economically, using inorganic fertilizers extremely increased the prices of many agricultural commodities. The chemical fertilizers used in conventional agriculture comprise a few minerals, which dissolve rapidly in damp soil providing the plants large doses of minerals (Vernon, 1999).

Organic manures such as compost improve soil structure, aeration mechanism, and slow releasing nutrient that support root development resulting in higher growth and yield of kohlrabi plants (Uddin et al., 2009 and Shams, 2012). Organic fertilizers can therefore be used to decrease the quantity of poisonous compounds (such as nitrates) formed by conventional fertilizers in vegetables like kohlrabi. Hence, improving the quality of produced salad vegetables as well as human health (Shams et al., 2013). Generally, alga cells extracts contain nutrients such as N, P, K, Ca, Mg and S as well as Zn, Fe, Mn, Cu, Mo and Co,

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some growth regulators, polyamines and vitamins applied to improve nutritional status (Zhang & Ervin, 2004 and Papenfus et al., 2013). Thus, spraying kohlrabi with algae extract can probably stimulate root establishment, root elongation and promote the vegetative growth of plants.

Spirulina platensis is a photosynthetic and multi-cellular blue green microalgae which grows in fresh, marine and brackish water (Marrez et al., 2014). Foliar application of algae extract has been reported to induce many positive effects, where spraying plants had led to improve crop yield and quality, increase nutrient uptake, resistance to frost and stress conditions (Spinelli et al., 2010 and Shams & Morsy, 2019). Algae were early considered as an important group of microorganisms capable of fixing atmospheric nitrogen, as well as it causes significant increase in root growth, fresh and dry weights of roots, total biomass, yield component, photosynthetic pigments and growth promoting hormones (Kim and Chojnacka, 2015). Because of the functional activity, there is an increase of photosynthetic apparatus through raising the contents of total carbohydrates, starch, amino acids and protein (Raupp & Oltmanns, 2006 and Yassen et al., 2007). *Spirulina platensis* is a rich source of potassium and contains considerable amounts of Ca, Cu, Fe, Mg, Mn, P and Zn, hence it increases uptake and accumulation of these elements in plants (Marrez et al., 2014). This in turn explains the significant increase of vegetative growth and yield and its components as well as content of N, P and protein in leaves (Abd El-Mawgoud et al., 2010 on strawberry and Shalaby & El-Ramady 2014 on garlic, Anitha et al., 2016 on tomato and Abd El-Aleem et al., 2017 on fennel).

Indeed, organic vegetables production is highly requested for its health and nutritional benefits. There is paucity of information on the use of organic and bio-stimulant (alga cells extract) in vegetable production and therefore the objective of this study was to assess the influence of nitrogen fertilizer regimes "mineral vs. organic-N" and biostimulants "Spirulina extract" on growth, yield, quality and organoleptic properties of kohlrabi knobs in Egypt.

Materials and Methods

Materials of study

Seeds of kohlrabi (*Brassica oleracea* var. *gongylodes*) were brought from Modesto Seed Co. Inc., Modesto, California. Fresh algae "*Spirulina platensis"* was obtained from the Algal Biotechnology Unit, National Research Center, Egypt. Vermicompost was obtained from Central Laboratory for Agriculture Climate, Agriculture Research Center, Egypt. Its chemical composition is shown in Table 1.

Portions of the fresh algae materials (equivalent to one kg) were cut into small pieces, weighted, extracted using blender and then filtered through a double layered of muslin cloth to remove debris. Afterwards a foliar extract (5 g L^{-1}) was prepared from the filtrate by adding tap water and refrigerated between 0 - 4 ºC until use according to Pise and Sabale (2010). Chemical composition of the prepared algeal extract is presented in Table 2.

TABLE 1. Chemical analysis of the vermicompost used.

Parameter	Unit	Value	Parameter	Unit	Value
EC (1:5 extract)	dS m^{-1}	6.67	Total-N	%	1.51
pH (1:5 extract)	-	8.17	Total-P	%	1.27
Organic matter	%	33.57	Total-K	%	0.59
Density	kg m^{-3}	715	N-NO3	mg kg^{-1}	81.1
C:N ratio	-	12.26 : 1	N-NH4	mg kg^{-1}	65.7

TABLE 2. Chemical analysis of the prepared algeal extract.

Parameter	Macro elements (%)			Micro elements (%)			
	N	P	K	Fe	Zn	Mn	Cu
Value	4.43	2.36	0.17	2.15	2.47	3.16	0.77

Experimental procedures

During the two successive seasons of 2015/2016 and 2016/2017 the following experiment was carried out in the Experimental Farm of the Environmental Studies and Research Institute, El-Sadat City University. Effect of N fertilizer sources and alga extracts as well as their interactions on the growth, yield components and nitrate content of kohlrabi (*Brassica oleracea* var. *gongylodes*) cv. White Vienna grown under sandy loam soil using drip irrigation system was investigated. Kohlrabi plants were transplanted at the first week of December in the two growing seasons and harvested after 10 weeks from transplanting.

The experimental design was a randomized complete block design (RCBD) with 3 replicates. The experiment included two factors as follows: the first factor included five nitrogen fertilizer regimes (treatments): (1) 100% mineral-N as ammonium nitrate (33.5 % N), (2) 75% mineral-N + 25% organic-N as vermicompost manure, (3) 50% mineral-N + 50% organic-N, (4) 25% mineral-N + 75% organic-N and (5) 100% organic-N (designated as T1, T2, T3, T4 and T5, respectively) with or without spirulina extract (the second factor) as a foliar application (A1 or A0) which was added three times starting 7th days after transplanting and then sprayed every 10 days intervals at concentration of 5 g/ liter.

Nitrogen, phosphorus and potassium fertilizers were added to all treatments as NH_4NO_3 (33.5 % N), Ca $(H_2PO_4)_2$. $CaCO_3$ (16% P_2O_5) and K_2SO_4 (48 % K_2O). The organic manure and phosphate fertilizers were added to each experimental plot during the soil preparation. Meanwhile, NH_4NO_3 and K_2SO_4 fertilizers were added weekly within the drip irrigation system. Nitrogen (96 kg N ha^{-1}), phosphorus (77 kg P_2O_5 ha^{-1}) and potassium (86 kg K_2O ha^{-1}) fertilizers were added to all treatments. The added rates of organic- and inorganic fertilizers were calculated on basis of N % in both of them.

Soil and plant analyses

Before transplanting, random soil samples were taken for chemical and physical analyses as described by Chapman and Pratt (1961) and Jackson (1965). The experimental farm soil physical and chemical properties are given in Table 3.

Measurements

Four plants from each plot were randomly taken to assess vegetative growth characters i.e., plant length, knob diameter, average weight of knob, and total fresh yield. Chlorophyll *a*, *b* and total chlorophyll were determined in leaves according to the method described by AOAC (2000).

Samples of kohlrabi leaves were taken from each plot, oven dried at 70 °C for 48 h, weighed, ground, and then digested in a mixture of concentrated sulphuric and perchloric acids (2:1 ratio) as mentioned by Page et al. (1982). N, P and K were determined in the plant digests according to AOAC (2000) as follows: N by micro-Keldahl, P by spectrophotometer (Jenway 6705 UV/Vis) using ammonium molybdate and ascorbic acid reagents and K by flame photometer (Jenway pfp7).

Four kohlrabi knobs were dried at 70 °C until constant weight and then dry matter of knob was calculated. Nitrate content in knobs and fiber were determined according to the method described by Cataldo et al. (1975) and AOAC (2000), respectively. TSS, L-ascorbic acid and acidity were determined according to AOAC (2000). Carbohydrates content was determined according to Merrill and Watt (1973).

Statistical analysis

The randomized complete block design in factorial arrangement was used for treating the obtained data using Duncan's Multiple Range Test at 5 % level to compare between treatment means as described by Gomez and Gomez (1984).

TABLE 3. Physical and chemical analyses of the soil.

Particle size distribution (%)				pH*	EC**	$CaCO_3$	Organic matter
Sand	Silt	Clay	Texture		dS m^{-1}	g kg^{-1}	
85.7	6.9	7.4	Sandy	7.3	4.54	3.5	8.0

Available NPK (mg kg^{-1})			Cations (mmole L^{-1})				Anions (mmole L^{-1})			
N	P	K	Ca^{++}	Mg^{+}+	Na^{+}	K^{+}	C O^{--}	H CO_3^{--}	Cl^{-}	SO_4^{--}
23	13	79	17.1	9.8	18.1	2.2	0.0	8.0	23.0	14.1

* pH of 1:2.5 w:v water soil suspension and ** EC of paste extract.

Results and Discussion

Kohlrabi vegetative growth, chlorophyll and NPK content

Regarding the effect of N fertilizing regimes, data in Table 4 show that plants supplied with T3 (50% mineral-N + 50% organic –N) gave the best plant growth, i.e., the highest plant length, the largest knob diameter as well as the highest total chlorophyll and N, P and K contents of leaves as compared to other N-fertilizer regimes in both seasons. Meanwhile, plants supplied with T2 (75% mineral-N + 25% organic –N) and T1 (100% mineral-N) came in the second rank followed by T4 (25% mineral-N + 75% organic –N) then T5 (100% organic–N) with significant differences among them in all vegetative growth characteristics.

TABLE 4. Vegetative growth, chlorophyll content and NPK of kohlrabi plant as affected by N-fertilizer regimes, with or without alga cell extract and their interaction during the winter seasons of 2015 and 2016.

N-fertilizer regimes	Alga cell extract foliar application (A)											
	2015/2016 season			2016/2017 season			2015/2016 season			2016/2017 season		
	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean
	Plant length (cm)						Knob diameter (cm)					
T1	51.72 cde	53.35 cd	52.53 C	53.13 de	54.93 cd	54.03 C	8.10 bc	9.13 ab	8.51 BC	8.30 bc	9.24 ab	8.77 B
T2	53.1 cd	58.82 ab	55.96 B	54.65 cd	61.77 ab	58.21 B	8.03 bc	9.00 ab	8.61 B	8.40 bc	9.21 ab	8.80 B
T3	55.69 bc	61.60 a	58.64 A	57.60 bc	63.37 a	60.48 A	9.00 ab	9.83 a	9.41 A	9.33 ab	10.17 a	9.75 A
T4	48.10 ef	50.64 de	49.3 D	49.43 efg	51.66 def	50.54 D	7.37 cd	8.30 bc	7.83 C	7.67 cd	8.67 bc	8.17 B
T5	44.10 f	45.95 f	45.0 E	46.70 g	48.27 fg	47.48 E	6.17 d	7.10 cd	6.63 D	6.70 d	7.73 cd	7.21 C
Mean	50.5 B	51.7 A		52.30 B	53.46 A		7.73 A	7.90 A		8.08 A	8.25 A	
	Total chlorophyll (mg 100 g^{-1} FW)						N (g kg^{-1})					
T1	159.6 bc	167.1 b	163.3 C	169.5 c	174.9 bc	172.2 C	2.47 cd	2.64 abc	2.55 B	2.45 c	2.72 abc	2.61 B
T2	157.6 c	194.6 a	176.1 B	179.6 b	246.7 a	213.1 B	2.57 abc	2.70 abc	2.63 B	2.60 bc	2.69 abc	2.64 B
T3	161.5 bc	198.4 a	179.9 A	184.5 b	251.2 a	217.8 A	2.81 ab	2.85 a	2.83 A	2.90 ab	3.03 a	2.96 A
T4	141.5 d	145.4 d	143.4 D	149.0 de	153.0 d	151.0 D	2.40 cd	2.60 abc	2.50 BC	2.56 bc	2.66 bc	2.58 B
T5	117.1 e	123.6 e	120.3 E	133.9 f	140.2 ef	137.0 E	2.22 d	2.53 bcd	2.37 C	2.40 c	2.61 bc	2.50 B
Mean	147.4 B	154.8 A		163.3 B	176.6 A		2.49 A	2.50 A		2.58 A	2.61 A	
	P (g kg^{-1})						K (g kg^{-1})					
T1	0.31 abc	0.32 abc	0.31 C	0.30 cd	0.32 cd	0.31 C	1.90 abcd	2.53 abc	2.21 B	1.93 bc	2.51 abc	2.22 B
T2	0.34 ab	0.34 ab	0.34 B	0.33 bc	0.33 bc	0.33 B	1.95 abcd	1.97 abcd	1.96 C	1.98 abc	2.05 abc	2.01 C
T3	0.34 ab	0.36 a	0.35 A	0.37 ab	0.41	0.39 A	2.57 ab	2.60 a	2.58 A	2.54 ab	2.62 a	2.58 A
T4	0.30 bc	0.31 abc	0.30 D	0.31 cd	0.31 cd	0.31 C	1.87 cd	2.53 abc	2.20 B	1.90 bc	2.50 abc	2.20 BC
T5	0.28 c	0.29 bc	0.28 E	0.28 d	0.30 cd	0.29 D	1.80 d	2.48 abcd	2.14 BC	1.87 c	2.44 abc	2.15 BC
Mean	0.31 B	0.32 A		0.32 B	0.33 A		2.02 A	2.02 A		2.04 A	2.06 A	

Values followed by the same letters are not significantly different by Duncan's test at 0.05 level.

N-fertilizer regimes (T): 100% mineral-N as ammonium nitrate (T1), 75% mineral-N + 25% organic-N (T2), 50% mineral-N + 50% organic-N (T3), 25% mineral-N + 75% organic-N (T4) and 100% organic-N (T5). **Alga cell extract foliar application:** with (A1) and without (A0).

In this connection, Zaki et al. (2008) on sweet pepper and Calskan et al. (2004), Bekhit et al. (2005) and Salem et al. (2010) on potato, Shams (2012) on kohlrabi, Morsy et al. (2017) on snap beans and Morsy et al. (2018) in melon plants found that addition of organic manure combined with chemical fertilizers improved vegetative growth. Improving of vegetative growth may be due to the favorable effect of the mineral nitrogen application on the activity of microorganisms responsible for organic fertilizer decomposition in the soil (Follett et al., 1981) which increased available N in soil, N-uptake and consequently encouraged vegetative growth of the plant.

Kohlrabi plants, which supplied spirulina extract significantly had a better vegetative growth (plant length and total chlorophyll) and higher P content in leaves than control (plants sprayed with water). On the other hand, spirulina extract treatment did not increased knob diameter, N and K content in leaves (Table 4).

These results may be due to that alga extract is considered a source of high protein, which split into natural amino acids involved directly in the metabolism (Marrez et al., 2014). It also contains some essential macronutrients for growth and development of the plant as N, P and K. In addition, algae extract affect the nutrients uptake by plant roots (Abd El-Mawgoud et al., 2010). Furthermore, this algae extract contains polysaccharides, which induce the physiological activities of the grown plants, hence, positively reflects on their growth characteristics (Elarroussi et al., 2016).

It could be concluded from data in Table 4 that plants supplied with T3A1 (50% mineral-N + 50% organic –N and supplied with spirulina extract) or T2A1 (75% mineral-N + 25% organic –N and supplied with alga cells extract) showed the best plant growth with significant differences in plant length and total chlorophyll but without any significant differences in knob diameter as well as NK content in leaves as compared with T1A1 (100% mineral-N and supplied with alga cells extract) in both seasons.

Meanwhile, plants supplied with T5A0 (100% organic-N only) gave the lowest values and came in the last rank regarding to plant length, knob diameter, leaves total chlorophyll and NPK contents, as a general trend in both seasons. Also, T4A0 and T5A1 recorded similar increases in plant growth characteristics i.e., plant length, knob diameter and NK content in leaves.

The increases in all previous parameters by applying 50% mineral-N + 50% organic-N (T3) combined with the foliar spray of spirulina extract may be due to the process of mineralization of organic matter and increasing microbial activity in addition, using both of vermicompost manure and algae extract provided plants with macro and micro nutrients, amino acids, vitamins and auxins which promote plant photosynthesis activity (Abd El-Aleem et al., 2017).

Knob weight and Kohlrabi yield

It is clear from data in Table 5 that fresh and dry weights of knob,and total yield of kohlrabi were the highest when plants fertilized with T3 compared to other N fertilizer regimes. In addition, data show that nitrogen fertilizer regimes (T3, T2, T1, T4 and T5) significantly differed from each other in a descending order, with respect to fresh and dry weight of knob and total yield, and this trend was true in both seasons. These results are in harmony with those of Shams et al. (2013) on lettuce and Morsy et al. (2017) on snap beans.

Foliar application of kohlrabi plants with spirulina extract gave the highest values of fresh and dry weight and total yield over than non-sprayed ones. The superiority in yield due to alga cells extract is in agreement with the results obtained by Shalaby and El-Ramady (2014) on garlic and Abd El-Aleem et al. (2017) on fennel.

The supervisory effect of amino acids on growing could be clarified by the notion that some amino acids can affect plant development and growth through their influence on gibberellins biosynthesis (Walter and Nawacki, 1978). In addition, amino acids may play an important role in plant metabolism and protein assimilation which are necessary for cell formation and consequently increase fresh and dry mater. This regulatory effect was reported on strawberry (Abo Sedera et al. 2010), celery (Shehata et al. 2011) and garlic (Shalaby and El-Ramady, 2014)

Presented data in Table (5) indicate that the highest fresh and dry weight of knobs, and total yield were obtained by using T3A1 (50% mineral-N + 50% organic-N and treated with spirulina extract) followed by using the same nitrogen fertilizer regimes and without alga cells extract (T3A0) and T2A1 (75% N as mineral form+ 25% N as organic form and spraying with alga cells extract). Furthermore, using T5A0 or T5A1 (100% organic-N with or without alga cells extract) recorded the least fresh and dry weights of knobs and total yield in both seasons.

TABLE 5. Fresh and dry weights of knob, and total yield of kohlrabi plant as affected by N-fertilizer regimes with or without alga cell extract and their interaction during the winter seasons of 2015 and 2016.

N-fertilizer regimes	Alga cell extract foliar application (A)											
	2016/2017 season			2017/2018 season			2016/2017 season			2017/2018 season		
	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean
	Fresh weight of knob (g)						Dry weight of knob (g)					
T1	372.0 d	395.5 cd	383.8 C	392.6 d	403.4 cd	398.0 C	27.42 c	28.53 bc	27.98 C	28.53 c	29.06 bc	28.79 C
T2	402.0 bc	421.3 ab	411.6 B	398.5 d	446.0 ab	422.2 B	29.74 b	30.25 ab	29.99 B	29.67 bc	32.00 ab	30.83 B
T3	418.3 bc	445.3 a	431.8 A	427.2 bc	462.1 a	444.6 A	30.57 ab	32.04 a	31.31 A	30.67 abc	32.79 a	31.73 A
T4	316.59 e	324.4 e	320.5 D	314.4 e	319.2 e	316.8 D	24.13 d	24.41 d	24.27 D	24.00 d	24.12 d	24.06 D
T5	206.0 f	225.4 f	215.7 E	200.3 f	209.0 f	204.6 E	18.34 e	19.65 e	18.99 E	18.05 e	18.70 e	18.37 E
Mean	343.0 B	362.4 A		346.6 B	367.9 A		26.04 B	26.97 A		26.18 B	27.33 A	
	Total yield (t ha^{-1})											
T1	20.65 cd	21.95 bc	21.30 C	21.85 b	22.44 ab	22.15 B						
T2	22.42 abc	23.45 ab	22.93 B	22.17 b	24.97 ab	23.57 AB						
T3	23.19 abc	25.01 a	24.10 A	23.83 ab	25.70 a	24.77 A						
T4	17.61 e	18.23 de	17.92 D	17.58 c	17.78 c	17.68 C						
T5	11.43 f	12.62 f	12.03 E	11.17 d	11.65 d	11.41 D						
Mean	19.06 B	20.25 A		19.32 B	20.51 A							

Values followed by the same letters are not significantly different by Duncan's test at 0.05 level.
N-fertilizer regimes (T): 100% mineral-N as ammonium nitrate (T1), 75% mineral-N + 25% organic-N (T2), 50% mineral-N + 50% organic-N (T3), 25% mineral-N + 75% organic-N (T4) and 100% organic-N (T5). **Alga cell extract foliar application:** with (A1) and without (A0).

The superiority of adding 50% of N in the mineral form + 50% of N in the organic form over the other N-fertilizer regimes may be referred to the increase in microorganisms activity and increasing adsorbing capacity of essential nutrients against leaching. Moreover adding mineral + organic fertilizer together could improve the mineralization of organic-N (Tisdale and Nelson, 1975).

Quality and nitrate accumulation of kohlrabi knobs

Concerning the effect of N-fertilizer regimes on knob chemical characteristics, data in Table (6) show that using T3 (50% mineral-N + 50% organic-N) recorded the highest significant values of carbohydrates and vitamin C content in kohlrabi knobs as compared with the other N-fertilizer regimes, but it gave a moderate values of fiber. Likewise, Shams (2012) found that addition of organic manure combined with chemical fertilizers gave the best quality of kohlrabi (carbohydrate content). This agrees also with finding of Morsy et al. (2018) who reported that using of N as 50% mineral-N + 50% organic-N, gave the highest yield with the best fruit quality (total soluble solids and vitamin C) of melon plants grown in a sandy loam soil.

TABLE 6. Quality of kohlrabi knobs as affected by N-fertilizer regimes with or without alga cell extract and their interaction during the winter seasons of 2015 and 2016.

N-fertilizer regimes	Alga cell extract foliar application (A)											
	2016/2017 season			2017/2018 season			2016/2017 season			2017/2018 season		
	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean	A0	A1	Mean
	Carbohydrates (%)						Fiber (%)					
T1	13.04 ab	12.82 bc	12.93 B	13.30 c	13.18 cd	13.24 C	1.86 a	1.58 c	1.72 A	1.87 a	1.59 c	1.73 A
T2	12.82 bc	12.58 bc	12.70 C	13.58 bc	13.38 c	13.48 B	1.68 b	1.46 d	1.57 B	1.68 b	1.47 d	1.57 B
T3	13.98 a	13.88 a	13.93 A	14.58 a	14.46 ab	14.52 A	1.36 e	1.40 de	1.38 C	1.37 e	1.39 e	1.38 C
T4	11.02 d	11.88 cd	11.45 D	11.44 e	12.24 de	11.84 D	1.25 fg	1.32 ef	1.28 D	1.26 fg	1.33 ef	1.29 D
T5	11.14 d	11.92 cd	11.53 D	11.50 e	12.30 de	11.90 D	1.10 h	1.21 g	1.15 E	1.12 h	1.22 g	1.17 E
Mean	12.40 B	12.61 A		12.88 B	13.11 A		1.45 A	1.394 B		1.46 A	1.40 B	
	L-ascorbic acid (mg 100 g^{-1} F.W)						Nitrate content (mg kg^{-1} DW)					
T1	58.26 cd	50.91 e	54.58 C	59.06 bc	55.24 c	57.15 C	487.7 a	402.3 bc	445.0 A	511.1 a	494.3 ab	502.7 A
T2	60.16 bc	59.79 c	59.97 B	61.34 b	61.06 b	61.20 B	449.3 ab	409.0 bc	429.1 A	438.1 bc	356.4 de	397.2 B
T3	65.75 a	64.76 ab	65.25 A	70.17 a	69.02 a	69.59 A	369.3 c	356.3 c	362.8 B	387.5 cd	305.6 e	346.5 B
T4	44.72 f	53.39 de	49.05 E	47.52 d	55.99 bc	51.75 D	170.3 d	165.7 d	168.0 C	196.4 f	124.4 g	160.4 C
T5	45.60 f	58.16 cd	51.88 D	48.03 d	59.09 bc	53.56 D	91.7 e	91.3 e	91.5 D	100.6 gh	50.2 h	75.4 D
Mean	54.89 B	57.40 A		57.22 B	60.08 A		313.6 A	284.9 B		326.7 A	266.1 B	

Values followed by the same letters are not significantly different by Duncan's test at 0.05 level.
N-fertilizer regimes (T): 100% mineral-N as ammonium nitrate (T1), 75% mineral-N + 25% organic-N (T2), 50% mineral-N + 50% organic-N (T3), 25% mineral-N + 75% organic-N (T4) and 100% organic-N (T5). **Alga cell extract foliar application:** with (A1) and without (A0).

Foliar application of spirulina cell extract reflected in the highest values of carbohydrates and vitamin C and lowest values of fiber percentage of knob as compared to the treatments without alga cell extract in both seasons. Also data in Table 6 show that adding T3A1 or T3A0 (50% mineral-N + 50% organic-N with or without alga cell extract) gave the highest values of carbohydrates and vitamin C content of knob compared to all other treatments in both seasons.

Nitrate accumulation in knobs increased in the ascending order from T5 (100% organic-N) to T1 (100% mineral-N) with significant difference among them. This may be due to the increase in the rate of nitrogen absorption than the metabolism within the plant (Table, 6). It is clear also that plants supplied with all N doses in the mineral form with or without alga cell extract (T1A0 or T1A1) showed the highest nitrate-N accumulation in knobs and reached 445.0 and 502.7mg kg^{-1} DW, respectively (average of both seasons). On the other hand, the lowest nitrate accumulation in knob was 91.5 and 75.4 mg kg^{-1} DW in plants fertilized with all N as organic form with or without spirulina extract (T5A0 or T5A1) as an average in the first and the second seasons, respectively. In 1995, the European Commission Scientific Committee on Food (SCF) agreed to retain its earlier Acceptable Daily Intake (ADI) for the nitrate ion of 3.7 mg kg^{-1} body weight

(European Commission, 1997). It is worthy to mention that the determined nitrate concentration in kohlrabi knobs is still in the safe border for human consumption. These results are in harmony with Abadin et al., (1998), Mensinga et al., (2003) and Shams (2012).

Conclusion

It could be recommended that supplying of kohlrabi plants with *Spirulina platensis* cell extract and fertilizing plants with 50% N in organic form (vermicompost) + 50% N in mineral form (ammonium nitrate) gave the highest vegetative growth, total yield as well as the best knob quality of kohlrabi plants (*Brassica oleracea var. gongylodes*) cv. White Vienna grown under drip irrigation system in sandy loam soil. The previous combination led to less accumulation of nitrate in edible part, which did not exceed the international permissible limit. From the applied side, this study could be used to produce safe and healthy vegetable for local market and exportation and thus reducing contamination of soil and ground water with mineral N under a modern irrigation system at newly reclaimed sandy soil of Egypt.

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إنتاجية وجودة نبات الكرنب أبو ركبة المنزرع فى أراضى رملية حديثة الإستصلاح بإستخدام أنظمة من التسميد النيتروجيني المعدنى والعضوى مع أو بدون الرش الورقى بمستخلص الطحالب *Spirulina platensis*

نهلة مختار مرسى

قسم التنمية المتواصلة للبيئة وإدارة مشروعاتها – معهد الدراسات والبحوث البيئية – جامعة مدينة السادات - مصر.

أجريت تجربه حقلية على نبات الكرنب أبوركبة صنف فينا الأبيض بمزرعة التجارب بمعهد الدراسات والبحوث البيئية – جامعة مدينة السادات، خلال مواسم الشتاء من عام ٢٠١٥ ، ٢٠١٦ تحت نظام الرى بالتنقيط . وتهدف هذه التجربة لدراسة تأثير التسميد العضوى مع أو بدون التسميد المعدنى مع او بدون الرش الورقى بمستخلص الطحالب السبيرولينا على النمو والمحصول والجودة للجزء الإقتصادى لنبات الكرنب أبوركبة. وقد أظهرت النتائج أن إستخدام ٥٠٪ نيتروجين معدنى + ٥٠ ٪ نيتروجين عضوى جنبا إلى جنب مع الرش الورقى بمستخلص الطحالب قد حسن نمو النبات والمحصول وجودة الجزء الإقتصادى مقارنة بنظم التسميد النيتروجينى الأخرى. وفى هذا الصدد قد اعطى الرش الورقى لنباتات الكرنب أبوركبة بمستخلص الطحالب افضل النتائج. علاوة على أن هذه المعاملة أعطت أفضل نمو وأدت إلى زيادة المحصول الكلى مع أفضل جودة للجزء الإقتصادى مقارنة بمعاملة المقارنة. تم تسجيل أعلى محتوى من النترات فى الجزء الإقتصادى (٤٧٣,٨٥ ملجم لكل كجم وزن جاف – كمتوسط للموسمين) بإستخدام ١٠٠٪ من النبتروجين المعدني، كما سجل أقل مستوى لتراكم النترات عند إستخدام ١٠٠٪ من النيتروجين العضوى (٨٣,٤٥ ملجم لكل كجم وزن جاف – كمتوسط للموسمين) . ومن الجدير بالذكر أن تركيز النترات فى الجزء الإقتصادى للكرنب أبوركبة لايزال فى الحدود الآمنة للإستهلاك الآدمى.

الكلمات الدالة : المنشطات الحيوية، الرى بالتنقيط، مستخلص خلايا الطحلب، الفيرمي كمبوست، محتوى النترات.