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Effect of Organic Fertilization of Broad Bean *(Vicia faba* L.) By Using Different Marine Macroalgae in Relation to the Morphological, Anatomical Characteristics and Chemical Constituents of the Plant

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Abstract: *Vicia faba* plants (cultivar Assiut 86) were treated with the powdered algae as organic fertilizers in comparison with chemically fertilized and unfertilized plants, during the two successive winter seasons of 2005/2006 and 2006/2007. The main objectives of this study were to test different marine macroalgae as organic fertilizers of broad bean, and to study the morphological, and anatomical manifestations as well as chemical constituents as affected by this fertilization. The results indicated that, *Sargassum* species contains the highest percentage of phosphorus (0.12 - 0.13 %) while *Asparagopsis* species contains the highest amount of potassium (105.96 ppm) in all the collected algal species. The highest ratios of plant growth stimulators in macroalgae were: abscisic acid in the red alga *Corallina* sp. (0.18 - 0.22 %); GA_3 in the brown alga *Sargassum* sp. (0.6 %) and IAA in the green alga *Enteromorpha* sp. (0.34 %). NPK content in plants treated with *Sargassum* sp. reached four fold the negative control and two fold the positive control. Treating the soil with algae powders as organic fertilizers improved the vegetative characters as well as structural characteristics of *Vicia faba* plants and subsequently, yield components in comparison with untreated and chemically fertilized plants.

Key words: Marine macroalgae, *Vicia fab*a, Morphology, Anatomy, Chemical constituents

INTRODUCTION

Oceans and Seas are the greatest store for algae, which are good sources for foods, fodders and fertilizers and therapeutically useful drugs. Morever, marine algae exhibit antiviral, hypocholesterolemic, hypotensive, antibacterial, anticoagulant, antihelmintic, anticancer, antialgal, cytotoxic and antifungal activities (Saleh *et a*l., 1993). *Asparagopsis taxiformis* (Delile) Trevisan is a species of phylum Rhodophyta (Family: Bononemaisopiaceae). El-Baroty *et al*., (2007) studied several chemical characteristics of *Asparagopsis taxiformis* (Delile) Trevisan, including isolation and identification of its volatile constituents, fatty acids, sterols and minerals. Moreover, they studied its biological activity as antioxidant, anticancer, antimicrobial, cytotoxic, antiviral and antialgal agent. Therefore, it was thought to adopt this powdered alga in organic fertilization of broad bean, and to study the botanical aspects (morphological and anatomical characters) as affected by this fertilization.

MATERIALS AND METHODS

The present study was conducted during the two successive winter seasons of 2005/2006 and 2006/2007 at the Experimental Nursery of the Botany Department, Faculty of Agriculture, Cairo University, Giza, Egypt. Mechanical and chemical analyses of the sandy soil were carried out before planting according to Chapman and Pratt (1961) and the characteristics are shown in Table (1).

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Table 1: Physical and chemical characteristics of the sandy soil used for growing *Vicia faba* plants during 2005/2006 and 2006/2007 seasons.

Characters	2005/2006	2006/2007
A. Physical properties:		
Soil texture	Sandy	Sandy
Coarse sand %	31.6	32.2
Fine sand %	62.9	62.5
Silt %	1.5	1.3
Clay %	3.4	3.6
Field capacity (% V)	15.5	15.9
B. Chemical properties:		
pH	7.3	7.5
E.C. (ds/m)	0.72	0.75
CEC (meq /100 g)	5.2	5.4
CaCO3 %	0.41	0.45
Organic matter %	1.25	1.32
N (ppm)	18.8	19.5
P (ppm)	3.5	3.7
K (ppm)	94.8	96.3

Plant Material:

Seeds of broad bean *(Vicia faba* L.) cultivar Assiut 86 were obtained from Legume Research Division, Field Crop Research Institute, Agricultural Research Center, Giza.

Thalli materials were collected from Cleopatra beach at Marsa Matrouh city in August 2005 and Abu Quir beach at Alexandria city in April, June and August 2005 and 2006. Materials were cleaned from sand, and the alga was identified by the Botany Department, Faculty of Science, El-Fayoum University.

Cultivated plants were divided into three groups:

- Plants treated with the powdered alga as organic fertilizer
- Plants treated with chemical fertilization
- Plants untreated with any fertilizer

Experimental Procedure:

Seeds were planted on October 17th 2005 and 2006 in pots, 25 cm in diameter, filled with sandy soil. Two dry grams of each used alga were incorporated with the potting medium before planting. Nitrogen was added in the form of ammonium sulfate (20.5% N), while phosphorus was applied as calcium super phosphate (15.5% P_2O_5). Ten seeds per pot were sown, and pots were irrigated. Seedlings were thinned to two plants per pot after three weeks from sowing date. Potash was not added as the soil is very rich in this element.

The layout of the experiment was randomized block design. The experiment included 8 treatments. Each treatment consisted of 3 replicates and each replicate contained 6 pots. Data were subjected to analysis of variance, and the means were compared using the "Least Significant Difference (LSD)" test at the 0.01 level, as recommended by Snedecor and Cochran, (1982).

Recorded Data:

The vegetative characters including plant height (cm), stem length (cm), No. of internodes of the main stem, main stem diameter (mm), determined by using a clipper, No. of lateral branches/plant and No. of leaves/plant were recorded at 25, 50,75 and 100 days after sowing . While, leaf area (cm^2), shoot fresh and dry weights/plant (g), root fresh and dry weights/plant (g) were recorded at 50 days after sowing.

For determination of leaf area, five full mature leaves on the fifth node of the main stem were taken for each replicate. The average area/leaf was determined by using Portable leaf area meter, Licor (Model Li-3000).

The yield characters, including No. of pods/plant, No. of seeds/plant, seed yield/plant (g) and specific seed weight (g) were recorded at maturity (130 days after sowing).

Anatomical Studies:

A comparative microscopical examination was carried out on plant material which showed the most prominent response of plant growth to the investigated treatments.

Specimens were taken at the beginning of the flowering stage (50 days old) from the middle of the 5 th internode of the main stem, the middle portion of the leaflet lamina on the 5 th node including the midrib as well as the main root, 2 cm away from the base as the roots were extracted easily from the sandy soil.

All samples were killed and fixed for at least 48 hours in F.A.A.(10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70%), washed in 50% ethyl alcohol, dehydrated in normal butyl alcohol and embedded in paraffin wax (56 °C m.p.), sections 20 μ thick, were cut by using a rotary microtome, and stained with light green/safranin combination, cleared in xylene and mounted in Canada balsam (Willey, 1971). Slides were microscopically examined and the measurements of different tissues were taken using a micrometer eye piece and averages of 10 readings were calculated and Photomicrographs Were Also Taken.

Chemical Parameters:

Determination of Phosphorus:

Available phosphorus was extracted using the method described by Soltanpour, (1985) and determined spectrophotometrically as mentioned by Olsen and Watanab, (1965).

Determination of Potassium:

Available potassium was extracted using the method described by Soltanpour, (1985) and determined using Flame photometric method (APHA, 1992).

Determination of Total Nitrogen:

The determination of total nitrogen was carried out with Micro-Kjeldahel method. (A.O.A.C., 1990).

Quantitative Determination of Endogenous Phytohormones:

Plant growth regulators in algal cells were extracted according to Sadeghian, (1971) and determined as mentioned by Vogel, (1975).

RESULTS AND DISCUSSION

Chemical Contents:

NPK in Macroalgae:

Table (2) showed the mean percentage of NPK in different algal cells. The obtained result indicated that seaweeds are rich in nitrogen and phosphorus, but relatively poor in potassium., *Sargassum* species collected during spring season contains the highest percentage of phosphorus (0.13%) while the ASP contained the lowest percentage of phosphorus and the highest amount of potassium (105.96 ppm) in all the collected algal species, Fuller and Roger (1952) observed a greater uptake of P by plants from algal materials than from inorganic phosphates when applied in equal amounts.

Table 2: The macro elements contents in different macroalgae (as dry weight).

Algae*	P%	N%	K (ppm)
G1	0.15[a]	2.98[a]	90.30[b]
G2	0.09[e]	0.95[f]	68.43[c]
E1	0.11[d]	2.16[c]	34.00[f]
E2	0.11[d]	2.25[b]	33.63[g]
S1	0.13[b]	1.88[d]	68.20[d]
ASP	0.03[f]	0.80[g]	105.96[a]
$LSD_{0.01}$	6.97	0.025	0.133

E1: *Enteormorpha* collected from Alex. during spring; E2: *Enteormorpha* collected from Alex. during summer
S1: *Sargassum* sp collected from Alex. during spring; ASP: *Asparagopsis* sp collected from Marsa Matrouh
G1: *Gellidium* sp collected from Alex; G2: *Corallina* sp collected from Alex.
The values in the column followed by the same letter are not significantly different at P=0.01.
LSD: Least significant difference.

Table 3: Percentage of plant growth regulators in the studied macroalgae.

Plant growth regulators a	G1	G2	E1	E2	S1	ASP
IAA	0.0035	0.062	0.034	0.340	0.0	0.019
ABA (cis)	0.0	0.220	0.0	0.180	0.0	0.007
ABA (trans)	0.0	0.180	0.110	0.0	0.0	0.030
GA_3	0.0	0.005	0.0	0.008	0.6	0.0

a IAA: Indole acetic acid; ABA: Abscisic acid and GA_3: Gibberellic acid.

Plant Growth Stimulator in Macroalgae:

Data in Table (3) indicated that the red algae *Gellidium* sp., *Corallina* sp and *Asparagopsis* which were collected from two different localities of the Mediterranean Sea showed variations in the concentration of plant growth regulators. Auxins presented in the algal species were 0.0035, 0.062 and 0.019%, respectively, while gibberellic acid was 0.0, 0.005 and 0.0% respectively. However, *Carollina* sp. has the highest conc. of abscisic acid (cis and trans). The green alga *Enteromorpha* sp collected at the summer season has the greatest conc. of auxin. In addition, the brown alga *Sargassum* sp collected at the spring season has the highest conc. of gibberellic acid (0.6%). Similar observations had been recorded by Conrad *et al.*, (1959) for *Ulothrix* and for unicellular green algae belonging to several genera.

NPK in Treated Plants:

The NPK contents in *Vicia faba* (Assiut 86) after treatment with macroalgae (dry matter) as organic fertilizer are shown in Table (4). The results indicated that, the nitrogen content increased in plant treated with algae and reached four times, the negative control and two times, the positive control in *Sargassum* sp. The same result will occur with the other elements (P and K). These results were agreed with the results obtained by Lean and Nalewajko, (1976) they reported that seaweeds are rich in nitrogen and potash, but poor in phosphates. Seaweed addition is best suited for light sandy soils, generally deficient in potash. Physical condition of the soil improves by seaweed application because of their gelatinous nature. They are also valuable as a source of trace elements and other organic substances like amino acids, auxins, gibberellins and vitamins.

Vegetative Characters:

Plant Height (cm):

Results in Table (5) show that, in the first season plant height increased at all ages by using algae as an organic-fertilizer with significant differences at the ages of 75 and 100 days and at all ages in the second season, comparing with both untreated and chemically fertilized plants.

Table 4: The % of NPK contents in plant cells after cultivation with algae as organic-fertilizers.

Treatments	N%	P%	K%
*Cont.-	0.05	0.07	0.64
*Cont.+	0.11	0.17	1.22
G1	0.19	0.26	1.77
G2	0.18	0.12	1.52
E1	0.04	0.04	0.51
E2	0.06	0.07	0.60
S1	0.20	0.33	1.76
ASP	0.10	0.14	1.62

*Cont. + (Positive control); Cont. - (Negative control).

Table 5: Effect of chemical and organic-fertilization on plant height (cm) of *Vicia faba* L. during 2005/2006 and 2006/2007 seasons.

Treatments	First season Days after sowing (DAS)				Second season Days after sowing (DAS)			
	25	50	75	100	25	50	75	100
Cont. (-)	17.00	29.67	49.60	52.17	19.21	29.87	47.55	55.50
Cont. (+)	19.67	32.50	62.00	67.50	20.13	34.50	67.81	83.14
G1	21.50	33.33	55.80	63.00	25.13	36.48	58.44	69.61
G2	21.83	32.33	58.30	60.50	24.77	36.05	58.95	65.11
E1	21.54	32.00	50.71	59.52	30.05	41.22	62.55	73.16
E2	22.00	35.17	63.67	70.67	27.43	38.19	60.15	72.54
S1	22.00	33.50	60.90	69.67	27.22	39.18	73.65	86.01
ASP	22.31	35.01	65.24	72.33	30.11	48.25	77.20	90.15
$L.S.D._{0.01}$	NS	NS	4.75	6.53	4.11	3.50	7.05	5.66

Stem Length (cm):

As indicated in Table (6), *Vicia faba* stems were taller in the second season than in the first one. Differences were significant between treatments in the two seasons.

Number of Internodes of the Main Stem:

Table (7) shows that chemically fertilized plants were superior in No. of internodes of the main stem comparing with other treatments, especially at 75 and 100 DAS in both seasons.

Main Stem Diameter (mm):

Data in Table (8) indicate that, organic-fertilization significantly increased diameter of the 5^{th} internode of the main stem as compared to the untreated control. The thickest received ASP organic fertilizer at 100 DAS in both seasons, respectively.

Table 6: Effect of chemical and organic-fertilization on stem length/plant (cm) of *Vicia faba* L. during 2005/2006 and 2006/2007 seasons.

Treatments	First season Days after sowing (DAS)				Second season Days after sowing (DAS)			
	25	50	75	100	25	50	75	100
Cont. (-)	14.21	24.05	39.43	41.16	14.56	24.22	37.43	44.22
Cont. (+)	16.56	27.11	50.11	53.10	17.33	29.16	48.96	72.15

Table 6: Continued.

G1	17.44	28.17	44.55	48.61	20.11	31.19	42.10	60.05
G2	17.36	26.66	46.32	50.33	20.66	31.45	44.03	55.43
E1	18.15	28.55	38.25	44.51	26.33	35.44	46.55	66.55
E2	19.50	29.32	49.96	51.30	23.61	33.62	42.33	63.55
S1	19.17	27.32	49.13	55.63	22.50	34.36	53.40	76.31
ASP	19.41	29.67	52.33	57.13	27.25	40.33	60.13	79.83
$L.S.D._{0.01}$	NS	NS	3.11	3.51	3.41	3.71	4.15	5.62

Table 7: Effect of chemical and organic-fertilization on No. of internodes of the main stem of *Vicia faba* L. during 2005/2006 and 2006/2007 seasons

Treatments	First season				Second season			
	Days after sowing (DAS)				Days after sowing (DAS)			
	25	50	75	100	25	50	75	100
Cont. (-)	5.00	7.50	13.00	14.17	5.32	8.11	13.56	15.10
Cont. (+)	5.33	8.00	18.50	22.00	5.67	8.90	19.22	24.16
G1	5.83	8.50	15.00	18.67	5.91	9.60	15.50	17.65
G2	6.17	8.60	15.33	18.33	6.32	9.21	16.13	18.66
E1	5.50	8.60	13.00	17.33	6.17	9.23	14.50	18.22
E2	5.67	8.50	16.70	20.50	5.84	9.40	15.81	19.05
S1	5.67	8.50	15.47	19.50	6.51	9.75	16.35	20.31
ASP	6.00	8.80	16.80	21.67	5.95	9.45	17.94	22.75
$L.S.D._{0.01}$	NS	NS	2.76	2.11	NS	NS	2.55	2.05

Number of Lateral Branches/plant:

It is evident from Table (9) that, ASP was the highest in No. of lateral branches that ranged between 1.0-2.5 and 1.0-3.0 branches in both seasons, respectively. While, these numbers ranged between 0.0-1.0 and 0.0-1.5 branches for untreated plants, and between 0.0-2.0 for positive control, in the two successive seasons, respectively.

Number of Leaves/plant:

Table (10) shows that, No. of leaves increased gradually from 4.0 up to 22.0 leaves in the first season, and from 5.0 up to 23.0 leaves in the second one at 25, 50, 75 and 100 DAS. Such differences between

Table 8: Effect of chemical and organic-fertilization on main stem diameter (mm) of *Vicia faba* L. during 2005/2006 and 2006/2007 seasons.

Treatments	First season				Second season			
	Days after sowing (DAS)				Days after sowing (DAS)			
	25	50	75	100	25	50	75	100
Cont. (-)	4.02	4.37	4.47	4.67	4.95	5.32	5.56	5.61
Cont. (+)	4.47	4.90	5.80	6.00	5.56	5.91	6.31	6.50
G1	4.60	5.23	6.20	6.40	5.16	5.75	6.11	6.41
G2	4.70	5.02	5.83	6.73	5.42	5.92	6.25	6.58

Table 8: Continued.

E1	4.65	5.00	5.60	6.10	5.82	6.32	6.65	6.82
E2	4.60	5.13	5.38	5.88	5.51	6.10	6.45	6.68
S1	4.60	4.75	6.03	6.20	5.80	6.41	6.75	6.91
ASP	4.92	5.80	6.73	7.76	5.92	6.60	6.96	7.22
$L.S.D._{0.01}$	NS	0.33	0.35	0.41	NS	0.43	0.32	0.34

Table 9: Effect of chemical and organic-fertilization on No. of lateral branches/plant of *Vicia faba* L. during 2005/2006 and 2006/2007 seasons.

Treatments	First season				Second season			
	Days after sowing (DAS)				Days after sowing (DAS)			
	25	50	75	100	25	50	75	100
Cont. (-)	0.0	0.0	1.0	1.0	0.0	0.5	1.0	1.5
Cont. (+)	0.0	1.0	2.0	2.0	0.0	1.5	2.0	2.0
G1	0.5	0.5	2.0	2.5	0.5	1.0	2.0	2.5
G2	1.0	1.0	2.0	2.0	1.0	1.5	2.0	2.0
E1	0.5	0.5	2.0	2.5	0.5	1.0	2.0	2.5
E2	1.0	1.0	2.0	2.5	1.0	1.5	2.5	2.5
S1	1.5	1.5	1.50	2.0	1.0	1.5	2.0	2.0
ASP	1.0	1.5	2.50	2.50	1.0	2.0	3.0	3.0
$L.S.D._{0.01}$	0.20	0.25	0.52	0.20	0.23	0.22	0.20	0.20

untreated and all treated plants were significant. In this regard, Mostafa, (2004) stated that inoculation of sandy soil with dry *Spirulina* recorded the highest number of tomato leaves (30.0 and 34.1/ plant from 2 / pot for dry *Spirulina* and chemical fertilization, respectively).

Leaf Area (cm^2):

As indicated in Table (11), untreated plants had significantly smaller leaf areas (16.26 and 18.37 cm^2) in both seasons, respectively, than all other treatments. Fertilization with NP significantly increased leaf area (24.76 and 28.43 cm^2) in both seasons, respectively. Maximum increase was gained by ASP, followed by G1 and then by E1 with insignificant differences in both seasons.

Table 10: Effect of chemical and organic-fertilization on No. of leaves/plant of *Vicia faba* L. during 2005/2006 and 2006/2007 seasons.

Treatments	First season				Second season			
	Days after sowing (DAS)				Days after sowing (DAS)			
	25	50	75	100	25	50	75	100
Cont. (-)	4.00	9.33	13.00	14.17	5.10	10.33	13.91	15.20
Cont. (+)	4.17	11.50	18.50	22.00	5.32	11.96	16.50	21.91
G1	4.60	9.80	15.00	18.70	5.82	10.72	15.42	18.95
G2	4.83	11.17	15.17	18.30	5.81	13.11	16.05	19.41
E1	4.80	10.67	13.00	17.33	5.72	12.10	16.30	18.41
E2	4.70	11.67	16.67	21.67	5.96	13.43	17.85	21.50
S1	4.77	10.67	15.50	19.50	5.43	12.51	17.33	20.16
ASP	5.27	12.83	16.83	20.67	6.42	14.26	18.23	23.17
$L.S.D._{0.01}$	NS	NS	2.75	1.61	NS	0.94	1.50	2.11

Table 11: Effect of chemical and organic-fertilization on means of some morphological characters of *Vicia faba* L. at 50 days after sowing in the two successive seasons of 2005/2006 and 2006/2007.

Characters	Leaf area (cm^2)		*SFW (g)		*SDW (g)		*RFW (g)		*RDW (g)	
Treatments	F.S	S.S	F.S	S.S	F.S	S.S	F.S	S.S	F.S	S.S
Cont. (-)	16.26	18.37	8.47	9.22	0.85	0.90	16.03	16.95	2.53	2.59
Cont. (+)	24.76	28.43	11.38	13.28	1.05	1.25	18.35	21.17	2.17	2.48
G1	30.56	35.95	14.27	16.21	1.49	1.54	18.36	20.41	2.41	2.46
G2	29.67	30.05	14.73	16.33	1.78	1.83	10.10	15.05	1.76	1.80
E1	30.37	33.29	16.27	19.11	1.72	1.75	15.34	17.55	1.89	1.94
E2	23.47	28.11	17.68	18.40	1.74	1.80	15.32	18.30	2.49	2.55
S1	28.36	31.44	15.30	17.45	1.55	1.65	13.62	15.21	2.57	2.65
ASP	30.66	36.17	20.43	23.90	2.47	2.76	20.29	24.05	3.75	3.95
$L.S.D._{0.01}$	1.75	3.14	2.11	3.33	0.35	0.55	2.13	2.56	0.31	0.32

*SFW: Stem fresh weight; SDW: Stem dry weight; RFW: Root fresh weight; RDW: Root dry weight.

Shoot Fresh Weight (SFW)/plant (g):

Data in Table (11) indicate that, the herb fresh weight/plant was significantly increased in all organic-fertilization treatments of both seasons compared to the negative or positive control. The highest fresh weight (20.43 and 23.90 g) were obtained by ASP followed by E1 or E2, in the 1st and 2nd seasons, respectively.

Shoot Dry Weight (SDW)/plant (g):

Table (11) shows that untreated control plants gave the lowest herb dry weight/plant (0.85 and 0.90 g), compared with chemically or organic fertilized plants. While the highest were from plants received ASP organic fertilizer followed by G2. The highest increases were 190.6 % and 206.7 % in the 1st and 2nd seasons, respectively, over the negative control.

Root Fresh Weight (RFW)/plant (g):

Results in Table (11) show that, untreated plants had a slightly higher root F.W than E1 and E2 in the 1st season and G2 and S1 in the 2nd one. Among all organic-fertilization treatments, ASP realized the highest increasing ratios. The results agree with those of Smith and Staden, (1983), who studied the effect of a commercially seaweed *(Ecklonia maxim*a) on tomato plants and reported that such treatment improved root growth and was accompanied with a reduction in root infection with nematode.

Root Dry Weight (RDW)/plant (g):

Data presented in Table (11) clarify that, the RDW obtained from untreated plants were 2.53 g and 2.59 g in the first and second seasons, respectively. The differences between negative control and treatments of fertilizers were insignificant in both seasons. ASP alga gave the heaviest RDW, being 3.75 and 3.95 g/plant. Data agreed with the results of Carolyn *et al.,* (2001) on tomato plants.

Yield Characters:

Number of Pods/plant:

It is evident from Table (12) that, all chemical and organic-fertilization treatments significantly increased No. of pods per plant in both seasons. The maximum increase was obtained by positive control followed by ASP in both seasons. Meeting *et al.*, (1988) suggested that plant growth regulator may be produced by the Cyanophyta and be responsible for enhancing crop yield.

Table 12: Yield and yield components of *Vicia faba* L. as affected by chemical and organic-fertilization in the two successive seasons of 2005/2006 and 2006/2007.

Characters / Treatments	No. of pods/ plant		No. of seeds/ plant		Seed yield/ plant (g)		Weight of 100 seeds (g)	
	F.S*	S.S*	F.S	S.S	F.S	S.S	F.S	S.S
Cont. (-)	3.0	4.1	6.6	8.2	2.75	3.56	41.21	43.41
Cont. (+)	9.0	13.0	24.1	32.8	12.85	18.20	53.32	55.49
G1	6.0	9.0	17.5	25.4	8.66	13.03	49.49	51.30
G2	7.0	10.0	15.3	23.7	7.45	11.66	48.69	49.20
E1	6.5	9.5	17.3	26.2	8.93	14.07	51.62	53.70
E2	7.5	11.0	21.2	24.5	11.07	12.96	52.22	52.90
S1	7.0	10.4	19.1	26.1	9.72	13.47	50.89	51.61
ASP	8.0	11.5	22.7	29.5	11.99	15.96	52.82	54.10
$L.S.D._{0.01}$	1.5	2.3	5.0	6.0	2.25	2.55	1.93	2.21

*F.S: first season and S.S: second Season.

Number of Seeds/plant:

Data in Table (12) show that, all chemical and organic-fertilization treatments significantly increased No. of seeds/plant in both seasons, over negative control plants. Chemically fertilized plants gave the highest No. of seeds per plant among all treatments, being 24.1 and 32.8 seeds in both seasons, respectively. These data are in agreement with the results obtained by Crouch and Staden, (1992) who studied the effect of seaweed concentrate (SWC) *Ecklonia maxima* (Osbeck) Papenfuss on the yield of tomato plants and found significant improvement of seedling growth when applied as a soil drench. Also, treated plants exhibited early fruit ripening and increase in weight and number of fruits.

Seed Yield/plant (g):

Results in Table (12) reveal the same trend of No. of seeds per plant. The highest yield was achieved by chemical fertilization being 372.4 and 411.2% over negative control in both seasons, respectively.

Weight of 100 Seeds (g):

Data in Table (12) indicate that, weight of hundred seeds of *Vicia faba* cultivar Assiut 86 showed a significant increase due to chemical and organic-fertilization treatments over untreated ones, giving percentages of increases ranged between 18.2 and 29.4 % for G2 and positive control, respectively, in the first season, while between 13.3 and 27.8 % over the negative control in the second one. The present data agree with the results obtained by Adam, (1999) who found that algal filetrate of the cyanobacterium *Nostoc muscorum* significantly increased germination of wheat grains and their growth parameters compared to controls. Ghallab and Salem, (2001) applied some biofertilizer treatments; Cerealin (*Azospirillum* spp.) and Nemales (*Serratia* spp.) on wheat plant, in field experiment, they found that the two biofertilizers increased growth characters and nutrients, sugar, amino acids and growth regulators (IAA, GA3 and Cytokinin) and crude protein content in the plant. Similarly, Abdel-Monem *et al.*, (2001) reported that fertilization with *Azospirillum brasilense* or commercial biofertilizer Cerealin, improve the growth and yield of maize in rotation with wheat as affected by irrigation regime.

Table 13: Measurements in microns of certain anatomical features in transverse sections of the main root of *Vicia faba* L. in 50 days old plants as affected by chemical and organic-fertilization (Means of 10 readings).

Characters	C^-	C^+	± % to C^-	ASP	± % to C^-	± % to C^+
Diameter of root (μ)	2420	2674	10.5	3870	59.9	44.7
Thickness of cortex (μ)	560	648	15.7	805	43.8	24.2
Diameter of vascular cylinder (μ)	1206	1327	10.0	1950	61.7	47.0
No. of cortex layers	15	17	13.3	20	33.3	17.7
Diameter of xylem vessel (μ)	13.5	17.5	29.6	20	48.2	14.2

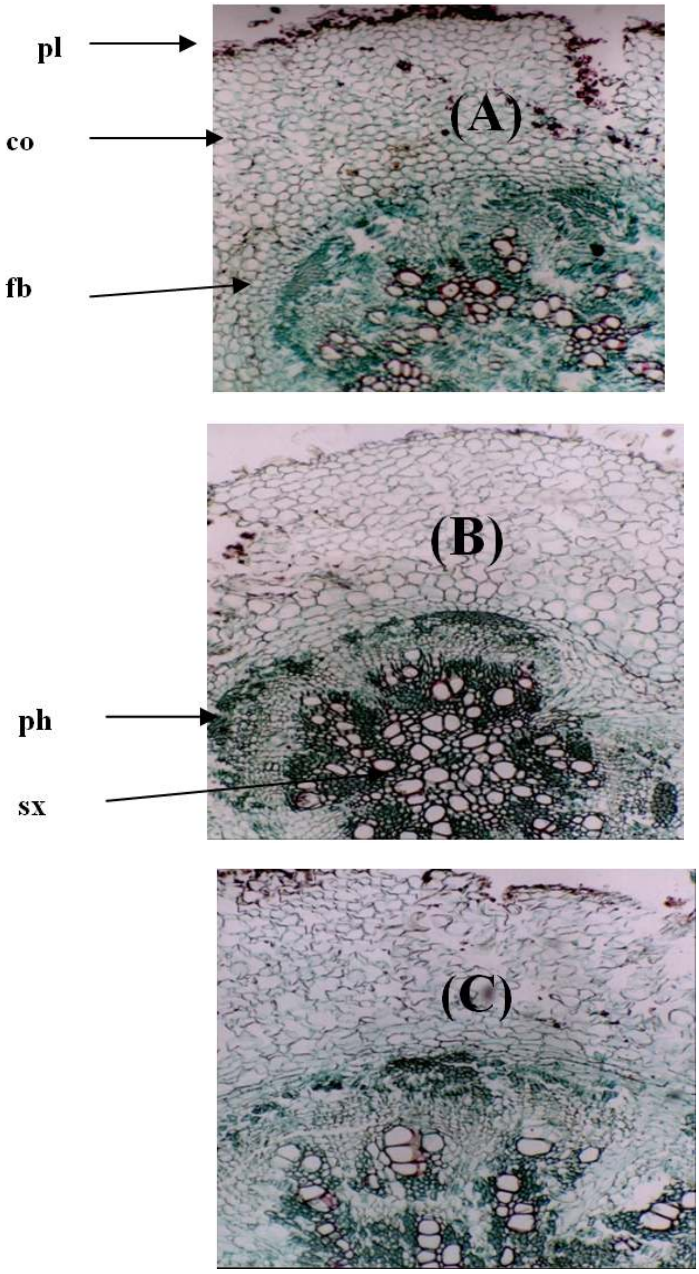

Fig. 1: Transverse sections of *Vicia faba* main root of 50 days old plants. (X40).
A) Untreated plant (C^-)
B) Chemically fertilized plant (C^+)
C) Organic-fertilized plant (ASP)
Details: co, cortex; pl, protective layer; fb, fibers; ph, phloem tissue; sx, secondary xylem.

Anatomical Studies:

Structure of the Main Root:

Table (13) and Fig. 1 (a, b and c) indicate the anatomical structure of the root in 50 days old plants. Results revealed that plants treated with ASP surpassed those treated with NP fertilizers or untreated plants in root diameter being 44.7 and 59.9% over the positive and negative controls, respectively. This increase was mainly due to the increase in thickness of the vascular cylinder (47.0 and 61.7%) and the cortex (24.2 and 43.8%) over the positive and negative controls, respectively, the increase in cortex was due to the

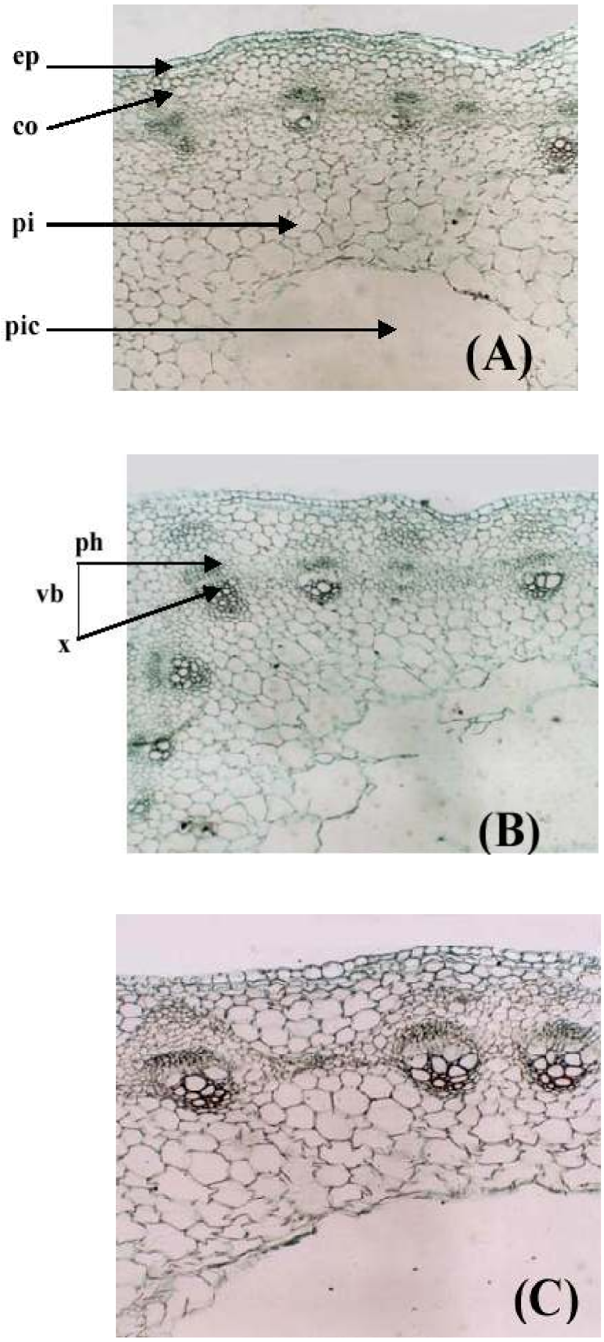

Fig. 2: Transverse sections through the middle portion of the 5th internode from the top of *Vicia faba* main stem. (X40).
A) Untreated plant (C^-)
B) Chemically fertilized plant (C^+)
C) Organic-fertilized plant (ASP)
Details: co, cortex; ep, epidermis; ph, phloem tissue; pi, pith; pic, pith cavity; vb, vascular bundle; x, xylem.

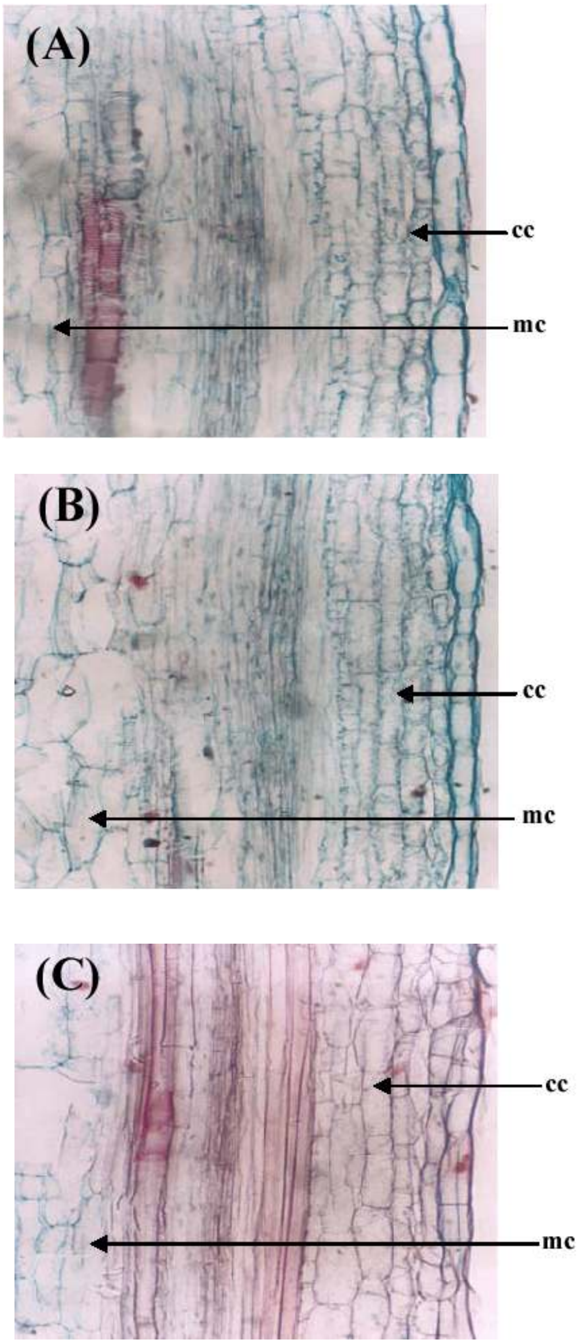

Fig. 3: Longitudinal sections through the middle portion of the 5th internode from the top of *Vicia faba* main stem. (X100).
A) Untreated plant (C^-)
B) Chemically fertilized plant (C^+)
C) Organic-fertilized plant (ASP)
Details: cc, cortical cells; mc, medullary cells.

increase in No. of layers by 17.7 and 33.3% over both controls, respectively. Moreover, xylem vessels had wider cavities as a result of treating the plants with organic-fertilizers; being 14.2 and 48.2% more than chemical fertilizers and negative control, respectively.

Structure of the Main Stem:

Data in Table, 14 and Fig., 2 a, b and c indicate the anatomical structure of the 5th internode of stem of 50 days old plants. The stem is tetragonal in outline. Size of epidermal cells was larger in ASP organic-fertilization treatment than positive and negative controls; being 36, 20 and 13 µ, respectively. Cortex was 6-7 layers of parenchyma that ranged between 180-255 µ in thickness of cortex in the furrows. The dimensions of stem were higher in organic-fertilized plants by 77.4 % in length, and by 88.9 % in width. These increments were mainly due to the increase in the thickness of cortex, pith cavity and dimension (length and width) of large and small bundles more than the negative control.

Table 14: Measurements in microns of certain anatomical features in transverse and longitudinal sections of the 5th internode of the main stem of *Vicia faba* L. in 50 days old plants as affected by chemical and organic-fertilization (Means of 10 readings).

characters	C^-	C^+	± % to C^-	ASP	± % to C^-	± % to C^+
Cross section:						
Dimensions of stem (µ):						
Length	3168	3540	11.7	5620	77.4	58.8
Width	2880	3260	13.2	5440	88.9	66.9
Thickness of epidermis (µ)	13	20	53.9	36	176.9	80.0
Thickness of cortex (µ)	180	240	33.3	255	41.7	6.3
No. of cortex layers	6	6	0.0	7	16.7	16.7
Thickness of pith (µ)	504	386	- 23.4	353	- 30.0	- 8.6
Diameter of pith cavity (µ)	945	1134	20.0	2880	204.8	154.0
Dimensions of large bundles (µ):						
Length	364	420	15.4	540	48.4	28.6
Width	182	252	38.5	540	196.7	114.3
Dimensions of small bundles (µ):						
Length	210	224	6.7	360	71.4	60.7
Width	140	154	10.0	324	131.4	110.4
Thickness of xylem tissue (µ):						
Large bundles	210	266	26.7	360	71.4	35.3
Small bundles	70	98	40.0	216	208.6	120.4
Thickness of phloem tissue (µ):						
Large bundles	70	72	2.9	84	20.0	16.7
Small bundles	42	56	33.3	72	71.4	28.6
No. of xylem rows::						
Large bundles	6	7	16.7	8	33.3	14.3
Small bundles	3	3	0.0	4	33.3	33.3
Longitudinal section:						
Cortical cells (µ):						
Length	81.0	135.0	66.7	171.0	111.1	26.7
Width	36.0	36.0	0.0	58.5	62.5	62.5
Medullary cells (µ):						
Length	90.0	162.0	80.0	180.0	100.0	11.1
Width	36.0	40.5	12.5	54.0	50.0	33.3

Longitudinal sections (Figs., 3a, b and c) through the 5th internode of plants fertilized with ASP organic-fertilizer or NP chemical fertilizers revealed increase in cortical cells in length by 111.1 and 66.7%, and in width by 62.5% (in ASP only) over the negative control, in both treatments, respectively. Treatment with ASP recorded the highest increase in length and width of medullary cells; being 100.0 and 50.0% over negative control, and 11.1 and 33.3% over positive control, respectively. This increase in cell length could be the reason of elongation of the internodes of the treated plant, while the increase of stem diameter could be attributed in part, to the increase in width of cortical and medullary cells.

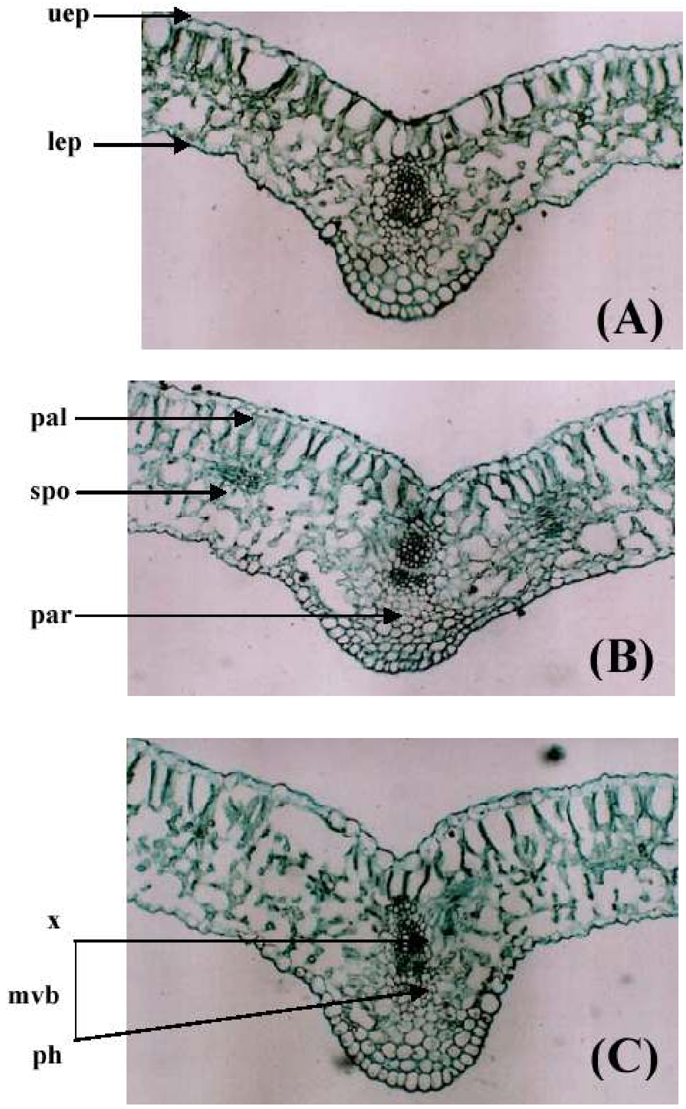

Fig. 4: Transverse sections of *Vicia faba* leaflet blade on the 5th node of the main stem through the midrib. (X40).
A) Untreated plant (C^-)
B) Chemically fertilized plant (C^+)
C) Organic-fertilized plant (ASP)
Details: lep, lower epidermis; mvb, midvein vascular bundle; pal, palisade tissue; par, parenchyma; ph, phloem tissue; spo, spongy tissue; uep, upper epidermis; x, xylem.

Structure of the Leaflet:

Results in Table (15) represent certain measurements of microscopical characters of the leaflet blade of the compound leaf developed on the 5th internode of the main stem of plants treated with NP chemical fertilization or ASP organic-fertilization versus untreated control plants. Microphotographs depict these blades are given in Fig. 4 (a, b and c).

Treating the plants with ASP organic-fertilizer or NP chemical fertilization increased thickness of both lamina and midvein of leaflet blades by 43.5 and 26.1% in lamina, and by 26.3 and 2.6% in midvein more than the untreated control, in both treatments, respectively. It is clear that the increase in lamina thickness was accompanied with 100 and 33.3% increments in thickness of upper epidermis, 150.0 and 50.0% increment

Table 15: Measurements in microns, of certain anatomical features in transverse sections of the leaflet blade of the compound leaf developed on the 5th node of the main stem of *Vicia faba* L. in 50 days old plants as affected by chemical and organic-fertilization (Means of 10 readings).

characters	C^-	C^+	± % to C^-	ASP	± % to C^-	± % to C^+
Thickness of lamina (μ)	322	406	26.1	462	43.5	13.8
Thickness of upper epidermis (μ)	21	28	33.3	42	100.0	50.0
Thickness of lower epidermis (μ)	14	21	50.0	35	150.0	66.7
Thickness of palisade tissue (μ)	98	112	14.3	112	14.3	0.0
No. of palisade tissue layers	1	1	0.0	1	0.0	0.0
Thickness of spongy tissue (μ)	179	240	34.1	259	44.7	7.9
Thickness of midrib (μ)	532	546	2.6	672	26.3	23.1
Dimensions of midrib bundle (μ):						
Length	162	178	9.9	210	29.6	18.0
Width	84	84	0.0	96	14.3	14.3
Thickness of xylem tissue (μ)	80	80	0.0	124	55.0	55.0
Thickness of phloem tissue (μ)	55	60	9.1	80	45.5	33.3
Thickness of parenchyma below midrib bundle (μ)	196	210	7.1	266	35.7	26.7
Thickness of palisade tissue above midrib bundle (μ)	105	75	- 28.6	120	14.3	60.0

in thickness of lower epidermis, 14.3% increment in thickness of palisade tissue as well as 44.7 and 34.1% increment in thickness of spongy tissue in both treatments (ASP and NP), respectively, compared with untreated control plants.

The main vascular bundles of the midvein increased in size as a result of either ASP organic-fertilizer or NP chemical fertilization. The increment was mainly due to the increase in length by 29.6 and 9.9% and in width by 14.3% (in ASP only) over the negative control in both treatments, respectively. Also, thickness of xylem increased by 55.0 % in ASP treatment and phloem by 45.5 and 9.1 % over the negative control in both treatments, respectively. Increasing thickness of midrib region could be attributed to an increase in length of midrib bundle by 29.6, and 9.9 %, thickness of parenchyma below midrib bundle by 35.7 and 7.1% as well as thickness of palisade tissue above midrib bundle by 14.3% (in ASP only) more than the untreated control in both organic and chemical fertilization treatments, respectively. Such detailed information concerning the effect of algae as organic-fertilizers on structure of *Vicia faba* plant organs are not available in the literature.

From the previous mentioned results, it could be concluded that, there was apositive correlation between No. of leaves/plant and each of; plant height, No. of lateral branches/plant and leaf area. In addition, the same relationship was clear between seed yield and vegetative characters. Thus, using algae as organic-fertilizers improved the vegetative characters as well as structural characteristics of *Vicia faba* plants, subsequently yield characters in comparison with untreated and chemically fertilized plants.

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