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Effect of Some Bio-Stimulants Materials On Growth, Yield And Quality Of Snap Bean Pods

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ABSTRACT

Two plastic house experiments were carried out during the winter seasons of 2014 - 2015 and 2015 - 2016 at the Agricultural Experiment Station, Faculty of Agriculture, Cairo University and Laboratory of Handling of Vegetable Crops Department, Giza to study the effect of some bio-stimulants materials, i.e., seaweed extract (SWE) as foliar spray, humic acid (HA) and effective microorganisms (EM) as soil application and combination between them compared with the control (spray with water only) on vegetative growth parameters, total yield and its components and pod quality of snap beans (*Phaseolus vulgaris* L.) cv. Hama. Results show that snap bean plants treated with SWE, HA and EM either alone or combination between them had a significantly increased vegetative growth parameters (plant height, number of leaves/plant and chlorophyll reading in leaves), total yield and its components (pod weight, number of pods/ plant and total yield) and pod quality (pod length, texture, dry mater, ascorbic acid, total chlorophyll content, protein % and total carbohydrate %) compared to untreated plants (control). However, the combination of SWE + HA + EM was the most favorable treatment for enhancing these characters followed by HA + EM with significant differences between them. These treatments gave the minimum value of fiber content % in pods, while SWE treatment or untreated plants (control) had the maximum ones. Plants treated with SWE, HA and EM alone were less effective in enhancing vegetative growth parameters, total yield and its components and pod quality as compared with using the mixture between them.

Keywords: Snap bean, *Phaseolus vulgaris*, seaweed extra, humic acid, effective microorganism, growth, yield, quality.

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INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) is one of the most important members of leguminous crops grown in Egypt for either local consumption or exportation. This crop is widely used as a source of energy. It is rich in protein, dietary fibers, minerals (Ca, P, Fe, K, Mg and Mn) and vitamins (A, B1, B2 and C) with high amino acids [27]. Pre-harvest plant nutrition is a major factor influence on fruit and vegetable quality [26]. Increasing the productivity of snap bean pods with high quality is considered an important aim that could be achieved through using some bio-stimulant materials, i.e., seaweed extract (SWE) as foliar spray, humic acid (HA) and effective microorganisms (EM) as soil fertilizer[2,11,9] respectively.

Seaweed extract is a new generation of natural organic fertilizers containing highly effective nutritious and promotes faster germination of seeds and increase yield and resistant ability of many crops, unlike the chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animals and birds [6]. [32] showed that seaweed application caused an increment in fresh and dry weight of leaves, number of leaves/plant and chlorophyll content in leaves and plant height in beans, increased plant growth of pea plant[22], increased number of leaves per plant and average leaf area, also exhibited the highest significantly pod yield compared to untreated control[2] on snap bean.

Nowadays the use of humic acid has increased with increasing the agricultural production and the most economical humic acid is almost applied directly to the soil and/or as a foliar application to the plants. Bio-organic fertilizer has been reported to be important in reducing the environmental pollution along with reducing the production coast [11]. Humic acid is a commercial product contains many elements which improve the soil fertility and increasing the availability of nutrient elements and consequently affected plant growth and yield [25]. Many investigators reported that soil application or foliar spray with humic acid improved plant growth, the productivity and green pod quality [8,12,17] on snap bean; [18] on pea. However, the magnitude of increase was higher in soil than the foliar application [4] on snap bean.

Effective microorganisms (EM) are a commercial biofertilizer that contains a mixture of co-existing beneficial microorganisms collected from natural environments. Microorganisms in EM improve crop health and yield by increasing photosynthesis, producing bioactive substances such as hormones and enzymes, accelerating decomposition of organic materials and controlling soil-borne diseases [14]. Previous studied on EM application have revealed that plant growth in EM applied treatment was just as good or better, and quality of plant products was superior to conventional farming [16] on snap bean.

Therefore, the aim of this work was to study the effect of seaweed extract, humic acid and effective microorganisms alone or combination between them compared with the controlon vegetative growth, yield and its components and pod quality of snap beans.

MATERIAL AND METHODS

This experiment was carried out under plastic house conditions during winter seasons of 2014 - 2015 and 2015 - 2016 at the Agricultural Experiment Station, Faculty of Agriculture, Cairo University to study the effect of some bio-stimulants materials, i.e., seaweed extract (SWE) as foliar spray, humic acid (HA) and effective microorganisms (EM) as soil application and combination between them compared with the control (spray with water only) on vegetative growth parameters, total yield and its components and pod quality of snap beans (*Phaseolus vulgaris* L.) cv. Hama. The physical and chemical properties of the loamy soil under study (Table 1) were determined at the Soil and Water Research Institute, ARC. Seeds of snap bean cv. Hama were sown in 15th and 21th October in 2014 and 2015 seasons respectively. The plastic house was 40 m long and 8 m wide (320 m^2) and divided into five beds, each 1 m wide and 40 m long. The experiment occupied three beds. Seeds were sown in hills on two sides of each bed and 50 cm apart, plants were thinned leaving one plant/hill.

Seaweed extract (Oligo-X as commercial name) was obtained from Union for Agriculture Development (UAD) Company, Cairo, Egypt; it contains organic matter (6% total amino acid, 35% carbohydrate, 10%alginic acid, 4% mannitol, 0.04% betaines); growth regulators (0.03% IAA, 0.02% cytokinins (adenine)) and some macro and micro elements(3.12 % N, 2.61 % P_2O_5, 4.71 % K_2O, 0.25 %Ca, 3.56 % S and 0.58% Mg). Humic acid (Hammer as a commercial name) was obtained from Union for Agriculture

Development (UAD) Company, Cairo, Egypt; it contains humate potassium 85% and potassium oxide 10%. Effective microorganisms (EM commercial name) were obtained from Ministry of Agriculture and Land Reclamation; it contains (photosynthetic bacteria, lactic acid bacteria, yeast and the others).

This experiment included eight treatments as follow:

1- Foliar spray with water (control).
2- Seaweed extract (SEW) at 0.2% (2cm/l).
3- Humic acid (HA) at 0.2% (2g/l).
4- Effective microorganisms (EM) at 0.2% (2cm/l).
5- Seaweed extract + Humic acid (SWE + HA).
6- Seaweed extract + Effective microorganisms (SWE + EM).
7- Humic acid + Effective microorganisms (HA + EM).
8- Seaweed extract + Humic acid + Effective microorganisms (SWE + HA + EM).

These treatments were added three times during the growth period of snap bean plants at 30, 45, 60 days after sowing and the fertilizers weremanually added separately for each plant.

The previous treatments were arranged in a complete randomized block design with three replicates. The area of each plot was 5 m^2 with 20 plants. Each replicate considered as of one plot. The recommended agricultural practices for commercial snap bean production, i.e., drip irrigation; fertilization and weed control were followed according to Ministry of Agriculture recommendation.

The following data were recorded:

Vegetative growth

A representative sample of 5 plants was taken by random 65 days after sowing (flowering stage), from each experimental plot for measuring plant growth characters:

Plant height from the soil surface to the highest point of the plant (cm), number of leaves per plant, total chlorophyll content in leaves was measured as SPAD units using monitor chlorophyll meter (SPAD- 501).

Yield and its components

At harvesting time during the first week of January (75 days from sowing) snap beans were picked for estimation of yield parameters:

Pod weight/plant (g), number of pods/plant,total yield/ plot (kg) (Determined for all pickings and calculated as total fresh weight of pods).

Pods quality characteristics

A random sample of 30 pods from each replicate was taken at harvest and examined for the following characters:

Physical properties

Pod length (cm)and pod diameter (mm) was measured by a Vernier Caliper, pod texture (g/cm^2) was recorded by TA-1000 texture analyzer instrument using a penetrating cylinder of 1 mm diameter, to a constant distance (3 and 5mm) inside the pulp of fruits, and by a constant speed 2mm per sec., and the peak of resistance was recorded in g/cm^2.

Chemical properties

Dry matter percentage (%), ascorbic acid content (mg/100g pod fresh weight) was determined by titration method using 2,6 dichloro-phenol-indo-phenol the dye as described in [1], total chlorophyll content

(mg/100g pod fresh weight) in pods: it was determined according to the method described by [33], total carbohydrates percentage (%) in pods:It was measured according to[7],protein percentage (%) in pods: it was calculated by multiplying the total nitrogen by the factor 6.25, it was determined according to [1], fiber percentage (%) in pods: it was determined according to [23].

Statistical analysis

Data in the two seasons were subjected to statistical analysis as described by [29]. Treatment mean differences were compared using LSD test to evaluate the significant differences of the data at $p \geq 0.05$.

RESULTS AND DISCUSSION

Vegetative growth

Data in Table 2 showed that snap bean plants treated with SWE, HA and EM alone or the mixture between them had a significantly increased on all studied vegetative growth parameters (plant height, number of leaves/ plant and chlorophyll reading (SPAD) in leaves compared to the untreated plants (control) treatment. In this respect; plants treated with the mixture SWE + HA + EM produced the highest value of all growth parameters, followed by plant treated with the mixture of HA + EM with significant differences between them. On the other hand, the lowest values in this respect were recorded in the control treatment, plants treated with SWE, HA and EM alone were less effective in enhancing vegetative growth. These results were true in the two seasons and in agreement with [12] for humic acid on snap bean; [2]for seaweed on snap bean and [9] for HA or EM on snap bean.

Table 1: Physical and chemical characteristic of experimental soil as average of both seasons 2014/2015 and 2015/2016

Physical properties								
Sand %	Silt %		Clay %		Organic matter %		Texture	
19	48.4		30.4		2.2		loamy	
Chemical properties								
EC m.mhos/cm	pH	Cations (Meq.L^{-1})				Anions (Meq.L^{-1})		
		Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{-}
0.91	8	4.3	5.1	0.7	1.3	1.2	5.4	4.6

Table 2: Effect of some bio-stimulants materials on vegetative growth of snap bean plants during 2014 / 2015 and 2015 / 2016 seasons

Treatment [z]	2014 / 2015			2015 / 2016		
	Plant height (cm)	No. of leaves / plant	Total chlorophyll (SPAD)	Plant height (cm)	No. of leaves / plant	Total chlorophyll (SPAD)
Control	161.42	12.03	36.07	160.05	12.10	37.26
SWE	176.11	13.33	38.37	171.25	13.50	40.40
HA	193.56	15.08	39.37	188.17	15.25	41.46
EM	184.77	14.25	39.17	179.25	14.17	41.00
SWE + HA	199.57	15.92	39.57	198.50	16.17	41.87
SWE +EM	189.11	15.08	39.30	191.58	15.00	41.40
HA + EM	208.57	16.83	40.47	204.75	16.96	42.30
SWE + HA + EM	220.78	18.12	42.60	222.58	18.33	43.30
LSD at 5%	12.03	1.27	2.10	11.00	1.33	0.98

[z]**SWE:** seaweed extract; **HA:** Humic acid; **EM:** effective microorganisms

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The beneficial effect of seaweed extract application may be due to that seaweed extract contain naturally occurring supplying nutrients, plant growth hormones (auxins, cytokines and gibberellins) as well as other plant bio-stimulants; e.g. amino acids, vitamins, that could maintain photosynthetic rates, improve plant resistances, delay plant senescence and control cell division have been reported [2], improved total chlorophyll in leaves [3].

The increment in vegetative growth of bean plants by adding HA to the plant may be due to that HA contains many elements which improve the plant growth and its acting as a source of plant growth hormones. Also, increase the soil organic matter which improved retention of nutrients and increased the soil microbial activity, which converts the nutrients from organic to mineralized form as reported by [30]. Humic acid compounds including increased photosynthesis and respiration rates in plants [5]. And positive effects on chlorophyll contents of soybean [28].

The enhancing effect of EM of snap bean plant growth may be due to the activity of the introduced beneficial microorganisms, which enhanced the decomposition of organic materials and the release of nutrients for plant uptake [15]. Also, the activity of photosynthetic bacteria such as *Rhodopseduomanaspalustris* and *Rhodobactersphaeroides* present in EM solution. These bacteria are a group of independent, self-supporting microbes. They synthesize useful substances from secretions of plant roots, organic matter and harmful gases such as hydrogen sulfide, by using sunlight and the heat of soil as sources of energy [20]. The useful substances produced by these bacteria include amino acids, polysaccharides, nucleic acids, bioactive substances, and sugars, all of which promote plant growth and development. The metabolites developed by these microbes are absorbed directly by plants [24].

Yield and its components

Data in Table 3 showed that snap bean plants treated with SWE, HA and EM either alone or in combination between them had significantly increased pod weight, number of pods/plant and total pod yield compared to control plants. However, plants treated with the combination SWE, HA and EM was the most favorable treatment for enhancing pod weight (9.73 and 9.71 g), number of pods per plant (67.23 and 69.83) and total pod yield (126.17 and 129.66 kg/plot) in the first and second seasons respectively, followed by plants treated with HA+EM with significant differences between them in the two seasons. The increase in yield was due to increases in number of pods as well as weight of pod per plant. Whilethe lowest values in this respect were recorded in the untreated plants (control) treatment.

Table 3: Effect of some bio-stimulants materials on total yield and its components of snap bean plants during 2014 / 2015 and 2015 / 2016 seasons.

Treatment [z]	2014 / 2015			2015 / 2016		
	Pod weight /plant (g)	No. of pods / plant	Total pod yield (kg)/plot	Pod weight /plant (g)	No. of pods / plant	Total pod yield (kg)/plot
Control	8.00	51.67	82.96	8.06	48.83	80.13
SWE	8.40	54.00	90.61	8.23	52.58	86.45
HA	8.84	56.10	99.04	8.66	57.00	100.31
EM	8.65	54.81	94.70	8.53	53.72	91.75
SWE + HA	9.10	57.68	104.76	8.92	56.42	102.20
SWE +EM	8.77	56.00	98.10	8.60	54.00	92.80
HA + EM	9.26	59.14	109.40	9.41	57.25	108.82
SWE + HA + EM	9.73	67.23	126.17	9.71	69.83	129.66
LSD at 5%	0.38	2.20	6.41	0.16	2.35	6.10

[z]**SWE:** seaweed extract; **HA:** Humic acid; **EM:** effective microorganisms**.**

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These results were true in the two seasons andin agreement with [12] for humic acid on snap bean; [2] for seaweed on snap bean and [9] on snap bean for HA and EM.

The beneficial effect of seaweed extract application on yield and its components of snap bean may be due to the increasing in vegetative growth parameters, also increase in number of pods as well as weight of pods per plant [2,19] found that treatment with seaweed extracts on yield has enhancement effects due to improved chlorophyll content in leaves of various crop plants have been attributed to the betaines present in seaweed, yield increases in seaweed-treated plants are thought to be associated with the hormonal substances present in the extracts, especially cytokinins; cytokinins in vegetative plant organs are associated with nutrient partitioning, whereas in reproductive organs, high levels of cytokinins may be linked with nutrient.

The enhancing effect of humic acid on yield and its components could be explained as humic acid is rich in both organic and mineral substances which are essential to plant growth and consequently increase yield quality and quantity [11]. Also, humic acid enhancing effect on increase soil moisture holding capacity, improve soil texture as well as promote the uptake of nutrients leading to stimulation of plant growth and consequently on total pods yield and its components [35].

The enhancing effect of EM of snap bean yield may be due to that EM may have induced other mechanisms that exert a positive effect on the yield [13].

Pod quality

Data in Table 4&5revealed that all studied applications significantly increased pod quality (pod length, texture, dry matter, ascorbic acid, total chlorophyll content, total carbohydrate, and protein) in snap bean pods comparing with control pods. In this respect, snap bean pods obtained from the plant treated with SWE + HA + EM was the most effective treatment for improving pod quality ,followed by HA+ EM treatment with significant differences between the mof these characters. The lowest values of these characters were resulted by untreated plants control. However, concerning pod diameter, there were no significant differences between all treatments in the two seasons.

Table 4: Effect of some bio-stimulants materials on physical properties of snap bean pods during 2014 / 2015 and 2015 / 2016 seasons

Treatment [z]	2014 / 2015				2015 / 2016			
	Pod length (cm)	Pod diameter (cm)	Pod texture (g/cm^2)	Dry matter (%)	Pod length (cm)	Pod diameter (cm)	Pod texture (g/cm^2)	Dry matter (%)
Control	12.77	8.27	23.00	5.80	12.89	8.43	21.30	5.32
SWE	13.44	8.43	24.22	6.30	13.76	8.55	22.60	5.69
HA	14.58	8.57	26.40	6.93	14.40	8.71	26.20	6.16
EM	13.91	8.51	25.80	6.74	13.82	8.67	25.10	6.04
SWE + HA	14.93	8.67	27.00	7.13	14.74	8.80	27.63	6.49
SWE +EM	14.38	8.64	26.20	6.85	14.28	8.74	25.94	6.24
HA + EM	15.41	8.76	27.30	7.40	14.92	8.80	27.87	6.78
SWE + HA + EM	15.94	8.82	28.00	7.82	15.37	8.84	28.93	7.26
LSD at 5%	0.49	NS	0.67	0.38	0.40	NS	1.03	0.36

[z]**SWE:** seaweed extract; **HA:** Humic acid; **EM:** effective microorganisms

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Table 5: Effect of some bio-stimulants materials on chemical properties of snap bean pods during 2014 / 2015 and 2015 / 2016 seasons

Treatment [z]	Ascorbicacid (mg/100 g f.w.)	Total chlorophyll (mg/100 g f.w.)	Total carbohydrate (%)	Protein (%)	Fiber (%)
	2014 / 2015				
Control	15.00	40.02	22.34	15.80	13.62
SWE	15.40	40.71	23.69	17.05	13.10
HA	16.01	41.62	24.30	18.31	12.70
EM	15.82	41.41	24.00	17.60	12.90
SWE + HA	16.81	41.72	24.75	18.62	12.50
SWE +EM	16.60	41.53	24.40	18.40	12.60
HA + EM	17.00	43.04	26.00	19.10	12.20
SWE + HA + EM	17.70	43.63	27.51	20.74	11.40
LSD at 5%	0.38	0.58	1.33	1.20	0.46
	2015 / 2016				
Control	15.37	39.77	24.41	17.30	12.50
SWE	16.07	40.90	26.20	18.60	12.12
HA	16.83	42.20	27.24	19.40	11.80
EM	16.30	41.92	27.11	19.00	12.00
SWE + HA	18.13	42.83	27.98	19.80	11.61
SWE +EM	17.50	42.10	27.43	19.60	11.70
HA + EM	18.57	43.62	28.68	20.80	11.10
SWE + HA + EM	19.10	44.30	31.11	22.30	10.21
LSD at 5%	0.52	0.67	1.46	1.25	0.30

[z]**SWE:** seaweed extract; **HA:** Humic acid; **EM:** effective microorganisms

The improvement of growth of snap bean plants in response to application of SWE + HA + EM may result in improving the quality of snap bean pods. These results were in agreement with [12] for humic acid on snap bean;[2] for seaweed extract on snap bean and [9] for HA and EM on snap bean.

There was significant reduction in fiber content in pods obtained from plants treated with SWE + HA + EM as compared with the other treatments or untreated control (Table 5). On the other word the minimum values of fibers (11.40 and 10.21) were obtained from plants treated with SWE + HA + EM; while, untreated plants gave a maximum values of crude fibers (13.62 and 12.50)in the first and second seasons, respectively. These results were in agreement with [2] for seaweed on snap bean; [22] for HA and SWEon pea and [9] for HA and EM on snap bean.

[10] found that the SWE treatment on improved viciafaba quality might be due to the consequence of uptake of magnesium content from SWE; SWE can improve the accumulation of total carbohydrate, total protein, and total chlorophyll content.

The stimulatory effects of humic substances have been directly correlated with enhanced uptake of macronutrients, such as nitrogen, phosphorus, and sulfur [5], increasing plant growth promoters [17], which reduce fiber contents in addition to increasing assimilate production which mean higher carbohydrate going to the pods and less stress on the growing pods [31], increase total chlorophyll, protein % and total carbohydrate % of common bean pods [12].

The exact mechanisms of EM interacts and functions have been attributed to many factors including suppression of plant pathogens and diseases, enhanced nutrient availability and stimulated plant growth i.e., auxinmediated effects [13]. Also, it has a beneficial role in accelerating the mineralization processes of organic and helps nutrient release under temperate conditions and this enhances activity [21] and photosynthesis [34].

CONCLUSION

From the previous results, it could be concluded that snap bean plants cv. Hama treated with the mixture of SWE + HA + EM improved vegetative growth parameters of plants, total yield and its components and pod quality.

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