Journal of Horticultural Science & Ornamental Plants 4 (3): 235-240, 2012
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2012.4.3.252

Effect of Different Seaweed Extracts and Compost on Vegetative Growth, Yield and Fruit Quality of Cucumber

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Abstract: The current study was carried out in the Experimental Farm of the Faculty of Agriculture Cairo University, Egypt, during the two summer seasons of 2008 and 2009 on cucumber plants (*Cucumis sativus* L.). The experiment was conducted to investigate the effect of three seaweed extracts viz., red alga (*Asparagopsis spp*), red alga (*Gelidium pectinutum*) and green alga (*Enteromorpha intestinelis*)), compost and the commercial seaweed extract Algreen on cucumber hybrid Prince. Direct seeds were sown on May in both seasons. Plants were sprayed with different seaweed extracts with or without compost application. Results showed that using seaweed extract of green alga (*E. intestinelis*), red alga (*G. pectinutum*) or commercial seaweed extracts with compost is considered a suitable application to improved vegetative growth and yield of cucumber plants.

Key words: Cucumber · Seaweed · Compost · Vegetative growth · Yield

INTRODUCTION

Seaweed extracts have been marketed for several years as fertilizer additives and beneficial results from their use have been reported [1]. Booth [2] observed that the value of seaweeds as fertilizers was not only due to nitrogen, phosphorus and potash content, but also because of the presence of trace elements and metabolites. These extracts enhance seed germination, growth, yield and uptake of nutrients by the plants. Seaweed extracts are now available commercially under different names [3]. The extract also contend hormones (IAA and IBA), cytokinins, trace elements (Fe, Cu, Zn, Co, Mo, Mn, Ni), vitamins and amino acids [4]. Thus, these extracts when applied to seeds or when added to the soil, stimulate growth of the plants [5].

Crouch and Staden [6] revealed that seaweed concentrate (SWC) significantly improved growth of tomato seedlings when applied as a soil drench. SWC-treated plants exhibited early fruit ripening and total fruit fresh weight increase by 17%. The number of harvested fruits was also increased by about 10%.

Seaweeds extracts were suggested for use as biofertilizers because of their benefit to agriculture [7]. There was significant effect due to seaweed extract (sea force1) on stem length, plant dry weight, chlorophyll, carbohydrates, fruits diameter and length, early and total yield, firmness, total soluble solids and vitamin C contents in fruits and nitrogen, phosphorous and potassium in leaves of cucumber plants [8].

Taha *et al.* [9] showed that spraying seaweed extract resulted in positive significant difference in shoot characteristics and in all yield traits of cucumber as compared to the control. Abou El-Yazied *et al.* [10] indicated that spraying plants with seaweed extract at higher rate (750 ppm) significantly increased number of leaves per plant, average leaf area, leaf and stem fresh weight per plant, leaf and stem dry weight per plant and percentage of fruit set of snap bean compared to control.

For nitrate content, Clark *et al.* [11] found that nitrate content in tomato fruits was the lowest in the organic system and highest in the conventional system as the differences were highly significant.

On squash, Ozores-Hampton *et al.* [12] showed that plants had increased yields when planted in municipal solid waste compost amended soil in spite of application of NPK fertilizers at recommended rates. On pepper, Hsieh and Hsu [13] stated that early and total yields of all organic sources were significantly higher than that of chemical fertilizer. In the same direction on cucumber, Aly [14] found that organic treatment (compost) produced significantly greater early yield (1.85 kg/m^2) and total yield

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(4.49 kg/m^2) than chemical treatment which produced 1.38 kg/m^2 and 3.51 kg/m^2 for early and total yields, respectively.

Compost and growth stimulate agents could be a suitable alternative to mineral fertilizer. Plants of strawberries grown from compost fertilized plots exhibited generally higher plant length and fruit weight. Total yield was significantly increased by all treatments compared to mineral fertilizer [15].

This investigation aimed to study the effect of seaweeds liquid fertilizer (SLF) with or without compost fertilizer on growth, yield and fruit quality of cucumber compared with mineral fertilization.

MATERIALS AND METHODS

The experiments were carried out at the farm of Agricultural Researches Station, Wadi El-Natrown Area, Faculty of Agriculture, Cairo University during the two summer seasons of 2008 and 2009 to study the effect of three seaweed extracts viz., red alga (*Asparagopsis* spp.), red alga (*Gelidium pectinutum*) and green alga (*Enteromorpha intestinelis*)), compost and the commercial seaweed extract Algreen on cucumber hybrid Prince. In the two seasons, seeds were sown on May 15th. Each experimental plot was 7.5 m^2 consisted of three replicate; each replicate was 7.5 m length and 1 m width. The planting distance was 0.5 m apart on mid of ridge, All replicates received similar agricultural practice according to the recommendations of the Egyptian Ministry of Agriculture. Drip irrigation method was used.

Preparation of SLF: One kg of seaweed was cut into small pieces and boiled separately with 1: l weight of distilled water for an hour and filtered. The filtered was taken as 100 % concentration of seaweed extract. As the seaweed liquid fertilizers contained organic matter, they were refrigerated between 0 and 4°C.

Chemical Analyses of SLF

Determination of Phosphorus: Total phosphorus in different algae was extracted as reported by Soltanpour [16] and spectrophotometrically determined according to procedures of Olse and Watanab [17].

Determination of Potassium: Total potassium in tested samples was determined by Flame photometric according to APHA method [18].

Determination of Total Nitrogen: Determination of total nitrogen was carried out according to Micro-Kjeldahel method [19].

Endogenous Phytohormones: Ten grams of the algal material were homogenized, extracted twice with 200 ml methanol (96%), then twice with 200 ml methanol (40%), each for 24 hours [20]. The combined methanolic extract was evaporated in a rotary evaporator at 40°C to an aqueous solution. The aqueous solution was adjusted to pH 2.6-2.8 and extracted 4 times with ethyl acetate (50 ml, each). The ethyl acetate extract was dried over anhydrous sodium sulphate (10 g/100 ml). The ethyl acetate extract was filtered and evaporated to dryness; the residue was dissolved in 4 ml absolute methanol. The methanolic solution was used for the determination of gibberellic acid, abscisic acid and indole-3-acetic acid by gas-liquid chromatography (GLC) [21].

The Conditions of GLC: The GLC analysis was carried out with a Pro-GC gas chromatography, with a dual flame ionization detector. The glass column (1.5 m × 4 mm) was packed with 1% OV-17. Temperatures of injector and detector were 250°C and 300°C, respectively. The column was hold at 200°C for 3 min. then programmed from 200 to 240°C (at a rate of 10°C/min). Nitrogen as a carrier gas, hydrogen and air gases flow rates were 30, 33 and 330 ml/min, respectively. The identification of phytohormones was accomplished by comparing the peaks retention times with retention of authentic substances (ABA, IAA and GA3). The quantity of individual algal hormones was determined by comparing the peak area produced by known weight of the algal material with standard curves of the authentic substances which expressed the relation between different concentrations and their peak area. Results were tabulated in Table 1 and 2. Table 3 and 4 showed the analysis of the commercial seaweed extract (Algreen) from LEILI company and the applied compost.

The experiment in each season included ten organic and mineral treatments as follows:

- (T1) Organic manure (compost) at the rate of 5 kg/m^2.
- (T2) Red alga (*Asparagopsis spp*) extract at the rate of 1 l/feddan.
- (T3) Red alga (*Gelidium pectinutum*) extract at the rate of 1 l/feddan.
- (T4) Green alga (*Enteromorpha intestinelis*) extract at the rate of 1 l/feddan.

Table 1: Plant growth regulators in the studied marine macroalgae (mg/g d.wt)

Algal species	IAA	ABA cis	ABA trans	GA3
Gelidium pectinutum	0.25	0.2	0.55	0.07
Enteromorpha intestinelis	1.85	0.85	0.5	0.05
Asparagopsis spp	0.12	0.075	0.0	0.0

Table 2: Percentage of ash and NPK mg/g in the studied marine macroalgae

Algal species	Ash	P	N	K
Gelidium pectinutum	138	1.3	22.4	79.8
Enteromorpha intestinelis	177	1.2	25.4	54.5
Asparagopsis spp	221	1.21	15.8	98.9

Table 3: Analysis of the commercial seaweed extract Algreen

Soluble dry matter	350 g/L
Organic matter	20 g/L
Alginic Acid	4 g/L
Total Nitrogen	60 g/L
MgO	60 g/L
S	70 g/L
Boron	5 g/L
Mo	2.6 g/L
Natural plant hormones	300 ppm

Table 4: Some chemical characteristics of the applied compost

pH	Ec ds/m	C/N ratio	Organic C%	N%	P%	K%
8.1	4.15	1:12	30.44	1.53	0.29	1.13

- (T5) Red alga (*Asparagopsis spp*) extract 1 l/feddan + Compost 5 kg/m^2
- (T6) Red alga (*Gelidium pectinutum*) extract 1l/feddan + Compost 5 kg/m^2
- (T7) Green alga (*Enteromorpha intestinelis*) extract 1 l/feddan + Compost 5 kg/m^2
- (T8) Algreen 1 l/ feddan with drop irrigation.
- (T9) Algreen 1 l/ feddan + Compost.
- Mineral fertilizers: the recommended NPK fertilizers were used according to the recommendation of Ministry of Agriculture in Egypt as a control. Seaweed extracts spraying was applied three times within 15 days intervals starting from 20 day after sowing.

Data Recorded:

- Vegetative growth: five plants from each replicate were used to determine the following characters: stem length, number of leaves/plant and leaf area/plant were determined 75 days after sowing.
- Chlorophyll content in the leaves: take after 75 day from planting by Chlorophyll meter; model SPAD-502 after 75 days from sowing.
- Total yield was determined as number and weight of fruits /plant of all pickings.

Fruit Chemical Analysis:

- Determination of phosphorus, potassium and total nitrogen using the method described in the chemical analyses of SLF section
- Nitrate content: was estimated by rapid colorimetric determination in fruits by nitration of salicylic acid according to Cataldo *et al.* [22].

Experimental Design and Statistical Analysis: The experiment included ten treatments, which were arranged in a randomized complete block design (RCBD) with three replicates. Data were subjected to analysis of variance and the means were compared using the LSD test at the 0.05 level, as recommended by Snedecor and Cochran [23].

RESULTS AND DISCUSSION

Vegetative Growth: Data in Tables 5 and 6 showed that all vegetative characters in cucumber plants was significantly affected by applying different treatments in both seasons compared with the control. Applying the T7 and T4 treatments produced the long plants having the highest number of leaves, highest fresh and dry weight and largest leaf area of cucumber plants in both seasons

Table 5: Effect of different seaweed and compost treatments on plant vegetative growth of cucumber during 2008 summer season

Symbol	Treatments	Plant height (cm)	No. of leaves	Plant fresh weight (g)	Plant dry weight (g)	Leaf area (cm^2)	Chlorophyll (%)
T1	Compost	97.0 d	21.67 e	468.5 f	68.40 de	162.8 g	44.17 ab
T2	Red alga (*A. spp*) extract	119.0 b	25.00 bc	504.0 b	71.67 b	189.9 b	32.63 b
T3	Red alga (*G. pectinutum*)	118.0 b	24.33 cd	495.9 cd	70.83 bc	184.0 c	43.21 ab
T4	Green alga (*E. intestinelis*)	125.7 a	26.67 ab	524.0 a	75.00 a	189.9 b	44.87 ab
T5	Red alga (*A. spp*) + compost	109.0 c	22.33 de	490.8 de	69.40 cd	179.5 d	43.91 ab
T6	Red alga (*G. pectinutum*) + compost	109.3 c	22.33 de	485.3 e	68.63 de	169.2 f	44.73 ab
T7	Green alga (*E. intestinelis*) + compost	129.0 a	27.67 a	527.8 a	77.00 a	199.9 a	46.03 a
T8	Algreen	97.7 d	21.00 e	486.7 e	71.97 b	173.5 e	47.57 a
T9	Algreen + compost	119.3 b	25.67 abc	502.8 bc	72.03 b	188.3 b	49.27 a
	Control	89.67 e	16.67 f	468.3 f	66.63 e	162.1 g	41.87 ab

Table 6: Effect of different seaweed and compost treatments on plant vegetative growth of cucumber during 2009 summer season

Symbol	Treatments	Plant height (cm)	No. of leaves	Plant freshweight (g)	Plant dry weight (g)	Leaf area (cm^2)	Chlorophyll(%)
T1	Compost	95.33 e	24.33 cd	466.8 e	67.40 e	160.9 e	43.84 ab
T2	Red alga (*A. spp*) extract	107.70 d	21.00 e	480.6 d	66.97 e	167.5 d	32.30 b
T3	Red alga (*G. pectinutum*)	107.70 d	25.67 abc	498.5 b	71.03 b	185.8 b	42.87 ab
T4	Green alga (*E. intestinelis*)	121.30 ab	26.67 ab	518.0 a	74.33 a	187.3 b	44.53 ab
T5	Red alga (*A. spp*) + compost	114.70 c	21.67 e	486.8 cd	68.07 de	177.2 c	43.57 ab
T6	Red alga (*G. pectinutum*) + compost	117.70 bc	25.00 bc	500.0 b	69.67 c	186.7 b	44.40 ab
T7	Green alga (*E. intestinelis*) + compost	125.00 a	27.67 a	521.4 a	73.33 a	198.8 a	45.70 a
T8	Algreen	92.33 e	22.33 de	491.9 bc	69.17 cd	180.2 c	47.23 a
T9	Algreen + compost	117.70 bc	22.33 de	482.7 d	69.63 c	170.3 d	48.93 a
	Control	83.67 f	16.67 f	463.0 e	64.77 f	157.3 e	41.53 ab

Table 7: Effect of different seaweed and compost treatments on yield and its component of cucumber during 2008 and 2009 summer seasons

		No. of fruits/plant		Plant yield (kg)		Total yield (ton/fed)	
Symbol	Treatments	2008	2009	2008	2009	2008	2009
T1	Compost	9.033 g	9.633 e	1.003 d	1.030 d	8.027 d	8.24 bcd
T2	Red alga (*A. spp*) extract	10.60 e	10.90 d	0.963 de	0.980 de	7.707 de	7.84 d
T3	Red alga (*G. pectinutum*)	12.17 d	12.83 c	1.090 c	1.143 c	8.720 c	9.15 abcd
T4	Green alga (*E. intestinelis*)	10.27 e	10.73 d	0.990 de	1.000 de	7.920 d	8.00 d
T5	Red alga (*A. spp*) + compost	12.73 c	12.80 c	1.147 bc	1.193 bc	9.173 bc	9.55 abc
T6	Red alga (*G. pectinutum*) + compost	13.00 c	13.43 b	1.180 b	1.200 b	9.440 b	9.60 ab
T7	Green alga (*E. intestinelis*) + compost	14.67 a	14.87 a	1.290 a	1.327 a	10.32 a	10.61 a
T8	Algreen	9.733 f	10.47 d	0.997 d	1.003 de	7.973 d	8.03 cd
T9	Algreen + compost	13.60 b	13.77 b	1.283 a	1.323 a	10.27 a	10.59 a
	Control	8.033 h	8.633 f	0.917 e	0.970 e	7.333 e	7.76 d

followed by T9, T2 and T3 treatments. Control plants had the lowest value for all vegetative characters in both seasons, followed by compost treatment for all mentioned characters. For chlorophyll, treatments T7, T8 and T9 gave the highest value of chlorophyll in both seasons. The T2 treatment produced the lowest value of chlorophyll, while there is non significant difference between other treatment. The favorable effect of T7 and T4 treatments on stem length, number of leaves, plant fresh and dry weights and leaf area may be due to that the high concentration of nitrogen in this alga type and the compost improved physical conditions of soil, providing energy necessary for microorganisms activity and increasing the availability and uptake of nutrients, which positively reflected on these characters [2, 9, 10]. The stimulation of plant growth by using green alga (*E. intestinelis*) + compost and green alga (*E. intestinelis*) only may be attributed to the combined effect of compost, (which contains humic acids, vitamins, amino acids and both of macro and micro nutrients, which enhanced cucumber growth) and alga, which contains some growth regulators such as auxins and gibberellins [4, 5].

Yield and its Component: It is obvious from Table 7 that T7 and T9 produced the highest values of number of fruits/plant, plant yield and total yield in both seasons compared with the control followed by using of T6 and T2. Compost only (T1) gave a little higher value than control. The commercial seaweed extract (Algreen) produced higher values than each of compost and control

Table 8: Nitrogen, Phosphorus and potassium percentage and nitrite content in cucumber fruit as affected by different seaweed and compost treatments during 2008 summer season

Symbol	Treatments	N (%)	P (%)	K (%)	NO_3^- mg /kg
T1	Compost	1.953 bc	0.1850 b	2.653 ab	53.80 e
T2	Red alga (*A. spp*) extract	1.997 bc	0.1683 b	2.513 abc	63.23 cd
T3	Red alga (*G. pectinutum*)	2.080 b	0.2080 b	2.400 bcd	54.98 de
T4	Green alga (*E. intestinelis*)	2.067 b	0.1743 b	2.197 cde	66.78 c
T5	Red alga (*A. spp*) + compost	2.030 b	0.1667 b	2.860 a	64.42 c
T6	Red alga (*G. pectinutum*) + compost	2.950 a	0.2627 a	2.323 bcde	69.48 c
T7	Green alga (*E. intestinelis*) + compost	3.057 a	0.2020 b	2.027 e	64.61 c
T8	Algean	2.040 b	0.1980 b	2.033 e	96.94 b
T9	Algean + compost	2.090 b	0.2053 b	2.477 bc	97.45 b
	Control	1.750 c	0.1827 b	2.110 de	150.6 a

Table 9: Nitrogen, Phosphorus and potassium percentage and nitrite content in cucumber fruit as affected by different seaweed and compost treatments during 2009 summer season

Symbol	Treatments	N (%)	P (%)	K (%)	NO_3^- mg /kg
T1	Compost	2.067 b	0.1967 ab	2.527 bc	58.17 d
T2	Red alga (*A. spp*) extract	1.980 b	0.1830 b	2.553 bc	65.63 c
T3	Red alga (*G. pectinutum*)	2.103 b	0.2133 ab	2.220 cde	57.51 d
T4	Green alga (*E. intestinelis*)	2.077 b	0.1797 b	2.067 e	58.07 d
T5	Red alga (*A. spp*) + compost	2.073 b	0.1963 ab	2.917 a	59.38 d
T6	Red alga (G. pectinutum) + compost	2.997 a	0.2670 a	2.157 de	59.33 d
T7	Green alga (*E. intestinelis*) + compost	3.097 a	0.2097 ab	2.720 ab	60.33 cd
T8	Algean	2.123 b	0.2227 ab	2.347 cde	98.61 b
T9	Algean + compost	2.177 b	0.2200 ab	2.440 bcd	97.49 b
	Control	2.027 b	0.1827 b	2.057 e	185.9 a

in both seasons. The performed higher number of fruits/plant, plant yield and total yield from treatments (No. 7 & 9) may be due to their higher nutritional contents, particularly Fe, Zn and Mn in compost and K, Ca, Mg, S and Fe in seaweed extract [5]. These elements can encourage vegetative growth, total chlorophyll and photosynthetic rate, which enhance flowering and fruiting leading to an increase in early fruit maturity.

These results agree with previous studies [8, 12-14]. They showed that applying of seaweed extract and organic treatments increased total yields compared to using chemical fertilizers.

Fruit Chemical Analysis: Data presented in Tables 8 and 9 indicated that both of T7 and T6, significantly, produced higher value of nitrogen content in both seasons. Control plants had the lowest value of nitrogen content compared with all treatments, while, there is non significant difference among all other treatments in both seasons. This results my be due to the higher value of nitrogen in both green alga ((*E. intestinelis*) and red alga (*G. pectinutum*). (Table 2) and the compost was very rich in NPK contents. On the other hand, the highest value of phosphorus significantly obtained from T6, while, there is non significant difference among all other treatments in the first season. In second season, T6 also produced the highest phosphorus value followed by all treatments except T2, T4 and the control which gave the lowest value. Spraying seaweed extract increased fruit content of phosphorus which may be due to the high content of phosphorus in all used seaweeds in this investigation (Table 2) and the higher content of NPK in compost. For potassium content in cucumber fruits, Tables 8 and 9 indicated in both season, that the highest value obtained from using treatment 5 (red alga (*Aspragopsis. spp*) + compost) followed by both compost and T2 and the lowest value obtained from control plants. Table 2 showed the high potassium content of red alga (*Aspragopsis spp*) which maybe the reason for the higher fruit content of potassium. These results agree with those obtained by [2, 3].

Tables 8 and 9 showed nitrate content in cucumber fruits and it is obvious that all treatments reduced nitrate content compared with the control. In both seasons, treatment 1 (compost only) had the lowest value of nitrate content flowed by T3 (red alga (*G. pectinutum*)). Control in both season had the highest values of nitrate content, followed by T8 and T9.

The highest nitrate content due to chemical fertilization maybe attributed to that mineral fertilizer salts are soluble and nitrogen is immediately available for plant uptake soon after fertilizer application, otherwise, organic N fertilizers release nutrients slowly [11].

CONCLUSION

From previous results, it could be suggested that using seaweed extract of green alga (*E. intestinelis*), red alga (*G. pectinutum*) or commercial seaweed extract (Algreen) in addition to compost is considered a suitable application to improve vegetative growth and yield of cucumber plants.

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