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Effect of mycorrhizal fungi inoculation and seaweed extract spray on some growth characters and yield of cucumber (*Cucumis sativus* L.)

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Abstract

A factorial experiment was conducted in green house in clay loam soil, according to randomized complete block design, to study the effect of seaweed extract applied as a foliar spray concentration (0, 1.0, 2.5, 4.0 and 5.5) ml.l^{-1} with or without mixture of fungus mycorrhiza (*Glomus fasciculatum* + *Acoulospora laevis*) on growth and yield of cucumber. The plant length, fresh weight, dry weight, percentage of total chlorophyll, leave area, number of fruits, yield per plant and total yield was found maximum at 2.5 ml.l^{-1} seaweed extract with fungus mycorrhiza compared to other concentration and increase significant (14.65, 112.32, 59.21, 15.97, 27.26, 52.28, 82.42 and 82.46%) respectively.

Key words: Mycorrhizae fungi, Seaweed extract, Foliar spray, Cucumber yield, Growth characters.

Introduction

There is an urgent need to increase the cultivated area of cucumber in Iraq , to increase the amount of production to keep up with consumer demand, but what is produced per unit area is still much lower when compared to neighboring countries from the Arab and what is produced in developed countries as well , therefore, it is necessary to know the reasons for failure and avoidance to increase production and including the large number and diversity of chemical fertilizers. as the long term use of traditional chemical fertilizers tends to damage the physical and chemical properties, the biological characteristics and the micro-ecology of soil, leading to deterioration of quality of plant products (Agro-Alliance, 2010). So as took recent research stay a way effort as possible or reduce the use of chemical fertilizers, introducing a material substitute to container nutrients (macro and micro) and the plant hormones natural (auxins, cytokinins and gibberellins), as well as being healthy and the absence harmful effects of side - impact use and cheap, economic, easy to prepare and use and these materials are extracts of seaweed (Abo-Arab *et al*., 1998). As well as bio-fertilizers were used as an entry different types of bacteria (symbiotic and non symbiotic) or fungi such as mycorrhiza or algae that equip with some of the elements of nutritional.

Many studies have found wide application in modern agriculture for the use of marine macroalgae as fertilizer, they are used as whole or finely chopped powdered algal manure or aqueous extracts. In recent years the use of these marine macroalgae in modern agriculture has been investigated by many (Rama Rao, 1990; Lopez-Musquera and Pazas, 1997). Seaweed fertilizer contains non-organic materials as well as copper, zinc, boron, potassium, calcium, magnesium, iron, iodine and particularly highly bioactive materials such as algal polysaccharides, mannitol, highly unsaturated fatty acids and natural growth regulators such as gibberellins, cytokinins, auxins, abscisic acid and betaines (Agro-Alliance, 2010).

Mycorrhizal fungi are the most widespread root fungal symbionts and are associated with the vast majority of higher plants (Sensoy *et al*., 2007). mycorrhizal fungi have been shown to improved soil structure (Miller and Jastrow, 2000), enhance plant nutrient acquisition P, N, Zn, Cu and Fe (Clark and Zeto, 2000), improve drought tolerance (Bryla and Duniway, 1997; Sanchez -Blanco *et al*., 2004) and alleviate cultural and environmental stresses

(Jeffries *et al*., 2003) through greater effective root area and penetration of substrate (s) and activation and excretion of various enzymes by infected mycorrhizal fungi roots and/or hyphae (Marschner, 1995; Smith and Read, 1997). Kuwada *et al*. (2006) reported that red and green algae not contain Am mycorrhizae stimulatory substances, but also contribute to mycorrhizal development in higher plants. In view of advantage of extracts of seaweed and fungi mycorrizae of the attributes of improve plant growth and yield and not to harm to humans and plant and get it and offset or reduce the amount of chemical fertilizers added, as so objective this research to study the effect of different levels of extract of seaweed with having a mixture of fungi mycorrhizal (*Glomus fasciculatum* + *Acoulospora laevis*) in the growth and yield the cucumber.

Materials and Methods

Experiment was conducted in the green house at the college of agriculture, University of Diyala, Iraq and on the cucumber (*Cucumis sativus* L.) class Karol in clay loam soil (pH=6.5, Ec=2.39 ds.m^{-1}), according to randomized complete block design, as factorial experiment with interaction two factors, the first factor is inoculation with a mixture of fungus mycorrhiza (*Glomus fasciculatum* + *Acoulospora laevis*) and two levels (without inoculation, –Am and inoculation + Am), as adding before agriculture by (5 g.$plant^{-1}$), cushion under seedlings, the second factor is the seaweed extract liquid is the a commercial product from China Ocean University Orgauism Project Development Co.Ltd, which contains 80 g.l^{-1} each N, P_2O_5, K_2O and seaweed extract >150 g.l^{-1} and Amino acid 10 > 10 g.L^{-1} also contains iodine, copper and znic which combine with humic acid to form a stable complex resistant to plant diseases . use five levels (0, 1, 2.5, 4.5, 5.5 ml.l^{-1}) of distilled water spraying on the plant. The number of treatment (10), treatments resulting from the interaction the two factors, repeated three times for treatment, underwent all the data for statistical analysis and compared to the are rages of treatments by Duncan's polynomial test at the 5% probability level.

Divided the land into three blocks comprising each block two lines from drip irrigation system, as the was area the experimental unit (1 m^2) containing four the dotted, all dotted on a single line , the distance between the dotted and another (50 cm) and thus the number plants in the experimental unit four plants . planted seedlings cucumber that has obtained from the nurseries Diyala province, a rate of four seedlings in the experimental unit, the process the spraying the seaweed extract an average of three the spatters, the first after (15) days from sowing and second after the spatter the first three weeks , and the third after the spatter the second three weeks. Control plants were sprayed with water. At the end of the experiment took the following measurements :

1- components of vegetative growth: plant length (cm), fresh weight of shoot (g.$plant^{-1}$), dry weight of shoot (g.$plant^{-1}$), leaf area (cm^2) and the percentage of total chlorophyll (%).
2- components of yield: the number of fruits (fruit.$plant^{-1}$), the average yield per plant (Kg.$plant^{-1}$) and the total yield (t.ha^{-1})

Data analyzed using SAS (2000) to conduct statistical differences, according to randomization complete block design, comparison between means were done using Duncan multiple range test.

Results and Discussion

Table (1) shows that the addition of the inoculation (*G. fasciculatum* + *A. leavis*) led to a significant increase in plant length, fresh weight and dry weight of shoots compared of add without inoculation, irrespective of the addition of seaweed extract, as the increase (3.36% , 28.87% and 8.78%) respectively, as the mycorrhizal seedling tissue had significantly increased concentration of N, P and Mg (Youssef Rouphael *et al*., 2010), they found also that the leaves, fruits and total dry weight increased by (24%, 17% and 22%) respectively, when plants were inoculated with live *G.intraradices* than non-inoculated cucumber plants.

Increased levels of seaweed extract led to a significant increase in plant length, fresh weight and dry weight, irrespective of addition inoculation fungal, as record level (2.5 ml.l^{-1}) values higher, reached (120.07cm, 276.25 g.$plant^{-1}$ and 71.24 g.$plant^{-1}$) respectively and significant increase (9.90 %, 31.23%, 39.24%) compared to the control treatment. the increase in vegetative growth components that may return to what they contain extracts of seaweed (bacta carotene, thiamin, Riboflavin and Vit. K) and in which the

trace elements linked to a grapple and are ready to plant (Dell, 2003), and also contain auxins which have an important role in increasing division and breadth of cells, which leads to the growth of the larges and wet and dry weight the largest (Gollan and Wright, 2006). Said Zodape *et al*. (2008) that the level of 2.5% of the liquid seaweed gave the highest plant length, wet weight and dry weight.

The interference between the inoculation and seaweed extract significant effect on plant length, fresh weight and dry weight, as the inoculation led to a significant increase in plant length at the levels (0, 1 and, 5.5) $ml.l^{-1}$ compared to no addition of the inoculation ,while led to a significant increase for all levels of both wet weight and dry weight. Record level of (2.5 $ml.l^{-1}$) the highest values (123.25 cm , 310.0 $g.plant^{-1}$ and 74.83 $g.plant^{-1}$) for each of plant length, fresh weight and dry weight, respectively and increased significantly (14.65%, 112.32% and 59.21%) compared with the level (0) and without a inoculation. Ferrini and Nicese (2002) reported that application of some commercial bio-stimulates (one of the biostimulants they used was a powder mixture of marine brown algae, Am fungi, vitamins, amino acid and humic acid) to Oak plants increase N concentration in leaf tissue and thus increase plant growth. Seaweed extract added with inoculation fungi mycorrhiza led to a significant increase in plant height and fresh and dry weight of shoots compared to the comparison treatment (Kuwada *et al*., 2006). and also studied the effect of extracts of algae on the growth of hyphae mycorrhiza and development and the impact on the processing and absorption of nutrients and its reflection positively on the growth and development of papaya.

Table (2) revealed that the inoculation led to a significant increase in the percentage of total of chlorophyll and leaf area compared without inoculation, irrespective of the addition of seaweed extract, as it was 2.97% and 19.82% respectively. Bhoopander and Mukerji (2004) reported that the content of chlorophyll was greater in the leaves of mycorrhiza-inoculated as compared to un inoculated seedlings, as was mycorrhizal seedling tissue had significantly increased concentration of N, P and Mg. That mycorrhiza lead to a significant increase in the content of elements (P, K, Mg, Na, Fe, Zn and Mn) in the leaves cucumber, as it they lead to a significant increase in leaf area of the cucumber (Youssef Rouphael *et al*., 2010).

Level 2.5 $ml.l^{-1}$ of seaweed extract led to a significant increase in the percentage of total chlorophyll and leaf area irrespective of inoculation, as was 8.78% and 8.77% respectively, promotive effects of liquid seaweed extract application might be because of increased root proliferation and establishment, thereby plants were able to mine more nutrients even from distant places and deeper soil horizons in balanced proportion (Zodope *et al*., 2008). Besides, liquid seaweed extract regulated plant bio-physiological activities, which collectively resulted in maintaining higher photosynthetic activities (Sing and Chandel, 2005). Whapham *et al*. (1997) got on significant increase in chlorophyll content in plants treated in the seaweed extracts, compared to the one that had not been treated.

Increasing levels of seaweed extract led to a significant increase in the percentage of total chlorophyll and leaf area and when you add the inoculation compared without inoculation, recorded the highest values at the level (2.5 $ml.l^{-1}$) with the inoculation, as he was 41.2% and 372.9 cm^2 respectively, and increased significantly to 15.97% and 27.26% to the level (0) and without a inoculation.

Table (3) shows the results that the inoculation led to a significant increase in the number of fruits, yield per plant and total yield compared without addition of the inoculation and irrespective of the addition of seaweed extract, as it was 25.44 %, 20.7% and 20.57% respectively. Total and marketable cucumber production and fruit number were significantly affected by mycorrhizal treatment, as the total and marketable yield increase by 10% and 21% respectively, when plants were inoculation with live *G. intraradices* (Youssef Rouphael *et al*., 2010).

Adding level 2.5$ml.l^{-1}$ led to a significant increase in the number of fruits, yield per plant and total yield compared to the level (0) irrespective of addition of the inoculation, as was 17.73%, 39.38% and 39.38% respectively. Jensen, (2004) noted that the use of extract of seaweed in plant nutrition leads to increased number of fruits and it affects the total yield they contain many nutrients macro and micro, auxins, cytokinins, gibberellins and vitamins that stimulate cell

Table 1. E**ff**ect of seaweed extract on plant length, fresh and dry weight .

Seaweed extract levels ($ml.l^{-1}$)	Plant Length (cm)			fresh wt. of plant ($g.plant^{-1}$)			Dry wt. of plant ($g.plant^{-1}$)		
	- Am	+ Am	mean	- Am	+ Am	mean	- Am	+ Am	mean
0.0	107.5d	111.0c	109.25c	146.0f	275.0b	210.5d	47.0e	53.33d	51.16d
1.0	114.5bc	121.5a	118.0ab	230.0d	305.0a	267.5b	64.0b	70.66a	67.33a
2.5	120.9ab	123.25a	120.0a	242.5c	310.0a	276.25a	67.66b	74.83a	71.24a
4.0	116.6b	118.0 b	117.3b	215.33e	240.0c	227.66c	63.00b	62.6bc	62.8b
5.5	112.5c	117.5 b	115.0b	221.5e	230.0d	225.75c	55.33d	61.66c	58.49c
mean	114.4b	118.25a		211.06b	272.0a		59.39 b	64.61a	

different letters with in each column are significantly different (P<0.05) by Duncan's test.

Table 2. E**ff**ect of seaweed extract on the percentage of total chlorophyll and leaf area.

Seaweed extract levels ($ml.l^{-1}$)	percentage of chlorophyll %			leaf area cm^2		
	- Am	+ Am	mean	- Am	+ Am	mean
0.0	36.3 d	40.0 b	38.15 c	293.0 e	337.0 c	315.0 b
1.0	38.7 c	41.2 a	39.95 b	269.4 f	362.2 b	315.8 b
2.5	40.0 b	42.1 a	41.5 a	312.4 d	372.9 a	342.65 a
4.0	40.52 ab	39.2 bc	39.86 b	310.4 d	363.4 b	336.9 a
5.5	39.7 b	38.5 c	39.1 bc	296.26 e	339.6 c	317.93 b
mean	39.04 b	40.2 a		296.29 b	355.02 a	

different letters with in each column are significantly different (P<0.05) by Duncan's test.

Table3. E**ff**ect of seaweed extract on the number of fruits, yield per plant and total yield.

Seaweed extract levels ($ml.l^{-1}$)	No. of fruits ($Fruit.plant^{-1}$)			Yield per plant ($Kg.plant^{-1}$)			Total yield. ($t.ha^{-1}$)		
	- Am	+ Am	mean	- Am	+ Am	mean	- Am	+ Am	mean
0.0	7.0c	8.0b	7.5b	0.66c	0.77b	0.71b	26.4bc	30.88b	28.64b
1.0	8.0b	9.0a	8.5a	0.78b	0.82b	0.80a	31.33b	32.97b	32.15b
2.5	7.0c	10.66a	8.83a	0.79b	1.20a	0.99	31.68b	48.17a	39.92a
4.0	6.0d	8.0b	7.0b	0.66c	0.74b	0.70b	26.62bc	29.82b	28.22b
5.5	6.0d	7.0c	6.5c	0.65c	0.74b	0.69b	26.13bc	29.6b	27.86b
mean	6.8 b	8.53 a		0.71 b	0.85 a		28.43 b	34.28 a	

different letters with in each column are significantly different (P<0.05) by Duncan's test.

division and increase the supply of manufactured articles to the fruits and thus increase the yield.

Give level 2.5ml.l^{-1} with the inoculation the highest number of fruits, yield per plant and yield total 10.66 fruit.plant^{-1}, 1.20 Kg.plant^{-1} and 48.17 t.ha^{-1} respectively, and increased significant to 52.28%, 82.42% and 82.46% compared to the level (0) and without the inoculation, which was 7.0 fruit.Plant^{-1}, 0.66 Kg.plant^{-1}, 26.4 t.ha^{-1} and decreased values when high levels of seaweed extract. Kuwada *et al*. (2006) found used all kinds of algae led to a significant increase in the growth of fungus hyphae Am, which affects positively on the processing and absorption of nutrients and increase the growth and yield of the plant, through greater effective root area and penetration of substrate and activation and excretion of various enzymes by infected arbuscular mycorrhizal fungi root and/or hyphae (Marschner, 1995; Smith and Read, 1997). Noted Barker and Taqu, (2000) that mycorrhiza enhance plant growth through the positive influence of certain substances produced by fungi such as materials of the organization of growth (auxins and gibberellins), as well as the extracts of seaweed contain auxins, cytokinins and gibberellins (Jensen, 2004). As is know the auxins role is to control the composition of the roots, as the gibberellins increase the rate of growth of roots and leaves and cytokinins involved in most processes related to formation of mycorrhiza (Paleg and West, 1972). According to Carr (1981) there are two important effects for growth regulators, the first is direct activation of the metabolic activities of the mycorrhiza, the second increase in the size of the leaves that promote the process of photosynthesis increase and then increase the processing of nutrients in the plant endomycorrhiza, as the extracts of seaweed increasing the concentration of nutrients, including iron (Butler and Hunter, 2006) and fungi mycorrhiza also enhance the absorption of iron in the shoots of the plant cucumber (Youssef Rouphael *et al*., 2010). Iron is an important cofactor of many enzymes and interferes with several aspects of plant biochemistry, including photosynthesis and pigment synthesis (Marschner, 1995).

From these results we find that the interaction between inoculation and seaweed extract had a positive impact in the components of vegetative growth and yield, and that the treatment 2.5ml.L^{-1} with the inoculation was the best treatment, as it recorded the highest values of the components of growth and yield. Foliar application of liquid seaweed fertilizer at lower concentration was most effective compared to control and other concentration of liquid seaweed fertilizer (Zodape *et al*., 2008). Aitken and senn (1965); Abtz (1980) reported that liquid seaweed fertilizer at very high concentration retard plant growth, may be du to very high salt index observed in seaweed extract that may be affecting growth and yield.

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