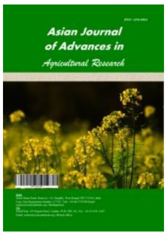

Asian Journal of Advances in Agricultural Research

19(4): 1-11, 2022; Article no.AJAAR.92833
ISSN: 2456-8864

The Effect of Spraying with Spirulina Extract and Microelements on the Growth and Yield of Cucumbers

Souad Abdel Latif Mohamed Al-Mursi Al-Najjar [a*]

[a] *Agriculture Research Department Under Modified Weather Conditions, Horticultural Research Institute, Agricultural Research Center, Al Dokki, Cairo, Egypt.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJAAR/2022/v19i4379

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/92833

Original Research Article

Received 06 August 2022
Accepted 13 October 2022
Published 19 October 2022

ABSTRACT

Algae extracts are an excellent source of chemical fertilizers (NPK) and plant growth promoters such as auxins, cytokinins, betaine, gibberellins, amino acids, macronutrients, microelements, and organic matter that improve plant productivity. The investigation was performed at 2019-2020 through winter seasons, in sandy soil at Ismailia Agricultural Research Station greenhouse. To investigate the impact of numerous levels of spraying of spirulina extract (after being diluted with half its volume of water) combined with or without microelements on the vegetative development and cucumber yield (*Cucumis sativus L*.) of Rocket cultivar. The experiment involved 7 different treatments (control, foliar fertilization by 5 ml, 10 ml, and 15 ml of spirulina extract/L water combined with or without concentrated microelements at 2 ml/L. Spraying was performed after 2 weeks planting three times 15 days intervals. The experiment was performed with three repetitions using a complete block randomized design (CBRD), and averages were compared using the test Duncan's at 0.05 level. Spraying with 15 mL spirulina with microelements achieved the highest plant height, main branches number, number of leaves, leaf area, length fruit, fruit diameter, stems and leaves fresh weight, stems and leaves dry weight, chlorophyll content and, NPK during two seasons. While the highest yield was recorded in terms of plant yield (1.27 and 1.31 kg), the yield of the experimental plot (25.59 and 26.25 kg), the total yield per fed. (10.74 and 11.02 tons) by spraying with 5 ml of spirulina extract incorporated with microelements during the two planting seasons,

**Corresponding author: Email: ibr23ibr23@yahoo.com;*

respectively. The results show that higher spirulina concentrations activate plant growth, chlorophyll and NPK in the leaves, while the concentration above 5 ml spirulina reduces the resulting yield.

Keywords: Algae; spirulina; spraying; microelements; cucumber.

1. INTRODUCTION

Cucumber is a chief vegetable crop in the Cucurbitaceae family planted in Egypt in the summer season, which can be successfully grown in protected environments under plastic tunnels or in greenhouses in winter. Cucumber fruit contains 96% water, 0.7 mg protein, 4 calories, 24 mg calcium, vitamin A producer, 0.075 mg riboflavin (vitamin B2) and 0.3 mg niacin per 100 g of fruit [1]. Egypt's total planted area is (46728) fed. and its productivity of fed. reached 9,481 tons/fed., with productivity of (443035 tons) in 2019/2020. Increased demand due to population growth and large losses due to disease outbreaks during cultivation requires the use of several ingredients that stimulate production, in addition to increasing disease resistance and improving fruit quality. Under protected cultivation, the production of cucumbers is 2 to 9 times greater than in the open field, which depends on technological levels, nutrition management, and control of climatic conditions, which are key factors for high yield in this type of vegetable. The nutrition of this crop is an important cause in increasing its production. In several regions, there is indiscriminate utilization of chemicals fertilizer, and excessive cultural practices have brought severe consequences to the environment. In addition, the high costs of chemical fertilizers made them out of the reach of producers, which led to lower yields, lower incomes, and lower quality of products [2]. Besides, when exporting vegetables, consumers tend to accept “innovative, different” and appropriate products that can contribute to a consistently healthy diet with the less environmental impact on natural resources [3].

The seaweed effected on the cell metabolism for the synthesis antioxidant molecules that boost plant development and stress tolerance, as well as protection against bacteria, yeast, and molds may explain the improved plant growth, yield, and quality [4]. Seaweed extract are soluble in water and act as organic fertilizers that promote the seeds germination, growth and yield of crops [5]. Marine algae are generally used as fertilizers, but their nitrogen and potassium content is similar to that of animal manure and organic fertilizers, but their phosphorus content is low. The seaweed used in production the products had anti activity against insects, fungal, and bacterial diseases [6]. In addition it act as supplements or biofertilizers that stimulate different activity on plants [7]. Also, it’s used foliar or in granular form as soil improvers and fertilizer [8]. Foliar fertilization with seaweed extracts, wealthy in naturalist plant hormones, vitamins, and several macro- and micronutrients, has a rapid effect on the preparation of plants with these requirements, thus increasing agricultural production in modern techniques. Sathya et al. [9] refer that seaweed extracts include diverse growth-stimulates like cytokinins, auxins, betaines, amino acids, gibberellins, and organic materials including macro- and micronutrients that improve crop and their quality. Ahmed and Shalaby [10] stated that seaweed extracts provide an alternative source of chemical fertilizers, as they not only contain nitrogen, phosphorus and potassium, but also a very wide range of phytohormones, amino acids, and organic acids encouraging plant metabolism. Sakr [11] confirmed that spraying sweet pepper with seaweed extract after 75 days of planting increased the percentage of flower set by 16.38% and the mean quantity of fruits by 6.83 fruits/plant compared to 3.88 fruits/plant for untreated plants. Saravanan et al. [12,13] discovered that spraying tomato plants with seaweed extracts at different concentrations increased the number of flowers and fruit set while decreasing the drop of young fruits of the plant and significantly increased the diameter of fruit in two studies. Additionally, tomatoes' weight and qualitative attributes such as total sugars, vitamin C, phenols, and lycopene are increased.

Spirulina is blue-green microalgae, including high-antioxidant components, organic and amino acids, high-quality proteins, Fe and Ca, unsaturated fatty acids, many types of vitamins including A, B2, B6, B8, B12, E, and K chlorophyll, carotenes, phycocyanin and plant hormones [14,15]. Spirulina contains 18 of the 20 known amino acids, all essential minerals, and trace elements, as well as enzymes [16].

The application of spirulina can reduce chemical fertilizers using and positively affect their growth and physiology [17]. Antimicrobial action of spirulina cell extract against different bacteria has been demonstrated due to large levels of acrylic acid in spirulina and organic acids such as propionic, benzoic, and mandelic [18]. Many agriculture products include antimicrobial [19], antifungal [20], and herbicide compounds [21] are manufactured from spirulina. The sulfated polysaccharides of spirulina showed activity against different virus replication [22]. Phycocyanin is the major pigment in spirulina that promote anthocyanin production in secondary metabolites and inhibits oxidative damage in plant DNA [23]. Phycocyanin is a powerful antioxidant that scavenging free radical.

The research aimed to investigate foliar spraying effect by spirulina and microelements on the growth and yield characteristics of a popular Egyptian cucumber cultivar (Rocket).

2. MATERIALS AND METHODS

2.1 Materials

This research was achieved at the Agricultural Research Center, in one of the greenhouses of the Ismailia Agricultural Research Station for two agricultural seasons in 2019/2020, to investigate foliar spraying effect by spirulina (1fresh spirulina :0.5 water) and microelements on the vegetative changes and yield of cucumber plant, cultivar Rocket.

The structure of microelements (Nature SA) was (2% zinc, 2.5% iron and 1% manganese, 0.5% copper, 3% magnesium, 3% sulfur, and 0.5% boron) and the recommended rate was 2 cm^3 / liter.

The greenhouse soil was prepared prior to conducting the experiment. The soil was split into lines ten meters long and one meter wide. The seedlings distance between plants is 50 cm. All agricultural services are carried out in accordance with the requirements of the plant. Experiment was performed according to RCBD's with three replicates. Spirulina seaweed extract was prepared by mixing fresh spirulina and water at a ratio of 1:0.5, homogenizing.

The study contained 7 treatments, the first being a control, while the other three consisted of spraying cucumber shoots with spirulina extract without micronutrients at (5 ml, 10 ml, and 15 ml spirulina extract/L^{-1} of water). The other three treatments consisted of sprays of spirulina extract combined with microelements at levels (5, 10 and 15 ml) of spirulina extract incorporated with 2 ml concentrated microelements / liter of water. The symbols of treatments are shown in Table 1. Spraying for cucumber plants was applied three times, the first one after two weeks of transplanting, then after 15 days for every one.

2.2 Methods

2.2.1 Vegetative characters

2.2.1.1 Plant length (cm)

The height of the plant was measured from the soil surface to the terminal of the plant

2.2.1.2 Branch number (mean)

The number of branches (mean) was calculated for the 3 plants allocated from each experimental unit, then divided the result by the number of plants.

2.2.1.3 Leaves number

The leaves of several plants were calculated randomly from each treatment and for all treatments, then calculated the average of one plant.

Table 1. The treatment symbols used in study

Treatments	Symbols
Control	Co
5 ml spirulina extract* / L water	S1
5 ml spirulina extract + 2 ml microelements** / L water	S11
10 ml spirulina extract / L water	S2
10 ml spirulina extract + 2 ml microelements / L water	S22
15 ml spirulina extract / L water	S3
15 ml spirulina extract + 2 ml microelements / L water	S33

**Spirulina extract: (1fresh spirulina: 0.5 water), **Microelements: (Nature SA) include (2% zinc, 2.5% iron and 1% manganese, 0.5% copper, 3% magnesium, 3% sulfur, and 0.5% boron)*

2.2.1.4 Leaf area cm^2

Leaf area (cm^2) was measured with a portable leaf area meter [24].

2.2.1.5 Fresh and dried weighing of stems and leaves

Three plants from each three replicate separated into leaves and stems and dried in an oven at 70 °C for two days to determine the dry weight during the early stages of fruit set.

2.2.2 Chemical characteristics

2.2.2.1 Determination of NPK (mg/kg) in leaves

A leaf sample weighing 0.5 g was taken and digested by adding 5 ml sulfuric acid, followed wth 3 ml of pyrochloric acid [25]. Nitrogen percentages were measured with a micro-Kjeldahl apparatus [26]. Phosphorus was measured at 882 nm by spectrophotometer [27]. Potassium percentage was measured with a flame photometer.

2.2.2.2 Determination of chlorophyll

The chlorophyll content of cucumber leaves was estimated using the 90% acetone extraction method and UV-Vis spectrophotometer at wavelengths of 645, 663 and, 750 nm, and the total amount of chlorophyll pigment was calculated as mg pigment /100 g fresh weight.

2.2.3 Characteristics of the yield

Fruit length (cm) was recorded with a tape measure. Verneir was used to measure the fruits diameter from the middle.

Plant yield (kg) was calculated by computing the total yield resulted from the three replicates of treatment and dividing by the number of plants. Plot yield (kg) was calculated by measuring the total fruit weight of the experimental unit. The total yield per fed. (ton/fed) was estimated by multiplying the number of plants per fed. in plant yield.

2.2.4 Statistical analysis

Statistical analysis was performed according to the RCBD design and Duncan's test was used to identify significant differences between means at the 5% probability level by SPSS 16 software.

3. RESULTS AND DISCUSSION

3.1 Vegetative Growth Characters

It is noted from Table 2 that spraying with spirulina extract has significantly affected the rise of the cucumber plant height, and the effect has increased when microelements combined with spirulina extract have been used. The spraying treatment at a concentration of 15 ml/L with the use of microelements recorded the highest height of the plant at 146 and 154 cm compared to the treatment of control (spraying with distilled water only) which recorded the lowest height of the plant at 111 and 119 cm for both seasons respectively.

It is also clear that foliar spraying with the same treatment (15 ml of spirulina extract/l water) with the use of microelements gave the highest number of side branches with a record of 4.5 and 5.2 compared to the comparison treatment of 3.2 and 3.6 during the planting seasons.

Spraying with S33 treatment recorded the highest values of leaves number by 70 and 79 and the leaf area 45.9 and 47.3 cm^2 compared to the control that recorded the lowest values. It is also noted that the combination of the use of spirulina and microelements increases the characteristics of vegetative growth significantly compared to the non-use of microelements.

Table 2. Effect of spirulina and microelements on vegetative growth of cucumber Rocket cultivar

	Plant length cm		Branch num.		Leave num.		leaf area cm^2	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
Co	111^g	119^g	3.2^g	3.6^g	36^g	45^g	25.6^g	26.3^g
S1	117^f	125^f	3.5^f	3.8^f	44^f	49^f	28.4^f	33.2^f
S11	124^e	128^e	3.6^e	4.1^e	54^e	58^e	32.3^e	35.5^e
S2	131^d	135^d	3.8^d	4.4^d	60^d	62^d	33.2^d	37.6^d
S22	138^c	142^c	4.1^c	4.7^c	62^c	68^c	36.5^c	41.8^c
S3	142^b	148^b	4.3^b	4.9^b	67^b	71^b	43.4^b	45.7^b
S33	146^a	154^a	4.5^a	5.2^a	70^a	79^a	45.9^a	47.3^a

Table 3. Effect of spirulina and microelements on fresh and dried weight of stems and leaves of cucumber Rocket cultivar

	Stem fresh weight (g)		Leave fresh weight (g)		Total fresh (g)		Stem dry weight (g)		Leave dry weight (g)		Total dry weight (g)	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
Co	645[g]	663[g]	682.4[g]	698.3[g]	1327.4[g]	1361.3[g]	59.67[g]	60.4[g]	148.2[g]	161.3[g]	207.9[g]	221.7[g]
S1	690[f]	703[f]	730[f]	759[f]	1420[f]	1462[f]	62.1[f]	67.4[f]	157[f]	181[f]	219.1[f]	248.5[f]
S11	705[e]	723[e]	780.8[e]	790.5[e]	1485.8[e]	1513.5[e]	66.96[e]	70.1[e]	177.5[e]	186.9[e]	244.4[e]	257[e]
S2	729[d]	739[d]	790.3[d]	803[d]	1519.3[d]	1542[d]	70.47[d]	74.3[d]	181.8[d]	190.5[d]	252.2[d]	264.8[d]
S22	749[c]	788[c]	803[c]	812.5[c]	1562[c]	1600.5[c]	76.4[c]	79.1[c]	186.9[c]	193.3[c]	263.3[c]	272.3[c]
S3	768[b]	805[b]	812.5[b]	828.4[b]	1580.5[b]	1633.4[b]	79.6[b]	82.4[b]	190.4[b]	196.4[b]	270[b]	278.8[b]
S33	783[a]	819[a]	828.4[a]	866.5[a]	1611.4[a]	1685.5[a]	83.4[a]	89.1[a]	196.3[a]	199.3[a]	279.7[a]	288.4[a]

In conclusion the results pointed to that employing foliar spraying with seaweed extracts (spirulina) improved plant and vegetative growth of cucumber fruit and these results are agree of with reported by different researchers [28,29,10,30,31].

Foliar sprays of various concentration of spirulina were encourage stems and leaves fresh weight compared with the control as well as total fresh weight as appear from Table 3. The maximum stems and leaves fresh weight during two season (783, 819, 828.4, and 866.5 g) were obtained by S33 treatment. Also, it clearly from the results that increase the concentration of spirulina led to increase total fresh weight as well as stems and leaves fresh weight. Incorporated microelements with spirulina significantly maximize the weight for both stems and leaves fresh weight and total fresh weight compared with utilized spirulina alone. This may be due to beneficial effects for the use of algae on physiological and biological activities, resulting in increased plant growth [29]. The same increase in fresh and dried weight of stem and leaves were achieved in cucumber plants [32,31] as result to apply seaweed extracts which may be due to high content of P, Mg, K, Zn, Fe, and Mn) and increase the level of photosynthesis process. In addition to the fact that seaweed extracts have growth hormones, macro, micronutrients and organic matters like, amino acids that improve nutritional status, vegetative growth incorporating fresh and dried weight of stem and [33,34].

The same trend of results on fresh weight (stems, leaves, and total) were obtained after dehydration not either by stems but also by leaves by increase concentration of sprayed spirulina which achieved higher level of dry weight for stems and also leaves as well as the total dried weight especially when incorporated with microelements. The highest dried weight of stem, leaves, and total dry weight recorded by S33 treatment during two season as follow (83.4, 89.1, 196.3, 199.3, 279.7, and 288.4 g), respectively. It was clear that the foliar application of spirulina alone or incorporated with microelements had a significant role in promoting the total dry weight of leaves and stems likened with the control, similar results obtained by [30] who applied foliar spray with algae in beans.

3.2 Chemical Constituents

3.2.1 NPK (mg/kg) in leaves

The results of Table 4 indicate that spraying with spirulina extract had a significant effect on increasing the proportion of nitrogen in the leaves as result for increasing the concentration of spirulina used in the spray. The proportion of nitrogen in the leaves increased as combined the microelements with spirulina in the spray liquid. Treatment S33 gave the highest level of nitrogen, 3.44, and 4.01 mg/kg during the two growing seasons, respectively. Compared to the control treatment, the nitrogen level in leaves was 2.91 and 3.17 mg/kg. Perhaps this is due to the high nitrogen content in spirulina.

The results also indicated a significant increase in phosphorous in the leaves after spraying with spirulina extract, and the effect increased when the spirulina extract was combined with microelements extract. The percentage of increase in phosphorus ranged from 42 to 57% when comparing the treatment with S33, which gave the highest rate of increase in phosphorous content in the leaves compared to the control.

Also, the same treatment S33 achieved the highest rate of potassium in the leaves compared to the control, which amounted from 34 to 38%. The increment of NPK in cucumber leaves increased by increase the concentration of spirulina that contain a higher capacity of macronutrients or NPK as reported by [32]. Others researchers emphasized on this result such [33,34].

Table 4. Effect of spirulina and microelements on NPK of leaves cucumber Rocket cultivar

Treatments	N (mg/kg)		P (mg/kg)		K (mg/kg)	
	S1	S2	S1	S2	S1	S2
Co	2.91^{g}	3.17^{g}	0.33^{g}	0.38^{g}	2.98^{g}	3.27^{g}
S1	2.99^{f}	3.32^{f}	0.37^{f}	0.41^{f}	3.31^{f}	3.46^{f}
S11	3.08^{e}	3.35^{e}	0.39^{e}	0.43^{e}	3.43^{e}	3.69^{e}
S2	3.16^{d}	3.37^{d}	0.41^{d}	0.49^{d}	3.59^{d}	3.81^{d}
S22	3.21^{c}	3.47^{c}	0.43^{c}	0.52^{c}	3.77^{c}	3.98^{c}
S3	3.28^{b}	3.58^{b}	0.46^{b}	0.55^{b}	3.93^{b}	4.14^{b}
S33	3.44^{a}	4.01^{a}	0.49^{a}	0.60^{a}	4.13^{a}	4.39^{a}

3.2.2 Leaf pigments

From Table 5, we can see that spraying spirulina extract has a significant effect on the total chlorophyll content of leaves, and the effect increases with increasing spirulina concentration. Using spirulina in combination with trace elements resulted in the highest-level chlorophyll compared to using spirulina alone. Utilizing S33 treatment maximized diverse chlorophyll types. Chlorophyll a achieved 50.51 and 51.6 mg/100g by S33 during two seasons, while chlorophyll b was 28.2 and 29.6 mg/100 g. Also, S33 treatments gave the maximum a value and b that reached to 78.7 and 81.2 mg /100 g and finally chlorophyll c reached to 4.2 and 4.4 mg/100 g during two seasons, respectively. The control treatments recorded 33.3 and 34.3 mg/100 g for Chlorophyll a, 22.3 and 22.8 mg/100 g Chlorophyll b, 55.6 and 57.1 mg/100 g Chlorophyll a and b and chlorophyll c were 2.9 and 3.0 mg/100 g in the two seasons, respectively. Application foliar with marine algae extracts significantly increased the different chlorophyll content [10,31].

3.3 Fruit Quality

Table 6 shows that the S33 treatment is significantly superior in fruit length to other treatments, as it gave the highest value for fruit length (16 and 16.3 cm) during the planting seasons, while the control treatment gave the lowest value (13.5 and 13.5 cm), respectively. Increasing the spirulina concentration led to increase fruits length. The incorporation spirulina with microelements achieved a higher fruits length compared with using spirulina without microelements.

From the results, it can be observed that the foliar spray of seaweed liquid extracts enhanced the yield parameters, such as, fruit length and fruit weight and the same trend obtained on cucumber by [35,36,10,37,38,39]. Zodape et al. [40] found the same enhancement by length and diameter fruits when pepper plants spraying by marine algae extract.

3.4 Characteristics of the Yield

It is clear from the results of Table 7 that spraying with spirulina extract on plant leaves has significantly affected the yield of one plant only when spraying at the level of 5 ml spirulina. The higher concentration about 5 ml spirulina has significantly led to a decrease in the yield resulting from one plant. The highest plant yield was recorded at S11 treatment by 1.27 and 1.31 kg, respectively during two seasons while the lowest plant yield was recorded by S3 treatment

Table 5. Effect of spirulina and microelements on Chlorophylls (mg/100 g) of leaves cucumber Rocket cultivar

	Chlorophyll a		Chlorophyll b		Chlorophyll a+b		Chlorophyll c	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
Co	33.3^{g}	34.3^{g}	22.3^{g}	22.8^{g}	55.6^{g}	57.1^{g}	2.9^{g}	3.0^{f}
S1	34.2^{f}	38.4^{f}	24.1^{f}	24.9^{f}	58.2^{f}	63.2^{f}	3.2^{f}	3.4^{e}
S11	35.0^{e}	41.4^{e}	24.9^{e}	25.6^{e}	59.9^{e}	67.0^{e}	3.4^{e}	3.5^{e}
S2	41.8^{d}	44.0^{d}	25.8^{d}	26.4^{d}	70.7^{d}	70.4^{d}	3.6^{d}	3.7^{d}
S22	43.5^{c}	47.6^{c}	26.6^{c}	27.3^{c}	70.2^{c}	74.9^{c}	3.8^{c}	3.8^{c}
S3	46.94^{b}	48.5^{b}	27.0^{b}	27.6^{b}	74.0^{b}	76.1^{b}	4.0^{b}	4.1^{b}
S33	50.51^{a}	51.6^{a}	28.2^{a}	29.6^{a}	78.7^{a}	81.2^{a}	4.2^{a}	4.4^{a}

Table 6. Effect of spirulina and microelements on fruit length and diameter of cucumber Rocket cultivar

	Fruit length (cm)		Fruit diameter (cm)	
	S1	**S2**	**S1**	**S2**
Co	13.5^{g}	13.5^{g}	3.2^{e}	3.4^{f}
S1	13.7^{f}	14^{f}	3.3^{e}	3.6^{e}
S11	14.1^{e}	14.3^{e}	3.5^{d}	3.8^{d}
S2	14.4^{d}	14.6^{d}	3.6^{d}	4^{c}
S22	14.7^{c}	14.9^{c}	3.8^{c}	4.1^{bc}
S3	15.2^{b}	15.6^{b}	4^{b}	4.2^{b}
S33	16^{a}	16.3^{a}	4.6^{a}	4.8^{a}

Table 7. Effect of spirulina and microelements on plant, plot, and total yield of cucumber Rocket cultivar

	Plant yield (kg)		Plot yield (kg)		Total yield (ton/fed)	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**
Co	1.19^{b}	1.22^{c}	23.91^{c}	24.55^{c}	10.04^{c}	10.31^{c}
S1	1.26^{a}	1.25^{b}	25.35^{b}	25.19^{b}	10.64^{b}	10.58^{b}
S11	1.27^{a}	1.31^{a}	25.59^{a}	26.25^{a}	10.74^{a}	11.02^{a}
S2	1.09^{c}	1.14^{e}	21.98^{e}	22.81^{e}	9.23^{e}	9.58^{e}
S22	1.11^{c}	1.16^{d}	22.37^{d}	23.35^{d}	9.39^{d}	9.80^{d}
S3	0.98^{e}	1.02^{g}	19.71^{g}	20.43^{g}	8.28^{g}	8.58^{g}
S33	1.07^{d}	1.10^{f}	21.43^{f}	22.15^{f}	9.00^{f}	9.30^{f}

by 0.98 and 1.02 kg during the planting seasons respectively. [10,31] illustrated that employing algae improve fruits weight as result for enhancing the leaves numbers leaf area and activate consequently the physiological activities as photosynthesis that end improve the plant yield, total yield, and crop quality of cucumber [41]. Increasing fruits number per plant is another reason for increase the plant yield or total yield by spraying cucumber plants with the seaweed extract [42,43]. The reason for the increase the plant yield may due to rise the quantity of fruits per plant for increasing the flowers and the proportion of nodes for increasing in the number of branches, leaf area, and chlorophyll content of leaves, which affected on carbon metabolism and accumulation of nutrients in the plant [44]. Additionally the action of nutrients included in spirulina extract that encourage flowering, nodes, carbon representation, respiration, and protoplasmic building processes. These nutrients enter into the synthesis of the necessary DNA and RNA dividing cells and then increasing the number of branches, which created the opportunity to form the largest amount of floral buds and then rise the number of fruits in the plant and thus increase the yield for one plant and then for fed. yield [45]. These effects are harmonious with what obtained by [32,46]. The third reason for increase the plant yield by spraying seaweed extract is improving fruit set and fruit retention [47,48].

The findings exhibited that spraying with spirulina extract at the first level at 5 ml of spirulina, whether with or without the use of microelements, exceeded the yield of experimental plots on the control and other spray levels. The S11 treatment recorded the highest experimental plots yield by 25.59 and 26.25 kg per plot, while S3 treatment was the lowest experimental plots yield by 19.71 and 20.43 kg during the two growing seasons, respectively.

It is also clear that spraying with spirulina extract has a significant impact on the total yield per fed. as the S11 treatment recorded the highest values of 10.74 and 11.02 tons per fed. compared to the control treatment (Co) which recorded 10.04 and 10.31 tons per fed. for the two growing seasons. Yield improvement connected using the hormonal substances (organic compounds) existing in the seaweed extracts, particularly, cytokinins which promote floral initiation, help earlier flowering than normal and increase nutrient mobilization**,** cytokinins from the roots to the which ameliorating the level or biosynthesis of endogenous fruit cytokinins and increase developing the fruits [49,50]. The results showed that the use of the highest level of spirulina at 10 ml and 15 ml led to a decrease in the total yield per fed. compared to the control sample. This may be due to pushing the plant more in the direction of vegetative growth than encouraging the formation of flowers and fruit set.

4. CONCLUSIONS

From the above results, foliar application of spirulina resulted in increased vegetative growth of cucumber plants, especially at higher concentrations of spirulina used like treatment S3, and enhanced the effect when spirulina was combined with microelements as in treatment S33. High concentrations of spirulina alone or in combination with microelements (S33, S3, S22, and S2) adversely affected yield per (plant, experimental plot, or fed. resulting in decreased output compared to control. However, compared to controls, yield (per plant, experimental plot, or fed.) was significantly increased when using a low concentration of spirulina, as in treatment S1. Utilizing microelements in addition to spirulina at lower level improved the outcome and increased yield as in the treatment S11.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Yousif KH. Effect of humic acid, biofertilizer (EM-1) and application methods on growth, flowering and yield of cucumber (*Cucumis sativus* L.). Master in Agricultural, University of Duhok, Kurdstan Region, Iraq; 2011.
2. Basak R. Benefits and costs of nitrogen fertilizer management for climate change mitigation: focus on India and Mexico. CCAFS Working Paper No. 161. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS): Copenhagen, Denmark.
Available:www.ccafs.cgiar.org
(accessed on 20 May 2017).
DOI:10.13140/ RG.2.1.4974.7448
3. United Nations Environment Program-International Resource Panel (UNEP-IRP). Food Systems and Natural Resources. Printed: UNESCO.
Available:http://www.unep..org/resourcepanel
(accessed on 15 August 2017).
4. Zhang X, Schmidt RE. Hormone containing products' impact on antioxidant status of tall fescue and creeping bentgrass subjected to drought. Crop Sci. 2000;40:1344-1349.
DOI.org/10.2135/cropsci2000.4051344x
5. Norrie J, Keathley JP. Benefits of *Ascophyllum nodosum* marine-plant extract applications to ‘Thompson seedless’ grape production. Acta Hortic. 2006;727:243–247.
DOI:10.17660/ActaHortic.2006.727.27.
6. Craigie JS. Seaweed extract stimuli in plant science and agriculture. J. Appl. Phycol. 2011;23: 371-393.
DOI:10.1007/s10811-010-9560-4
7. Van Oosten MJ, Pepe O, de Pascale S, Silletti S, Maggio A. The role of biostimulants and bioeffectors as alleviators of abiotic stress in crop plants. Chem. Biol. Technol. Agric. 2017;5:1–12.
DOI:10.1186/s40538-017-0089-5
8. Thirumaran G, Arumugam M, Arumugam R, Anantharaman P. Effect of seaweed liquid fertilizer on growth and pigment concentration of *Cyamopsis tetragonoloba* (L.) Taub. Am. Eur. J. Agron. 2009;2:50–56.
9. Sathya R, Kanaga N, Sankar P, Jeeva C. Antioxidant properties of phlorotannins from brown seaweed Cystoseira trinodis (Forsskål) C. Agardh. Arab. J. Chem. 2013;10:S2608–S2614.
DOI.org/10.1016/j.arabjc.2013.09.039.
10. Ahmed YM, Shalaby EA. Effect of different seaweed extracts and compost on vegetative growth, yield and fruit quality of cucumber. J. Hortic. Sci. Orna. Plants. 2012;4:235–240.
DOI.org/10.3390/agronomy8110264
11. Sakr MT, El-Sarkassy NM, Fuller MP. Exogenously applied antioxidants as biostimulants alleviate salt stress in sweet pepper. Zagazig J. Agric. Res. 2009;605-617.
12. Saravanan SF, Thamburaj SW, Veeraragavathatham DE, Subbiah AR. Effect of seaweed extracts and chlormequat on growth and fruit yield of tomato (*Lycopersicon Esculentum* Mill.). J. Agric. Res. 2003;37(2):70- 87.
13. Kumari RE, Kaur IU, Bhatnagar AK. Effect of aqueous extract of sargassum johnstonii setchell and gardner on growth, yield and quality of *Lycopersicon esculentum* Mill. J. Appl Phycol. 2011; 23: 623–633.
DOI:10.1007/s10811-011-9651-x
14. Gyenis B, Szigeti J, Molnar N, Varga L. Use of dried microalgal biomasses to stimulate acid production and growth of *Lactobacillus plantarum* and *Enterococcus faecium* in milk. Acta Agrar. Kapos. 2005;9:53–59.
15. Spolaore P, Joannis-Cassana C, Duranb E, Isamberta A. Commercial applications of microalgae. Journal of Bioscience and Bioengineering. 2006;101(2):87-96.
DOI: ORG/10.1263/JBB.101.87.
16. Fox D. Health benefits of Spirulina and propos for a nutrition test on children suffering from kwashiorkor and marasmus. In: Doumengue F, Durand Chastel H, Toulemont A, Eds. Spiruline algue de vie. Bulletin de l'Institut Océanographique Monaco, Musée Océanographique. Numéro Special. 1993;12:179-185.
17. Shaheen MA, Abd ElWahab SM, El-Morsy FM, Ahmed ASS. Effect of organic and bio-fertilizers as a partial substitute for NPK mineral fertilizer on vegetative growth, leaf mineral content, yield and fruit quality of superior grapevine. J. Hortic. Sci. Ornam. Plants. 2013;5:151-159.

DOI: 10.5829/idosi.jhsop.2013.5.3.1123
18. Balloni W, Tomaselli L, Govannetti L, Margheri MC. Biología fondamentale del genere Spirulina. In: Cantarelli C, Ciferri O, Florenzano G, Kapsiotis G, Materassi R, Treccani U, Eds. Progetto finalizzato "Ricerca di nuove fonti proteiche e di nuove formulazioni alimentary. Atti del Convegno: Prospettive della coltura di Spirulina in Italia. Consiglio Nazionale delle Richerche. Firenze-Academia dei Georgofili, CNR, Tipografía Coppini. 1980;49-82.
19. Gerwick W, Reyes S, Alvarado B. Two malyngamides from the Caribbean cyanobacterium *Lyngbya majuscula*. Phytochem. 1987;26:1701-1704. DOI.org/10. 1016/S0031-9422(00)82271-2
20. Clardy J, Kato Y, Brinen L, Moore B, Chen J, Pajterson G; Moore R. Paracyclophanes from blm:-green algae. J Am Chem Soc. 1990;112:4061-4063.
21. Entzeroth M, Mead D, Pajterson G, Moore R. A. Herbicidal fatty acid produced by Lyngbya aestuarii. Phytochem. 1985;24(12):2875-2876. DOI.org/10.1016/0031-9422(85)80017-0
22. Ayehunie S, Belay A, Baba TW, Ruprecht RM. Inhibition of HIV-1 replication by an aqueous extract of *Spirulina platensis* (*Arthrospira platensis*). J Acq Immune Def Syndromes Human Retrovirol. 1998;18(1):7-12. DOI: 10.1097/00042560-199805010-00002.
23. Bhat VB, Madyastha KM. Scavening of peroxynitrite by phycocyanin and phycocyanobilin from Spirulina platensis: protection against oxidative damage to DNA. Biochem. BiophysRes Commun. 2001;285:262-266. DOI.org/10.1006/bbrc.2001.5195.
24. Tekalign T, Hammes SP. Growth and biomass production in potato grownin the hot topics as influenced by paclobut razel. Plant Growth Regulation. Springer Netherland. 2005;45(1):37-46. DOI: 10.1007/s10725-004-6443-1.
25. Al-Sahhaf FH. Applied plant nutrition. Baghdad University. Minister of Higher Education and Scientific Research. 1989;259.
26. Milan P, Tea H, Adrijana M, Ana P. Tomislov C. Nitrogen management for potato by using rapid test methods. Faculty of Agric. Univ. of Mostar Slovakia. 2008;1795-1799. Available:https://www.jstor.org/stable/90003074
27. Olsen SK, Sommers LE. Phosphorus in page, A.L. et al (Eds) Methods of Soil Analysis. Am. Agron. Inc. Medison, Wisconsin, New York; 1982.
28. Khan W, Rayirath UP, Subramanian SE, Jithesh MN, Rayorath PW, Hodges DM, Critchley AT, Craigie JS, Norrie T, Prithiviraj BV. Seaweed extracts as bio stimulus of plant growth and development. J. Plant Growth Reg. 2009;28:386–399. DOI: 10.1007/s00344-009-9103-x.
29. El-Bassiony AM, Fawzy ZF, Abd El-Samad EH, Riad GS. Growth, yield and fruit quality of sweet pepper plants (*Capsicum annuum* L.) as affected by potassium fertilization. Journal of American Science. 2010;6(12):722-729. Available:http://www.americanscience.org.
30. Yehia YIA, El-Miniawy SEDM, El-Azm NAA, Hegazi AZ. Response of snap bean growth and seed yield to seed size, plant density and foliar application with algae extract. Ann. Agric. Sci. 2016;61:187–199. DOI:10.1016/j.aoas.2016. 09.001
31. Valencia RT, Acosta LS, Hernández MF, Rangel PP, Robles MÁG, Cruz RCA, Vázquez CV. Effect of seaweed aqueous extracts and compost on vegetative growth, yield, and nutraceutical quality of cucumber (*Cucumis sativus* L.) fruit. Agronomy. 2018;8:264. DOI:10.3390/agronomy 8110264.
32. Youssef R, Cardarelli M, Mattia E, Tullio M, Rea E, Colla G. Enhancement of alkalinity tolerance in two cucumber genotypes inoculated with an arbuscular mycorrhizal biofertilizer containing *Glomus intraradices*. Biol. Fert. Soils. 2010;46:499-509. DOI 10.1007/s00374-010-0457-9.
33. Abd El-Migeed AA, El-Sayed AB, Hassan HSA. Growth enhancement of olive transplants by broken cells of fresh green algae as soil application. J. Agric. Res. 2004;29(3):723-737.
34. Abd El-Moniem EA, Abd-Allah ASE. Effect of green algae cells extract as foliar spray on vegetative growth, yield and berries quality of superior grapevines. Am. Euras. J. Agric. and Environ. Sci. 2008;4(4):427-433.
35. Sethi SK, Adhikary SP. Effect of Seaweed liquid fertilizer (SLF) on vegetative growth and yield of black gram, brinjal and tomato.

Sea" Res. Utiln. 2008;30 (special issue):241-248.
36. Zodape ST, Mukherjee S, Reddy MP, Chaudharya DR. Effect of *Kappaphycus alvarezii* (Doty) Doty ex silva. extract on grain quality, yield and some yield components of wheat (*Triticum aestivum* L.). International J. Plant Prod. 2009;3:97-101.
DOI:10.22069/IJPP.2012.646
37. DeGannes A, Heru KR, Mohammed A, Paul C, Rowe J, Sealy L, Seepersad G. Tropical greenhouse manual for the Caribbean; CARDI: St. Augustine, Trinidad and Tobago. 2014;157.
38. Farrag DKH, Omara AA, El-Said MN. Significance of foliar spray with some growth promoting rhizobacteria and some natural biostimulants on yield and quality of cucumber plant. Egypt. J. Hort. 2015;42:321–332.
DOI:10.21608/EJOH.2015.1295
39. Wittwer SH, Honma S. Greenhouse tomatoes, lettuce, and cucumbers. Section 3, Greenhouse cucumbers. Michigan State University, USA.
Available:http://www.lpl.arizona.edu/~bcohen/cucumbers
(Accessed on 20 March 2017).
40. Mohammed GH. Effect of sea amino and ascorbic acid on growth, yield and fruits quality of pepper (*Capsicum annum* L). Int. J. Pure Appl. Sci. Technol. 2013;17(2):9-16.
41. Al-Saaberi MRS. Effect of some agricultural treatments on growth, yield of lettuce (*Lactuca sativa* L.). M.Sc. Thesis, Horticulture Sciences University of Mosul College of Agriculture and Forestry; 2005.
42. Crouch IJ, Van Staden JS. Effect of seaweed concentrate on the establishment and yield of greenhouse tomato plant. J. Applied Physiol. 2005;4(4):291- 296.
43. Al-Jebbouri M, Musa AA. Effect of humic acid and seaweed extracts on growth, flowering and yield of cucumber (*Cucumis sativus* L.). M.Sc. Thesis, College of Agriculture, University of Tekrit, Ministry of Higher Education and Scientific Research, Republic of Iraq (in Arabic); 2009.
44. Neeraja GI, Reddy BG. Effect of growth promoters on growth and yield of tomato cv. Marutham. J. Res. Angrau. 2005; 33(3):68-70.
45. Barker AV, Pilbeam DJ. Handbook of plant nutrition. Books in soils, plants, and the environment. Library of Congress Cataloging -in Publication Data. 2007;613.
46. Khalaf DA, Abdul Rahman HB. Effect of spraying with organic nutrients on the growth and yield of *Capsicum annuum* hybrids under greenhouse conditions. Journal of Kirkuk University for Agricultural Sciences. 2017;8(4).
47. Arthur GD, Stirk WA, Van Staden J. Effect of a seaweed concentrate on the growth and yield of three varieties of *Capsicum annuum*. S Afr J Bot. 2003;69:207–211.
DOI.org/10.1016/S0254-6299(15)30348-3
48. El-Sharony TF, El-Gioushy SF, Amin OA. Effect of foliar application with algae and plant extracts on growth, yield, and fruit quality of fruitful mango trees Cv. Fagri Kalan. J. Hortic. 2015;2:1–6.
DOI.org/10.4172/2376-0354.1000 162.
49. Featonby-Smith BC, Van Staden J. The effect of seaweed concentrate and fertilzer on growth and the endogenous cytokinin content of *Phaseolus vulgaris*. S Afr J Bot. 1984;3:375–379.
DOI:10.1016/s0022-4618(16)300 06-7
50. Bajpai VK. Antimicrobial bioactive compounds from marine algae: A. mini review. Indian J. Geo-Marine Sci. 2016; 45:1076–1085.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/92833