USE OF SOME EGYPTIAN SEAWEED AS FOLIAR FERTILIZER FOR *VICIA FABA* L.

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Abstract

Three common marine algae, *Enteromorpha intestinalis, Ulva lactuca* and *Sarconema filiformis* were collected from Suez Canal at Ismailia and chosen to examine their effects as a foliar spray on the growth and yield of faba beans in the Experimental Farm, Fac. of Agric., Suez Canal Univ., Ismailia in November 2006. The aqueous algal extracts were sprayed at concentrations of 0.05, 0.10 and 0.15; each was sprayed four times throughout the vegetative growth period of the plant. The results confirmed that application of eco-friendly fertilizers, derived from marine algae, was effective in increasing the measurements of growth and yield parameters. At the end of the growing season, *Vicia faba* plants grown with the foliar seaweed application had produced 1.6 to 2.25 folds of the unfertilized controls with using *E. intestinalis*, 1.7 to 2.4 folds using *U. lactuca* and 2.5 to 5.6 folds with using *S. filiformis*. This production may be referred to the minerals, hormone-like substances, amino acids and vitamins in different algae. The present production of broad bean did not reach the Egyptian yield of feddan and this may be attributed to the low PNK in algae. The present study concluded that seaweed products should be boosted with additional supplement of NPK.

Keywords: Faba bean, Natural fertilizer, Seaweed fertilizer.

Introduction

The natural biological biofertilizer has been identified as the best alternative to the chemical fertilizers in order to improve the soil fertility and, consequently, increase the crop production in sustainable farming. However, the continuous and judicious use of the biofertilizer improves the physical and chemical properties of nearly all soil types, particularly those which are shallow, coarse texture, or poor organic matter (**Aseri *et al*., 2008**). In recent years, biofertilizers have emerged as an important component of the integrated nutrient supply system and hold a great promise to improve crop yields through environmentally better nutrient supplies. It is containing living cells of different types of microorganisms, which have an ability to convert nutritionally important elements from unavailable to available form through biological processes (**Hegde *et al*., 1999 and Vessey, 2003**).

Biofertilizers such as seaweeds have a multiple uses in agriculture and they could be considered as a source of natural organic, non-polluted and renewable fertilizer. **Booth** (**1966**) observed that the value of seaweeds as

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fertilizers was not only due to nitrogen, phosphorus and potash content, but also because of the presence of trace elements and metabolites. Liquid extracts obtained from seaweeds have recently gained importance as foliar sprays for several crops (**Agenbag, 1989; Nelson and van Staden, 1984; Salah El Din *et al*., 2008**), because the extract contains growth promoting hormones (IAA and IBA), cytokinins, trace elements (Fe, Cu, Zn, Co, Mo, and Mn), vitamins and amino acids (**Challen and Hemingway, 1965**). Seaweed fertilizer was found to be superior to chemical fertilizer because of the high level of organic matter aids in retaining moisture and minerals in the upper soil level available to the roots (**Cardozo *et al*., 2007**). The effect of seaweed extract depends on the type of the crop, its stage and the composition as well as concentration of seaweed applied (**Blunden and Guiry, 1991; Salah El Din *et al*., 2008**). In biological agriculture, diluted seaweed extracts are applied with the aim of promoting growth, stress resistance; prevent pests and diseases, and improving the quality of the products (**Sanker *et al*., 2001; Zodape, 2001; Malaguti *et al*., 2002; Arthur *et. al*., 2003**).

In Egypt, seaweeds occur along coastlines of Red Sea and Mediterranean but little attention has been directed to use them as biofertilizers (e.g., **El-Sheekh and El-Saied, 2000**). The objective of this work was to explore the Egyptian seaweeds in preparing sprays that could be useful in promoting the growth characters and improving the quality of the *Vicia faba* L., one of the richest sources of protein, plays an important role in the socio-economic life of Egyptian populations.

Materials and Methods

Collection of seaweeds

Three seaweed species were used in the present study, *Ulva lactuca* (Linnaeus), *Enteromorphra compressa* (Linnaeus) Greville from Chlorophyta and *Sarconema filiforme* Rayss from Rhodophyta. They were collected from a concrete shore, a half meter below water mark, on the Suez Canal nearby Ismailia city. The collection was carried out during May, 2006 and June, 2007. Selection of these species was based on the common presence and whole year round availability in the considering area. Algal samples were hand picked and washed thoroughly with seawater to remove all the unwanted impurities, adhering sand particles and epiphytes. Thalli of each alga were quickly rinsed with the tap water for removing salts, dripped, quickly dried on blotting paper and weighed. The samples were air-dried in a dark room, grind, sieved to remove fine sand, re-weighed, and packed in labeled nylon bags. Species identification was carried out according to **Aleem** (**1993**).

Preparation of seaweed extract

A kilogram of each algal sample was soaked overnight in a liter of distilled water, then filter with a muslin cheesecloth tissue and freezed at -20°C. For use, the filtrate was milted and the concentration of the extract considered being 100%. Of this extract, different concentrations of 5%, 10%, and 15%) were prepared using distilled water.

Crop cultivar

The cultivar of *Vicia fabea* L. was Nubaria-1, a Leguminosae plant, whereas selected from Giza Blanka cultivar. Seeds were received from the Agriculture Research Center, Food Legumes Research Section, Giza, Egypt.

Experimental site and its characteristics

The experimental site located located at 30º 37' 4.47"N and 32º 15' 48.66"E, 15 m above sea level the Experimental Farm, Fac. of Agric., Suez Canal Univ., Ismailia, Egypt. The average high temperature of Ismailia region is 28.2°C, while the average low temperature is 14.7°C; the precipitation is 35 mm. The pH, texture, organic matter and available nutrients were first measured to characterize the soil fertility status and texture. The soil of the site was a sandy textured soil (94.5% sand, 2.5% silt and 3.0% clay) with pH of 7.8. The experimental soil contained available nitrogen (N), 3.15 and 3.33 ppm; available phosphorus (P), 1.81 and 1.84 ppm and available potassium (K), 11.68 and 11.76 ppm for seasons 2006 and 2007, respectively.

Experimental design

Three concentrations of each alga (0.05, 0.10 and 0.15) were used, in addition to control. Each subplot (Experimental unite) had an area of 5.40 m^2, with 4 ridges, 3 m long and 0.45 m width, with single seed per hill and a spacing of 20 cm between hills. The Nubaria-1 cultivar seeds were sowed in November 2006.

Algal Foliar applications

Four foliar applications of each concentration of the alga were applied at 30, 51, 72 and 93 days from sowing. No manure, chemical fertilizers or pesticides were used during the period of study. All recommended practices for Faba bean production were applied at optimum level.

Field data collection

Data on vegetative, yield and quality characters of the experimental crops was gathered during growth period and at harvesting at two days before second, third and forth sprays. Plant height (in cm), number of branches, number of leaves and date of the first flower emerge were recorded just before every spray with algal extract. At harvesting of faba, number of pods per plant, shedding rate, and weight of 100 seeds (gm), seed yield per plant (gm) were measured and the seed yield per plot (kg) was then estimated.

Laboratory data collection and analysis

Major (N, P, K) and minor (Ca, Fe, Mn, Zn and Mg) nutrients were measured in dried algae at Agriculture Analytical Laboratory Unit in Agric. Fac., Suez Canal University. While vitamins (A and C) and hormones (gibberellins, indole acetic acid, cytokinins and abscisic acid) were measured in fresh algae at the Central Lab of Agric. Fac. Centre, Cairo University. Moisture content, ash content, total carbohydrates (**de Pádua *et al.*, 2004**), total proteins, lipids, and crude fibers were estimated as described in **AOAC** (**1990**).

Statistical Analysas

Data were analysed using an analysis of variance of a split-plot design, with treatments (alga) as the main plot, concentration as sub-plot as well as replicates as blocks. Statistical analysis was done using MINITAB® Release 14.1, (MINITAB Inc., 111222333, 2003).

Results

Chemical composition of seaweeds

The macro- and micronutrients, vitamins and growth hormones were measured in *Enteromorpha intestinalis, Ulva lactuca* and *Sarconema filiformis* and presented in Tables (1). The marine derived foliar fertilizers used in this study had very low NPK values as they were 2.32, 0.40 and 0.50 in the first species, 1.45, 0.25 and 1.32 in the second and 1.63, 0.33 and 0.60 in the third species. All the three algae characterized by high contents of magnesium (268.56 $mg.100g^{-1}$ in *U. lactuca* to 362.48 $mg.100g^{-1}$ in *S. filiformis*) and low contents of iron (21.6$mg.100g^{-1}$ in *E. intestinalis* to 31.05$mg.100g^{-1}$ in *S. filiformis*). Calcium was high in both *E. intestinalis* and *U. Lactuca*, but low in *S. filiformis*.

Table (1): Macro-, micronutrients, vitamins and growth hormones measured in explored algae.

Algae	N	P	K	Ca	Mn	Mg	Zn	Fe	A	C
E. intestinalis	**2.32**	**0.40**	**0.50**	**173.1**	**72.8**	**253.7**	**21.9**	**21.6**	**2166.7**	**20.9**
U. lactuca	**1.63**	**0.33**	**0.60**	**203.9**	**116.8**	**268.6**	**82.6**	**26.6**	**2583.3**	**27.6**
S. filiformis	**1.45**	**0.25**	**1.32**	**84.6**	**67.8**	**362.5**	**77.9**	**31.1**	**1583.3**	**18.5**

N, nitrogen, P, phosphorous, and K, potassium measured as percentages; Ca, calcium, Mn, manganese, Mg, magnesium, Zn, zinc and Fe, iron measured as $mg.100g^{-1}$; A, vitamin A measured as $IU.100g^{-1}$and C, vitamin C measured as $mg.100g^{-1}$.

The zinc contents were varied from 21.85$mg.100g^{-1}$ in *E. intestinalis* to 82.62$mg.100g^{-1}$ in *U. lactuca*. The later species possessed the highest value of manganese (116.82$mg.100g^{-1}$). *U. lactuca* scored the highest content of vitamin A

(2583.30 IU.100g^{-1}), followed by *E. intestinalis* (2166.70 IU.100g^{-1}) and about the half was found in *S. filiformis* (1583.3 IU.100g^{-1}). Vitamin C was also low in *S. filiformis* (18.48mg.100g^{-1}) and high in the other species (20.93-27.58mg.100g^{-1} for *E. intestinalis* and *U. lactuca*, in respectively).

Gibberellins, indole acetic acid, abscisic acid, and cytokinins were identified and measured in different used algae (Table 2). *S. filiformis* characterized by high content of gibbrellic acid (58mg.100g^{-1}) and low content of abscisic acid (1.29 mg.100g^{-1}). Cytokinin was 34.4mg.100g^{-1} and indoleacetic acid was 3.18 mg.100g^{-1} in this alga. *E. intestinalis* and *U. lactuca* showed a high contents of cytokinin (46.3 and 65.4 mg.100g^{-1}, respectively) and gibbrellic acid (25.5 mg.100g^{-1} and 37.0 mg.100g^{-1}, respectively).

Table (2): The growth hormone contents (mg.100g^{-1}) measured in different algae.

Algae	Gibbrellic acid	Indole acetic acid	Abscisic acid	Cytokinin
E. intestinalis	**25.50**	**0.34**	**0.47**	**46.30**
U. lactuca	**37.00**	**3.12**	**1.42**	**65.40**
S. filiformis	**58.00**	**3.18**	**1.29**	**34.40**

Effects of algal extracts on vegetative characters during growth period of *Vicia faba* (Plant height)

Table (3) shows the variability of the plant heights with different algal concentrations, which measured after 49, 70 and 91 days of sawing date. It is worth to mention that plants were sprayed two weeks before each of these time schedule. After 49 days of sawing date, *S. filiformis* had a greater effect on the plant height than the other algal species with prominent at 0.05 concentration than its effect at 0.10 and 0.15 concentrations.

Table (3): Effects of algal concentrations on *Vicia faba* plant heights (mean ± SD cm) measured after 49, 70, and 91 days after sawing.

Treatment	Conc.	After 49 days	After 70 days	After 91 days
Control	**0.00**	**21.28 ± 1.79**	**31.79 ± 4.46**	**47.92 ± 6.95**
E. intestinalis	**0.05**	**25.19 ± 6.34**	**38.60 ± 7.44**	**52.67 ± 8.09**
	0.10	**27.07 ± 5.52**	**44.80 ± 6.55**	**64.38 ± 5.85**
	0.15	**27.59 ± 4.02**	**44.14 ± 4.32**	**60.88 ± 11.80**
U. lactuca	**0.05**	**21.33 ± 3.65**	**35.27 ± 7.44**	**53.57 ± 7.66**
	0.10	**23.59 ± 3.51**	**36.63 ± 7.45**	**51.25 ± 8.01**
	0.15	**24.81 ± 4.19**	**39.88 ± 5.01**	**46.25 ± 16.18**
S. filiformis	**0.05**	**33.18 ± 2.95**	**49.73 ± 7.65**	**56.30 ± 13.13**
	0.10	**31.15 ± 3.61**	**46.19 ± 12.05**	**63.78 ± 8.44**
	0.15	**30.46 ± 2.28**	**47.91 ± 4.78**	**67.00 ± 10.58**

E. intestinalis and *U. lactuca* (except the lower concentration) affected also the plant heights of *V. faba* when compared with the control. After 70 days of sawing date, all algae showed a superior effect of one third than the control, and the *S. filiformis* had also the greatest effect on the plant height as compared with the other species.

The effects of all concentrations of *U. lactuca* were close. On the other hand, the plant heights of *V. faba* increased with the increased concentration of *E. intestinalis*. After 91 days of sawing date, the all algae had a better effect than the control except for those treated with *U. lactuca* at concentration 0.15 and *E. intestinalis* at concentration 0.5. *S. filiformis* at 0.15 had the greatest effect on the plant height as compared with the other species.

Number of branches per plant

Almost all algal treatment had a similar effect on the number of branches per plant (Table 4). After 49 days of sawing date, three branches were approximately emerged on broad bean plants treated with *U. lactuca* and *E. intestinalis*; meanwhile the average on the plants treated by *S. filiformis* appeared similar with control plants. The average number of branches per plant, after 70 days of sawing date increased by 1 to 2 branches and *U. lactuca* had the greatest effect on number of the branches per plant as compared with the other species. While, after 91 days of sawing date, the number of branches per plant were remained more or less similar to that of the second treatment.

Table (4): Effects of algal concentrations on *Vicia faba* number of branches (mean ± SD) measured after 49, 70 and 90 days after sawing.

Treatment	Conc.	After 49 days	After 70 days	After 91 days
Control	**0.00**	**2.81 ± 0.98**	**2.86 ± 1.03**	**2.83 ± 1.03**
E. intestinalis	**0.05**	**3.38 ± 1.15**	**4.25 ± 1.29**	**3.22 ± 0.67**
	0.10	**2.88 ± 0.89**	**3.50 ± 0.85**	**3.50 ± 1.07**
	0.15	**3.19 ± 0.91**	**3.13 ± 1.25**	**5.13 ± 4.02**
U. lactuca	**0.05**	**3.69 ± 0.70**	**4.93 ± 1.22**	**4.57 ± 1.09**
	0.10	**3.19 ± 0.40**	**5.00 ± 1.86**	**4.92 ± 1.93**
	0.15	**3.69 ± 1.25**	**4.50 ± 1.51**	**3.88 ± 1.67**
S. filiformis	**0.05**	**2.44 ± 0.63**	**4.00 ± 1.77**	**3.60 ± 1.84**
	0.10	**2.63 ± 0.72**	**3.31 ± 1.35**	**4.33 ± 1.94**
	0.15	**2.63 ± 0.96**	**3.44 ± 1.09**	**4.00 ± 2.10**

Number of the leaves/plat and leaf area

The number of leaves per plant of *Vicia faba* (Table 5) showed that after 49 days, *E. intestinalis* and *U. lactuca* had a greater effect than *S. filiformis*, which was also less than the control plants. After 70 days, all algae had greater effects on the number of leaves of *Vicia faba.* After 75 days, the control plants produced leaves in a number approximately similar to *E. intestinalis* at 0.05 and 0.01 and *U. lactuca* at 0.05 and *S. filiformis* at 0.15; meanwhile the other concentrations produced leaves more than the control plants. It should be mentioned that no sign of nutrient deficiency or plant disease had been seen during the growth period of *Vicia faba.* The effects of the first algal treatments on leaf area (Table 5) showed that all concentrations increased the leaf area by 1-2 cm^2 compared with control plants. After the second treatments, the leaf areas appeared more or less similar to control except at 0.05 concentration of *E. intestinalis* where the area increased by 5.5 cm^2.

Table (5): Effects of algal concentrations on *Vicia faba* number of leaves and leaf area (mean ± SD) measured after 49, 70, and 91 days after seed sawing.

Treatment	Conc.	Number of leaves			Leaf area (cm^2)	
		After 49 days	After 70 days	After 91 days	After 49 days	After 70 days
Control	**0.00**	**21.1 ± 6.6**	**33.2 ± 11.6**	**64.1 ± 11.9**	**9.2 ± 1.2**	**20.2 ± 25.7**
E. intestinalis	**0.05**	**24.9 ± 8.9**	**52.4 ± 17.8**	**59.8 ± 20.3**	**13.4 ± 1.5**	**25.7 ± 35.2**
	0.10	**21.7 ± 6.7**	**47.0 ± 15.8**	**67.9 ± 14.9**	**12.6 ± 1.6**	**22.8 ± 26.5**
	0.15	**23.9 ± 5.9**	**43.8 ± 13.4**	**77.1 ± 13.4**	**12.2 ± 1.5**	**17.8 ± 26.3**
U. lactuca	**0.05**	**23.8 ± 3.5**	**46.1 ± 11.7**	**61.4 ± 14.4**	**11.9 ± 1.9**	**20.6 ± 27.3**
	0.10	**24.0 ± 4.9**	**51.3 ± 14.8**	**73.6 ± 21.1**	**13.8 ± 1.5**	**21.9 ± 29.3**
	0.15	**24.1 ± 6.7**	**51.2 ± 15.7**	**80.8 ± 24.9**	**12.1 ± 2.0**	**22.2 ± 27.4**
S. filiformis	**0.05**	**20.0 ± 3.8**	**58.5 ± 17.1**	**81.6 ± 16.6**	**13.8 ± 2.1**	**22.0 ± 26.2**
	0.10	**19.6 ± 4.7**	**52.1 ± 13.7**	**76.9 ± 19.6**	**13.3 ± 2.9**	**20.7 ± 26.7**
	0.15	**17.8 ± 7.7**	**49.1 ± 16.3**	**69.7 ± 22.9**	**11.8 ± 1.3**	**20.3 ± 24.6**

Effects of algal extracts on criteria of yield components in *Vicia faba*

The seed yield components of *Vicia faba* (Table 6) was measured at the end of the growing season (*i.e.* 91 days after seed sawing). All these criteria were superior in measurements than with the control. Exception was found for the measurements of the average length of the five buds. All algal applications increased the number of flowers from 41.5 to 93.38 than it was found with control (36.86). The effect was increased from 0.05 to 0.10 concentrations, but lower again at concentration 0.15, except with *U. lactuca* that had the greatest number of flowers per plant (93.38). The lack of adequate pollination and reduced seed setting can be major constraints to yield. Many flowers drop and seed abortions were found as the average number of buds (ANB) and the average number of pods are greatly decreased in comparison with the average number of flowers (Table 6). For all algal applications, the number of flowers was from 27.13 to 67.44 and the number of pods was 4.18-10.88 per plant. The number of flowers and pods increased with the increases in algal concentrations from 0.05 to 0.15, except S. filiformis at 0.15.

Table (6): The average number of flowers (ANF), buds (ANB), pods (ANP), height of first bud (AHFB) per plants as well as the average length of 5-pods (AL5P), the total number of seeds (TNOS) and their weights (TS Wt) per plot.

Treatments	Conc.	ANF	ANB	ANP	AHFP	AL5P	TNOS	TS Wt
Control	0	36.86	27.71	3.92	10.75	7.47	164	175.3
E. intestinalis	0.05	47.64	27.13	4.18	21.00	9.09	179	203.3
	0.1	81.58	45.58	5.58	12.58	8.33	266	394.4
	0.15	63.36	48.55	6.36	18.18	7.60	250	376.1
U. lactuca	0.05	66.63	48.75	5.88	12.63	5.86	220	304.9
	0.1	72.21	55.50	6.07	13.57	6.56	211	311.7
	0.15	93.38	67.44	10.88	16.88	7.60	267	423.6
S. filiformis	0.05	69.06	49.69	8.25	13.33	7.95	356	475.3
	0.1	71.50	64.75	10.31	19.56	9.00	600	980.5
	0.15	45.67	41.19	9.17	25.83	8.37	254	443.3

The average height of the first pod (AHFP) was ranged from 12.58 to 25.83 cm for all algal applications and 10.75 cm for the control (Table 7). The height increased with the increasing of algal concentration, except with *E. intestinalis*, where the lower concentration corresponded high position of the first pod. The average length of five pods (AL5P) fluctuated between 6.56 cm by application of *U. lactuca* at concentration 0.05 to 9.09 cm by application of *E. intestinalis* at the same concentration. The length of pods in control (7.6 cm) was approximately comparable to *E. intestinalis* and *U. lactuca* at 0.15 and to *S. filiformis* at concentration 0.05 (Table 7).

Table (7): General Linear Model of ANOVA of vegetative measures of *Vicia faba*. Values in the cells are the F variance ratio (above) and P level of probability (below).

Source of variance	Plant height (cm)			Number of branches/plant			Leaf area index	
	After 49 days	After 70 days	After 91 days	After 49 days	After 70 days	After 91 days	After 49 days	After 70 days
Species	45.76 0.000	20.73 0.000	9.95 0.000	10.21 0.000	8.98 0.000	0.70 0.496	0.45 0.640	0.67 0.512
Conc.	30.52 0.000	26.8 0.000	9.06 0.000	1.97 0.120	10.18 0.000	5.23 0.002	55.67 0.000	10.56 0.000
Species by Conc.	7.33 0.000	3.62 0.000	30.12 0.007	1.69 0.126	1.35 0.238	1.49 0.188	2.18 0.047	4.02 0.001

The algal extracts stimulated the crop yield of *Vicia faba* as it was obvious from the total number of seeds and their weight per plot (Table 7). Where the total number of seeds was 164gm.plot^{-1} for control, it was from 179 by the application of 0.05 of *E. intestinalis* to 600 by application of 0.10 of *S. filiformis*. The range with algal treatments corresponded 394.4 to 980.5 gm.plot^{-1}. The number of seeds and the corresponding weight increased by increasing algal concentrations from 0.05 to 0.10, and then decreased again by application of 0.15 of all algae.

Significance of the measurements characters of *Vicia faba*

The vegetative and yield criteria were analyzed using ANOVA and the results of this analysis are listed in Table (8). The high ANOVA F-tests with the low p-level in these tables indicate that there was a significant evidence for effects of different algae, different concentrations and their combinations on almost criteria of *V. faba*. Exception was found for the number of branches, leaf area index, and in lesser extent for the number and length of pods as the F values was low with p-value exceed 0.05.

Table 8: General Linear Model of ANOVA of yield measures of *Vicia faba*.

Source of variance	Flowers	Number of buds	Number of pods	Height of first pod	Length of 5 pods	Number of seeds	Seeds weight
	After 70 days	After 91 days	After 91 days	After 91 days	After 91 days	After 91 days	After 91 days
Species	8.86 0.000	15.14 0.000	11.72 0.000	8.40 0.000	7.24 0.000	28.66 0.000	26.16 0.000
Conc.	41.72 0.000	46.31 0.000	17.92 0.000	21.83 0.000	4.62 0.004	11.26 0.000	17.72 0.000
Species by Conc.	9.47 0.000	7.63 0.000	4.17 0.001	7.14 0.000	1.86 0.092	3.63 0.002	3.90 0.001

The nutritional composition of *Vicia faba*

Proximate nutritional composition of broad bean was represented in Table (9). The treated samples of broad beans contained higher contents of ash (10.01 to 11.58 g.100g^{-1}), when compared to the control treatment (8.87 g.100g^{-1}). The total carbohydrates in treated samples (44.2-53.7 g.100g^{-1}) were more or less similar to control sample (53.8 g.100g^{-1}).

Table (9): Proximate nutritional composition of broad bean expressed as g.100g^{-1}

Treatment	Conc.	Ash	Carbohydrates	Proteins	Lipids	Fibers
Control	0.00	8.87	53.80	16.9	1.93	7.0
E. intestinalis	0.05	11.58	50.10	19.9	1.33	5.5
	0.10	10.58	51.70	20.8	1.13	4.5
	0.15	11.44	49.00	22.1	1.53	5.5
U. lactuca	0.05	11.58	50.10	20.1	1.33	5.5
	0.10	10.01	46.00	23.8	1.83	7.5
	0.15	11.30	47.50	20.8	1.33	8.5
S. filiformis	0.05	10.01	53.70	20.8	1.13	5.5
	0.10	10.44	50.60	23.6	1.33	4.0
	0.15	10.87	44.20	25.9	1.51	7.5

The protein in the seeds of treated samples was greater (19.9-25.9 g.100g^{-1}) than control (16.9 g.100g^{-1}); and percentage increased by the increase of algal concentration except at 0.15 concentration of *U. lactuca*. The maximum protein content (25.9 g.100g^{-1}) was found when the plants treated with *S. filiformis*. Both total lipids (1.13-1.83 g.100g^{-1}) and crud fibers (4.0-8.5 g.100g^{-1}) were less varied from the control (7.0 g.100g^{-1}).

Discussion

The marine derived fertilizers used in this study had very low NPK values. The NPK ratios were 2.32-0.40-0.50 in *E. intestinalis*, 1.45-0.25-1.32 in *S. filiformis* and 1.63-0.33-0.60 in *U. lactuca*. It would be difficult to meet the macronutrient needs of a growing plant when used these ratios as soil fertilizers. Although, many studies (e.g., **Chauhan**, **2002**; **Garg and Chauhan**, **2003**) have been shown the dried powdered seaweeds as a good source of manure when mixed with soil in small quantities, other studies suggested algae as foliar application (e.g., **Saxena *et al*.**, **2004**; **Chauhan**, **2005**). So that, using these percentages as foliar fertilizers with multiple applications in this study would be efficient to supply the growing plants with sufficient nutrients.

The advantages of using seaweeds as plant fertilizers could be coming from their micronutrients and other algal constituents. **Blunden and Wildgoose** (**1977**); **Smith and van Staden** (**1983**) have concluded that trace elements in very low quantity form a significant proportion of the total requirements of the crops. The present applications had an advantage where no signs of mineral deficiency or microbial attack had been detected on either the broad bean or maize. Ca in the present seaweeds was 173.08, 84.62 and 203.85 mg.100g^{-1}; Mn was 72.8, 67.76, and 116.82; Mg was 253.73, 362.48 and 268.56; Zn was 21.85, 77.88, and 82.62; Fe was 21.6, 31.05, and 26.63mg.100g^{-1} in *E. intestinalis*, *S. filiformis* and *U. lactuca*, respectively. The mineral contents of the present algae were higher than those measured by **Hong *et al***. (**2007**) in Vietnamese seaweeds.

Vitamins are important co-enzyme factors that play an important role for plant health. In the present study, greater amounts of vitamin A were recorded as 2583.30 IU.100g^{-1} in *U. lactuca*, 2166.70 IU.100g^{-1} in *E. intestinalis* and 1583.3 IU.100g^{-1} in *S. filiformis*. Three pro- vitamins are known as precursors of vitamin A in the algae, α, β-and γ-carotenes (**Delia**, **2001**). Other important algal carotenoids include lycopene, lutein, zeaxanthin and ß-cryptoxanthin (**Francis *et al*.**, **2007**; **Salah El Din *et al*., 2008; Vílchez *et al***., **2011**) and all have antioxidant effects. The levels of vitamin C in the present study were 20.93mg.100g^{-1} in *E. intestinalis*, 27.58mg.100g^{-1} in *U. lactuca*, and 18.48mg.100g^{-1} in *S. filiformis* and these were higher than those measured by other authors (e.g., **Burtin**, **2003**; **Hong *et al***., **2007**).

In addition to macro-, micronutrients and vitamins, seaweed components such as cytokinins, auxins, and abscisic acid (ABA)-like growth substances affect cellular metabolism in treated plants leading to enhanced growth and crop yield (**Durand *et al*.**, **2003**; **Stirk *et al*.**, **2003**; **Ordog *et al*.**, **2004**). Gibberellic acid, in the present study, was 25.5, 58.0 and 37.0 $mg.100g^{-1}$; Indole acitic acid was 0.34, 3.18 and 3.12 $mg.100g^{-1}$; abscisic acid was 0.47, 1.29 and 1.42 $mg.100g^{-1}$; and cytokinin was 46.3, 34.4 and 65.4 $mg.100g^{-1}$ in *E. intestinalis*, *S. filiformis* and *U. lactuca*, respectively. The hormonal contents of the present algae were higher than those measured by **Hong *et al*.** (**2007**) in Vietnamese seaweeds. The seaweeds was sprayed in low concentrations (0.05, 0.10 and 0.15 wt/wt) and many studies showed that the bioactive at low concentrations (diluted as 1:1000 or more) induced growth enhancement (**Crouch and van Staden**, **1993**). Although many of the various chemical components of seaweed extracts and their modes of action remain unknown, it is plausible that these components exhibit synergistic activity (**Fornes *et al*.**, **2002**; **Vernieri *et al*.**, **2005**). The active substances in the seaweed extracts must therefore be capable of having an effect at a low concentration. In addition, seaweeds are a source of unusual and complex polysaccharides, not present in land plants, and considered biologically active substances (**Duarte *et al*.**, **2001**). For example, the green seaweeds (*Ulva* and *Enteromorpha*) contain sulfated mucilages (glucuronoxylorhamnans) and the red seaweeds (*Sarconema*) contain furcellaran and rhodymenan, all have antifungal activities (**Rioux *et al*.**, **2007**).

The vegetative and yield criteria indicated a significant evidence for effects of different algae, different concentrations and their combinations on almost criteria of *Vicia faba*. Exception was found for the number of branches, leaf area index, and in lesser extent for the number and length of pods. A month after seed sawing, all the algal treatments initiated the plant growth to variable heights that were greater than the control treatment by 4 to 13.5 cm. This was also pronounced after another month as the height of treated plants exceeded the control by one third. The *S. filiformis* had the greatest effect on the plant height as compared with other species. By the end of the vegetative growth, the plant treated with the green species (*U. lactuca* and *E. intestinalis*) had heights more or less similar to control, meanwhile *S. filiformis* initiated more plant heights (75-85 cm) than the control (65 cm). In this connection, **Nakao *et al*.** (**1994**) proved that hot water extract of *Chlorella vulgaris* promoted radish shoot and root growth. Furthermore, present results are in a good accordance with those of **van Staden *et al*.** (**1995**) who observed an increase in root and shoot growth in three species of *Eucalyptus* treated with seaweeds concentrate (Kelpak). Also **El-Sheekh and El-Saied** (**2000**) stated that the crude extracts from different seaweeds showed increase of length of the main root and shoot system of *Vicia faba.*

All the algal treatments initiated more leaves by time in a manner corresponded to the increased plant heights. For control plants, the mean number of leaves was increased from 21 leaves a month after planting to 33 by the second month then by 64 leaves after the third month. For plants treated with *E. intestinalis*, the mean number of leaves was 22-25 at first month, 44-53 at second month and 60-77 leaves at the third month. For *S. filiformis*, these numbers were 17-20, 44-53 and 70-82, respectively. For *U. lactuca*, these numbers were 24, 46-51 and 61-81, respectively. **Thirumaran *et al*.** (**2009**) proved that the seaweed liquid fertilizer enhance the growth and yield parameters such as (shoot length, root length, number of lateral roots, leaves, vegetables, and weight of vegetables as well as the photosynthetic pigments.

The number of branches of treated *Vicia faba* plants did not greatly depart from the control as it was 3 or 4 branches per plant but rarely 5. The leaf area index of treated *Vicia faba* plants did not also greatly depart from the control after the first month; it was 9.19 cm^2 for the control and 11-13 cm^2 for algal treatments. After two months (60 days after sowing date), the leaf area index was 20 cm^2 for the control and 18-25 cm^2 for the treated plants. The low concentration (0.05) of *E. intestinalis* and *S. filiformis* and the high concentration (0.15) of *U. lactuca* were responsible for the wider the area of the *Vicia faba* plants. In a recent study (**Rayorath *et al*., 2008**), extracts of *A. nodosum* have been shown to enhance *Arabidopsis* height and number of leaves at concentrations of 1 g l^{-1}. Seaweeds enhance plant chlorophyll content (**Blunden *et al*., 1997**).

The results showed that all algal applications increased the number of flowers from 41.5 to 93.38 than it was found with control (36.86). The effect increased from 0.05 to 0.10 concentrations, but lower again at concentration 0.15, except with *U. lactuca* that had the maximum number of flowers per plant (93.38). The results showed that many flowers drop and seed abortions were found as the average number of buds and the average number of pods are greatly decreased in comparison with the average number of flowers. For all algal applications, the number of flowers was ranged from 27.13 to 67.44 and the number of pods was 4.18-10.88 per plant. The number of flowers and pods increased with the increases in algal concentrations from 0.05 to 0.15, except *S. filiformis* at 0.15. In many crops, yield is associated with the number of flowers at maturity (**Arthur *et al*., 2003**). As the onset and development of flowering and the number of flowers produced are linked to the developmental stage of plants, seaweed extracts probably encourage flowering by initiating robust plant growth.

The average height of the first pod was ranged from 12.58 to 25.83 cm for all algal applications and 10.75 cm for the control treatment. The height of the first pod increased with the increasing of algal concentration, except with *E. intestinalis* where the lower concentration corresponded high position of the first pod. The average length of five pods fluctuated between 6.56 cm by application of

U. lactuca at concentration 0.05 to 9.09 cm by application of *E. intestinalis* at the same concentration. The length of pods in control (7.6 cm) was proximately comparable to *E. intestinalis* and *U. lactuca* at 0.15 and to *S. filiformis* at concentration 0.05.

The algal extracts stimulated the crop yield of *Vicia faba* as it is obvious from the total number of seeds and their weight per plot. Where the total number of seeds was 164 per plot for control, it was from 179 by the application of 0.05 of *E. intestinalis* to 600 by application of 0.10 of *S. filiformis*. The weight with all algal treatments was from 394.4 to 980.5 gm. Seed yield increases in seaweed-treated plants are thought to be associated with the hormonal substances present in the extracts, especially cytokinins (**Featonby-Smith**, **1983 a**, **b**). Cytokinins have been implicated in nutrient mobilization in vegetative plant organs (Gersani and Kende 1982) as well as reproductive organs (**Davey and van Staden**, **1978**). Such a response indicates that seaweed extracts are involved either in enhancing the mobilization of cytokinins from the roots to the developing fruit, or, more likely, by improving the amount or synthesis of endogenous fruit cytokinins (**Hahn *et al*.**, **1974**).

The treated samples of broad beans contained higher contents of ash (10.01 to 11.58 $g.100g^{-1}$) when compared to control (8.87 $g.100g^{-1}$). The total carbohydrates in treated samples (44.2-53.7 $g.100g^{-1}$) were more or less similar to control (53.8 $g.100g^{-1}$). The protein treated samples was greater (19.9-25.9 $g.100g^{-1}$) than control (16.9 $g.100g^{-1}$); and percentage increased by the increase of algal concentration except at 0.15 concentration of *U. lactuca*. The maximum protein content (25.9 $g.100g^{-1}$) was found when the plants treated with *S. filiformis*. Both total lipids (1.13-1.83 $g.100g^{-1}$) and crud fibers (4.0-8.5 $g.100g^{-1}$) were less varied from the control (7.0 $g.100g^{-1}$). The effect of the nutritive elements on amino acid and protein biosynthesis may be explained through the effective roles of each element. **Bloom and Finazzo** (**1986**) reported that, ammonia stimulated the metabolic rate of nitrates causing an increase in total amino acids and protein content in barley plants. **Guo *et al***. (**2008**) explained the positive effect of Cu as it increases metallothioneins biosynthesis and its distribution. **Sevilla *et al***. (**1982**) explained that, manganese increased amino acids biosynthesis through increasing superoxide dismutases enzyme. **Taiz and Zeiger** (**2006**) suggested that the increasing of amino acids and protein may be due to the enhancement effect of K on the biosynthesis of RNA. **Rufty *et al***. (**1990**) stated that amino acids and protein contents were increased because P increased the bioconversion of nitrate into amino acids. **Tabe and Droux** (**2002**) demonstrated that, the S stimulated protein biosynthesis through stimulating the conversion of organic sulfur compounds into S-containing amino acids. **Goldgur *et al***. (**2007**) pointed to the role of Zn in the mechanism of changing protein from unfolded to folded state which led to an increase in the protein biosynthesis.

Conclusion

In conclusion, application of eco-friendly seaweed fertilizers derived from *E. intestinalis*, *S. filiformis*, and *U. lactuca* were effective in increasing the growth and yield parameters. By the end of the season, *Vicia faba* plants grown with the foliar seaweed application had produced 1.6 to 2.25 folds of the unfertilized controls for *E. intestinalis*, 2.5 to 5.6 folds using *S. filiformis*, and 1.7 to 2.4 folds using *U. lactuca*. The present production does not reach the Egyptian yield of feddan. Hence, a soil organic fertilizer *via* seaweed fertilizers is recommended for attaining better germination, growth and yield.

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استخدامات بعض من الطحالب البحرية المصرية كمخصب ورقى لنبات الفول البلدى

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تم تجميع ثلاثه انواع من الطحالب البحريه (الاولفا والانترومورفا والساركونيما) من شاطىء القناه بالاسماعيليه بغرض اكتشاف مدى ملائمتهم للاستخدام كمخصب ورقى لمحصول الفول البلدى وذلك فى مزرعه كليه الزراعه جامعه قناه السويس بالاسماعيليه موسم نوفمبر 2006. تم تحضير المستخلص فى صوره ثلاث تركيزات مختلفه (0.05 , 0.10 و 0.15٪)، ورش المجموع الخضرى للنبات اثناء فتره النمو. اثبتت النتائج ان معالجه النباتات محل الدراسه بالمخصب صديق البيئه زاد من القياسات الخضريه للنباتات، وفى نهايه الموسم الزراعى عند الحصاد كانت الانتاجيه للنباتات المعالجه بطحلب الانترومورفا 1.6 الى 2.25 ضعف النباتات الغير معالجه و بلغت 1.7 الى 2.4 فى تلك المعالجه بالاولفا اما عند معالجتها بطحلب الساركونيما بلغت 2.5 الى 5.6 ضعف. هذه الانتاجيه كات استجابه لتواجد بعض العناصر المعدنيه والمواد الهرمونيه والاحماض الامينيه والفيتامينات فى الطحالب المستخدمه. مع الملاحظه انه انتاجيه الفول البلدى لم تصل الى الانتاجيه للفدان المتعارف عليها فى مصر وذلك نظرا لانخفاض المحتوى من النيتوجين ، الفوسفور والبوتاسيوم فى الطحالب. وتم استخلاص انه يجب اضافه هذه العناصر لتحسين الانتاجيه عند استخدام الطحالب كمخصبات عضويه.