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Chemical Constituents of Snap Bean Plant Foliage and Pods As Affected bySeveral Natural Safety Compounds

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Abstract

Snap bean is economically paramount leguminous crops in Egypt. Increasing the productivity with high quality of snap bean pods is considered as substantial aim that could be achieved through using some plant-stimulants as foliar application due to their short stay in the soil. So this experiment was conducted to investigate the effect of some plant-stimulants, i.e., of algae (2 and 4 cm/L), potassium silicate (2 and 4 cm/L) nano chitosan (60 and 90 mg/L) and moringa extract (4 cm and 6/L) as a pre-harvest application compared with untreated plants (control) on vegetative growth parameters, chemical constituents of foliage, yield components and pod quality of snap bean plants (Phaseolus vulgaris L.) cv. Sybaris. Results indicated that snap bean plants given any of the pre-harvest treatments showed significantly higher values of all studied vegetative growth parameters (plant height, number of leaves/plant, leave area as well as fresh and dry weight), chemical constituents of snap bean plant foliage (N, P, K and total chlorophyll), pods chemical properties (TSS, total chlorophyll, total carbohydrate and protein contents), total yield and its components (number of pods/plant, early yield and total yield/fed. as well as marketable and unmarketable yield) compared with untreated plants (control). Results show clearly that most these parameters were significantly improved as a result of foliar application of either algae (2 and 4 cm/L) or potassium silicate (2 and 4 cm/L) at 21, 35, 50 days after sowing during the growing season compared with the control treatment.

"Keywords: Phaseolus vulgaris, snap bean. algae, potassium silicate, nano chitosan, moringa."

1. Introduction

Snap bean(*Phaseolus vulgaris L.*) is economically paramount leguminous crops in Egypt. It's essential for human nutrition because it's inexpensive and very rich in protein, minerals, amino acids, and vitamins contents **[1, 2, 3]**.It's grown in Egypt either for local consumption or export especially to European countries. The cultivation of green snap bean plants reached 65671 fed. and the total productivity was 284299 tons with an average of 4,327 tons / fed. **[4]**.

It can be considered that increasing the production with high quality of snap bean pods is substantial aim that could be achieved through using some plant-stimulants, i.e., algae extract, chitosan, potassium silicate and moringa leaves extract, as foliar spray due to their short stay in the soil.

The use of algae (seaweed) extracts is one of the patterns of organic cultivation because it contains high levels of nutrients and hormones that have a great role in improving the growth and root system of the plant **[5].** Chitosan is derived from crustaceous shells such as crabs and shrimps so it is a natural carbohydrate polymer **[6]**. Chitosan had proved to protect plants against oxidative stress **[7]**. Silicon is not considered an essential element for most plants but research findings indicated that absorption of soluble silicon by plants is beneficial to crops via

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inducing resistance and protection against pest attack **[8, 9]**. Moringa leaves extract is source of essential minerals such as K, Ca as well as Fe and vitamins such as A, B as well as C **[10]**as well as powerful natural antioxidants, i.e., ascorbate and phenolics **[11].** The extract of moringa leaves is a natural plant growth regulator due to containing several mineral elements, essential amino acids compounds, ascorbates, cytokinin, vitamins, proteins and phenolics **[12, 13, 14, 15, 16, 17]**.

Thus, this expermint was carried out to study the influence of using some natural safety compounds i.e., algae extract, chitosan, potassium silicate and moringa leaves extracts as foliar spray on vegetal growth parameters, chemical constituents of plant shoots, yield components and pods quality of snap bean plants under the environmental conditions of Qalyubia Governorate.

2. Methods

This investigation was carried out during the two consecutive summer seasons of 2019 and 2020 in El-kanater Horticulture Research station Farm (Kalyubeia Governorate, Egypt), Vegetables Handling Research Department, Horticultural Research Institute (Giza Governorate, Egypt) to investigate the effect of some bio-stimulants, i.e., algae, potassium silicate, nano chitosan andmoringa leave extract as foliar application compared with untreated plants (spray with water only) as control vegetal growth parameters, chemical constituents of plant shoots, yield components and pods quality of snap bean plants (*Phaseolus vulgaris* L.) cv. Sybaris. The physical properties and chemical analysis of the soil **[18, 19]**under study are shown in Table 1.

The seeds under current study of cv. Sybaris were received from Horticulture Research Institute, Agricultural Research Center, Egypt. The seeds were sown on February 27th and 23rd at the first season and second one, respectively on ridge side at rate two seeds/hill and at 7 cm spacing.

Table (1): Physical and chemical characteristic of experimental soil as average of both seasons 2019 and 2020.

Mechanical			**Textural Class**	**pH (1-2.5 Soil : water suspension)**	**Ec: Soil paste 1:1 ds/m**	**Organic matter**	
Sand	**Silt**	**Clay**	**Clay**	**8**	**1.3**	**2.2%**	
18.8%	**21.7%**	**57.3%**					
Soluble Anions and Cations							
Anions (meq./L)				**Cations (meq./L)**			
CO_3^{--}	**HCO_3^{--}**	**Cl^-**	**SO_4^{--}**	**Ca^{++}**	**Mg^{++}**	**Na^+**	**K^+**
0.00	**5.42**	**1.20**	**4.6**	**4.30**	**5.10**	**1.30**	**0. 70**
Available macro and micro elements (mg/kg)							
N	**P**	**K**	**Fe**	**Mn**	**Zn**	**Cu**	
51.0	**2.3**	**400**	**24.3**	**9.4**	**7.6**	**3.6**	

The experimental plot area was estimated by 12 m^2, it contained 3 ridges with 6.0 meter long and 0.70 meter width. This experiment inclusive nine treatments as follow: 1. Untreated plants (control); 2. Algae extract at 2cm/L; 3. Algae extract at 4cm/L.; 4. Potassium silicate at 2cm/L.; 5.Potassium silicate at 4cm/L.; 6.Nano chitosan at 60 mg/L.; 7.Nano chitosan at 90 mg/L.; 8. Moringa leaves extract at 4cm/L.; 9. Moringa leaves extract at 6cm/L. The used treatments were arranged in a complete randomized block design with three replicates. These foliar spray treatments were applied three times during the growing period of snap bean plants at 21, 35, 50 days after sowing. All agricultural practices specific to commercial production of snap beans were followed up according to the recommendations of the Ministry of Agriculture. Six plants were taken from each experimental plot as a randomly sample after end the foliar spray (55 days from sowing) and the vegetative growth characteristics [Plant length, branches number /plant, leaves number /plant, fresh weight / plant (g) and dry weight / plant (g) of snap bean shoots];

chemical composition of plant foliage (Total nitrogen% **[20]**, phosphorus content **[21]**, potassium content**[22]**and total chlorophyll content **[23])**; Green pods yield and its components [Early yield (kg/fed), number of green pods / plant, marketable yield, unmarketable yield and total yield (ton/fed)]; physical fruit quality [Average pod weight, length and diameter] and chemical fruit quality [Total soluble solids, total protein% **[20]**, total carbohydrates% **[24]**and fiber percentage**[23]**were recorded then data were subjected to the statistical analysis by the method of Duncan's multiple range tests as reported by**[25]**.

3. Resultsand discussion

Vegetative growth characteristics

Data presented in Table 2 show the effect of algae (2 and 4 cm/L), potassium silicate (2 and 4 cm/L) nano chitosan (60 and 90 mg/L) andmoringa extract (4cm and 6/L) as a pre-harvest application compared with untreated plants (control) on vegetative growth of snap bean plants. Results indicat that snap bean plants given any of the pre-harvest treatments had significantly higher values of all studied vegetative growth parameters (plant height, leaves number/plant, leave area fresh weight and dry weight) compared with untreated plants (control).

Table 2.Effect of some growth stimulants on vegetative growth parameters of snap bean plants during the first (2019) and the second (2020) seasons.

Treatments	Plant height (cm)		Branches number/Plant		Leaves number/ Plant	
	First season	Second season	First season	Second season	First season	Second season
Control	52.0^{d}	42.3^{d}	4.3^{a}	4.0^{c}	9.9^{d}	5.6^{c}
Algae 2 cm/L	57.9^{abc}	50.3^{abc}	5.1^{a}	5.3^{a}	14.1^{b}	6.5^{ab}
Algae 4 cm/L	59.1^{ab}	54.7^{a}	5.4^{a}	4.7^{abc}	16.4^{a}	6.9^{a}
Potassium silicate 2cm/L	59.8^{a}	48.2^{bcd}	4.4^{a}	4.4^{bc}	11.3^{cd}	7.0^{a}
Potassium silicate 4cm/L	57.3^{abc}	48.0^{bcd}	4.9^{a}	4.5^{abc}	14.8^{ab}	6.7^{ab}
Nano chitosan 60 mg/L	57.0^{a-c}	52.1^{ab}	5.4^{a}	4.8^{abc}	14.3^{b}	6.5^{ab}
Nano chitosan 90 mg/L	56.0^{bc}	51.6^{ab}	5.4^{a}	5.0^{ab}	14.0^{b}	6.7^{ab}
Moringa 4 cm/L	57.7^{abc}	45.1^{cd}	5.1^{a}	4.4^{bc}	13.0^{bc}	6.5^{ab}
Moringa 6 cm/L	54.7^{cd}	42.5^{d}	5.4^{a}	4.7^{abc}	14.1^{b}	6.1^{bc}
Treatments	**Leaves area/ Plant (cm^2)**		**Fresh weight (g)**		**Dry weight (g)**	
	First season	Second season	First season	Second season	First season	Second season
Control	43.5^{d}	40.5^{c}	51.7^{b}	70.7^{b}	5.00^{b}	7.00^{d}
Algae 2 cm/L	48.3^{c}	44.4^{bc}	67.5^{ab}	69.7^{b}	6.00^{ab}	7.33^{d}
Algae 4 cm/L	55.4^{a}	53.5^{a}	60.8^{ab}	82.3^{a}	7.33^{a}	12.00^{a}
Potassium silicate 2cm/L	53.0^{ab}	53.0^{a}	70.8^{ab}	67.7^{b}	6.33^{ab}	9.00^{bcd}
Potassium silicate 4cm/L	52.3^{ab}	52.9^{a}	85.8^{a}	69.7^{b}	7.10^{a}	9.67^{a-d}
Nano chitosan 60 mg/L	50.8^{bc}	49.5^{ab}	70.8^{ab}	60.2^{b}	6.67^{ab}	10.67^{ab}
Nano chitosan 90 mg/L	55.1^{a}	53.2^{a}	80.8^{ab}	61.7^{b}	7.33^{a}	10.33^{abc}
Moringa 4 cm/L	53.3^{ab}	52.4^{a}	67.3^{ab}	75.7^{ab}	5.67^{ab}	7.67^{cd}
Moringa 6 cm/L	51.1^{bc}	50.4^{a}	73.0^{ab}	64.3^{a}	5.3^{b}	9.67^{a-d}

Values with the same letters in the column are not statistically different at the 0.05% level of probability according to Duncan'smultiple range test.

In this respect, plants treated with concentration 4cm/L of Algae produced the highest values of most growth parameters, followed by plants treated with 2 cm/L of potassium silicate without significant differences between them at the most parameters. On the other hand, the least values in this respect were recorded in untreated plants (control). Treatment with moringa extract 6cm/L was less effective in enhancing vegetative growth. These results are in agreement with those obtained by **[26, 27, 28, 29, 30, 31].** The beneficial effect of algae extract application on plant growth may be due to that seaweed extract contained components such as macro- and micro element, amino acids, vitamins, betaines and betaine-like compounds, gibberellins, cytokinins and auxins like growth substances. They may increase levels of endogenous hormones, i.e. Indol Acetic Acid (IAA), gibberellins (GA3) and active cytokinins in treated plants which promote cell division and cell elongation **[32].** Furthermore, it stimulate the uptake of N, P, K, Mg, Ca, Zn, Fe and Cu by plants that alleviate the inhibitory effect of Na toxicity and restore growth **[33]**, stimulate chlorophyll biosynthesis and improve total chlorophyll in leaves**[34]**, enhance plant resistance to diseases due to the antimicrobial activity of algae against bacteria, and molds, which could improve plant growth and plant resistance to stress **[35]**, as well as other compounds in the algae extract which affect cellular metabolism in treated plants leading to enhance growth and crop yield **[36, 37]**.

Moreover, the exceed of using potassium silicate may be due to the individual influence of both potassium and silica which play an great role in metabolism of plant and assimilation of protein which is necessary for cells formation and consequently increased dry matter in plant which are perfect indicators for plant growth.

Chemical constituents of snap bean plant foliage.

Recorded data in Table 3 show the influence of algae (2 and 4 cm/L), potassium silicate (2 and 4 cm/L), nano chitosan (60 and 90 mg/L) andmoringa (4cm and 6/L) as a pre-harvest application compared with untreated plants (control) on mineral constituents (N, P, K and total chlorophyll) of snap bean foliage during the two studied seasons. Results show clearly that total nitrogen, phosphorus, potassium and total chlorophyll were significantly increased as a result of foliar application three times with some growth stimulants after 21, 35, 50 days from sowing during the two studied seasons compared with the control treatment. Additionally, foliar nano chitosan at 90 mg/L offered the highest values of N and total chlorophyll followed by algae at rate 2 and 4 g/L during both seasons of study meanwhile, the highest values of P% were recorded with algae at rate 4 g/l. Moreover, foliar application of potassium silicate at rate 4 cm/lrecorded the highest values of K% of plant foliage.

Table 3.Effect of some growth stimulants on chemical constituents of plant foliage of snap bean plants during the first (2019) and the second (2020) seasons.

Treatments	Total chlorophyll (mg/100 g F.W.)		N%		P%		K%	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control	38.50^{d}	37.81^{c}	2.40^{b}	2.14^{d}	0.23d	0.19^{d}	2.56^{ab}	2.38^{ab}
Algae 2 cm/L	45.60^{ab}	43.37^{abc}	2.73^{ab}	2.67^{b}	0.36^{ab}	0.29^{bc}	2.62^{ab}	2.54^{ab}
Algae 4 cm/L	45.00^{abc}	45.33^{ab}	2.80^{ab}	2.76^{b}	0.39^{a}	0.42^{a}	2.47^{ab}	2.46^{ab}
Potassium silicate 2cm/L	45.88^{ab}	40.31^{bc}	2.50^{b}	$2.52b^{c}$	0.31^{bc}	0.30^{bc}	2.66^{ab}	2.60^{ab}
Potassium silicate 4cm/L	42.04^{c}	40.72^{bc}	2.57^{b}	2.25^{d}	0.35^{abc}	0.34^{ab}	2.84^{a}	2.97^{a}
Nano chitosan 60 mg/L	45.24^{ab}	44.17^{ab}	2.80^{ab}	2.62^{b}	0.29^{cd}	0.32^{abc}	2.35^{ab}	2.52^{ab}
Nano chitosan 90 mg/L	47.77^{a}	47.20^{a}	3.20^{a}	3.00^{a}	0.33^{abc}	0.33^{ab}	2.31^{ab}	2.32^{ab}
Moringa 4 cm/L	42.94^{bc}	39.10^{bc}	2.53^{b}	2.37^{cd}	0.28^{cd}	0.22^{cd}	2.37^{ab}	2.02^{b}
Moringa 6 cm/L	42.01^{c}	42.34^{abc}	2.76^{ab}	2.61^{b}	0.40^{a}	0.31^{bc}	2.18^{b}	2.20^{b}

Values with the same letters in the column are not statistically different at the 0.05% level of probability according to Duncan'smultiple range test.

In this regard, the increases in the concentration of the studied chemical components in the leaves of the plant due to the use of plant-stimulants may be due to their content of mineral and organic components which led to an increase in the root surface absorption of these macronutrients and consequently an increase in their concentration in the roots and their migration and accumulation in the leaves of the plant. These results are in agreement with those reported by **[38, 29, 39]**for Algaeand**[40, 41, 42, 43, 44]**for potassium silicate.

Pod quality characteristics

Physical pod quality

Data in Table 4 show the effect of algae (2 and 4 cm/L), potassium silicate (2 and 4 cm/L), nano chitosan (60 and 90 mg/L) andmoringa (4cm and 6/L) as a pre-harvest application as compared with untreated plants (control) on physical pod quality characteristics of snap bean. Results revealed that all pre-harvest applications significantly increased pods physical properties (pod weight, length, and dimeter) compared with pods obtained from untreated plants. In this respect, snap bean pods obtained from the plants treated with the algae 4cm/L had mostly the best physical pod quality in both seasons. The least values of these characters were noticed in the pods of the untreated plants. These results are in agreement with those obtained by **[37, 45, 27]**.

Chemical pod quality

Data in Table 5 show the effect of algae (2 and 4 cm/L), potassium silicate (2 and 4 cm/L), nano chitosan (60 and 90 mg/L) andmoringa leaves extract (4cm and 6/L) as a pre-harvest application as compared with untreated plants (control) on chemical pod quality characteristics of snap bean. Results reveal that all pre-harvest applications significantly increased pods chemical properties (TSS, total chlorophyll, total carbohydrate and protein contents) compared with pods obtained from untreated plants. In this respect, snap bean pods obtained from the plants treated with algae 2 or 4 cm/L) recorded the highest values of TSS and total chlorophyll content in both seasons. Snap bean pods obtained from the plants treated with potassium silicate 2 and 4 cm/L recorded the highest values of total carbohydrate content in first and second seasons, respectively. The highest value of protein contents in pods were recorde by foliar snap bean plants with potassium silicate at rate 2 cm/L. These results are in agreement with those obtained by **[37, 46, 47, 48, 49, 44, 50, 51]**.

The improvement of the vegetative growth of snap bean plants in response to application of either algae (2 and 4 cm/L) or potassium silicate (2 and 4 cm/L) may result in improving the pod quality of snap bean. These results are in agreement with those obtained by **[37]**.

Table 4.Effect of some growth stimulants on physical pod quality of snap bean plants during the first (2019) and the second (2020) seasons.

Treatments	Pod fresh weight (g)		Pod length (cm)		Pod diameter (mm)	
	First season	Second season	First season	Second season	First season	Second season
Control	6.0^{d}	4.7^{f}	10.7^{d}	11.1^{e}	5.8^{d}	5.4^{d}
Algae 2 cm/L	8.1^{b}	7.6^{bc}	12.8^{bc}	13.2^{ab}	8.0^{a}	6.9^{ab}
Algae 4 cm/L	8.1^{b}	9.3^{a}	13.6^{a}	13.7^{a}	7.9^{a}	7.0^{a}
Potassium silicate 2cm/L	8.2^{b}	7.7^{bc}	12.6^{bc}	11.0^{e}	6.9^{bc}	6.7^{ab}
Potassium silicate 4cm/L	8.9^{a}	8.4^{ab}	13.0^{ab}	12.0^{d}	6.6^{c}	6.8^{ab}
Nano chitosan 60 mg/L	7.8^{b}	7.8^{bc}	12.6^{bc}	12.8^{bc}	7.1^{b}	6.8^{ab}
Nano chitosan 90 mg/L	6.9^{c}	6.8^{cd}	12.0^{c}	12.7^{bc}	6.7^{bc}	6.3^{abc}
Moringa 4 cm/L	7.9^{b}	5.8^{e}	12.1^{c}	11.1^{e}	6.1^{d}	6.3^{abc}
Moringa 6 cm/L	7.1^{c}	6.4^{de}	12.4^{bc}	12.2^{cd}	6.7^{bc}	6.0^{cd}

Values with the same letters in the column are not statistically different at the 0.05% level of probability according to Duncan'smultiple range test.

Table 5.Effect of some growth stimulants on chemical pod quality of snap bean plants during the first (2019) and the second (2020) seasons.

Treatments	TSS %		Total Chlorophyll /mg)100 (.g F.W		Total Carbohydrate %		Total protein %	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control	5.01^{e}	6.97^{d}	38.55^{a}	39.85^{bc}	8.33^{d}	15.57^{e}	15.02^{b}	13.10^{b}
Algae 2 cm/L	8.06^{ab}	7.90^{b}	41.81^{a}	41.16^{ab}	12.83^{bcd}	19.38^{bc}	17.08^{ab}	18.42^{a}
Algae 4 cm/L	8.96^{a}	8.50^{a}	39.40^{a}	41.49^{a}	13.26^{abc}	21.49^{b}	17.50^{ab}	19.81^{a}
Potassium silicate 2cm/L	6.72^{cd}	7.88^{b}	39.20^{a}	39.53^{c}	17.71^{a}	18.65^{cd}	17.50^{ab}	16.42^{ab}
Potassium silicate 4cm/L	7.08^{bc}	7.17^{d}	40.51^{a}	40.51^{abc}	11.82^{bcd}	24.72^{a}	20.00^{a}	19.54^{a}
Nano chitosan 60 mg/L	7.61^{bc}	7.68^{bc}	41.49^{a}	40.51^{abc}	13.99^{ab}	17.36^{cde}	15.62^{b}	16.97^{ab}
Nano chitosan 90 mg/L	7.53^{bc}	7.73^{bc}	41.49^{a}	40.83^{abc}	9.03^{cd}	17.83^{cde}	16.08^{b}	16.92^{ab}
Moringa 4 cm/L	7.84^{b}	7.33^{cd}	39.85^{a}	40.18^{abc}	12.55^{bcd}	19.10^{bc}	15.83^{a}	17.20^{ab}
Moringa 6 cm/L	6.09^{d}	6.44^{e}	40.51a	41.16ab	11.94^{bcd}	16.63^{de}	17.23^{ab}	18.19^{ab}

Values with the same letters in the column are not statistically different at the 0.05% level of probability according to Duncan'smultiple range test.

4 Yield and its components

Data in Table 6 show the effect of algae (2 and 4 cm/L), potassium silicate (2 and 4 cm/L), nano chitosan (60 and 90 mg/L) andmoringa leaves extract (4cm and 6/L) as a pre-harvest application compared with untreated plants (control) on total yield and its components of snap bean plants. Obtained results show that snap bean plants treated with all pre-harvest stimulants had significantly increased number of pods/plant, early yield and total yield/fed. as well as marketable yield compared to untreated plants. However, treating plants with the algae (2 and 4 cm/L) were the most favorable treatment for enhancing number of pods /plant, early yield and total pod yield in the first and second seasons. The increase in yield was due to the increases in weight of pod as well as number of pods/plant. Meanwhile, the lowest values in this respect were recorded in the untreated plants (control). These results were achieved in the two seasons and were in agreement with those obtained by **[37, 52, 53**,**27, 37, 26,27, 54, 31]**for algae on snap bean.

Table 6.Effect of some growth stimulants on green pods yield and its components of snap bean plants during the first (2019) and the second (2020) seasons.

Treatments	Pods number/ plant		Early Yield (ton /Fed)		Unmarketable yield (ton/Fed)		Marketable yield (ton/Fed)		Total Pod yield (ton/Fed)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Control	9.3^{c}	10.6^{c}	2.580^{c}	2.600^{c}	1.970^{a}	1.075^{e}	3.775^{c}	4.703^{e}	5.745^{d}	5.778^{c}
Algae 2 cm/L	11.5^{b}	20.2^{a}	5.580^{a}	4.933^{a}	1.437^{a}	1.509^{bc}	8.082^{ab}	7.423^{ab}	9.519^{ab}	8.932^{ab}
Algae 4 cm/L	14.1^{a}	18.7^{ab}	4.520^{ab}	5.050^{a}	1.758^{a}	1.573^{b}	8.451^{a}	7.877^{a}	10.209^{a}	9.450^{a}
Potassium silicate 2cm/L	10.7^{b}	17.4^{ab}	3.400^{b}	3.333^{bc}	1.252^{a}	1.785^{a}	6.926^{ab}	6.715^{bc}	8.178^{bc}	8.500^{abc}
Potassium silicate 4cm/L	10.8^{b}	16.4^{ab}	4.660^{ab}	3.467^{bc}	1.808^{a}	1.299^{cd}	6.893^{ab}	6.290^{cd}	8.700^{abc}	7.589^{bc}
Nano chitosan 60 mg/L	11.7^{b}	18.3^{ab}	5.140^{a}	3.933^{abc}	1.818^{a}	1.495^{bc}	7.044^{ab}	6.772^{bc}	8.862^{abc}	8.267^{b}
Nano chitosan 90 mg/L	10.4^{bc}	18.4^{ab}	4.540^{ab}	4.300^{ab}	2.112^{a}	1.292^{cd}	6.993^{ab}	6.205^{cd}	9.105^{abc}	7.497^{bc}
Moringa 4 cm/L	13.9^{a}	15.4^{b}	4.880^{ab}	4.633^{ab}	1.332^{a}	1.181^{de}	6.492^{b}	5.440^{de}	7.824^{c}	6.621^{bc}
Moringa 4 cm/L	11.0^{b}	15.4^{b}	4.880^{ab}	4.100^{ab}	1.290^{a}	1.372^{cd}	6.924^{ab}	5.718^{d}	8.210b^{c}	7.09^{bc}

Values with the same letters in the column are not statistically different at the 0.05% level of probability according to Duncan'smultiple range test.

The beneficial effect of algae (2 and 4 cm/L) application on yield and its components of snap bean may be due to the increase in vegetative growth parameters which lead to increase in number of pods as well as weight of pods/plant that was reflected in total yield. It was found that algae extracts enhanced yield because it improved chlorophyll content in leaves of various crop plants which was attributed to the betaines present in seaweed extracts wich could be encouraged plants to flowering by initiating strong plant **[37]**.Yield is the result of metabolic reactions in plants. Thus any factor affecting this metabolic activity in any period of plant growth can affect yield **[55]**. It is believed that the increased yield in treated plants with seaweed is related to the hormonal substances present in the extracts, especially cytokinins **[56]**. This response suggests that seaweed extracts are involved in stimulating the mobilization of cytokinins from the roots to the reproductive organs or more likely by stimulating the amount or synthesis of endogenous fruit cytokinin **[57]**. This increase in cytokinin availability will eventually result in a greater supply of cytokinins to the maturing fruit **[58]**.

4. Conclusions

It could be stated that snap bean plants cv. Sybaris foliar spray with the algae extract (2 and 4 cm/L) and potassium silicate (2 and 4 cm/L) three times improved vegetative growth parameters of plants, total yield and its components and pod qualit under the conditions of Qalubia Governorate.

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