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Effect of some red marine algae as biofertilizers on growth of maize (*Zea mayz* L.) plants

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Abstract

The effect of three species of red marine algae (*Laurencia obtusa*, *Corallina elongata* and *Jania rubens*) was evaluated as biofertilizer to enhance growth of Maize (*Zea mays* L.) plants. After 60 days, application of single alga or their mixtures enhanced certain plant growth parameters. Application of *Laurencia obtusa* + *Jania rubens* caused 48.21% increase in plant length, 61.84% increase in potassium content and increase in leaves number in comparison to other treatments. Application of *Laurencia obtusa* + *Corallina elongata* caused 90.86% increase in plant fresh weight. Application of algae mixture caused 72.41% increase in plant dry weight and 73.97% increase in phosphorus content. However, application of *Jania rubens* alone caused 129.23% increase in the plants nitrogen content compared with control.

Introduction

Maize (*Zea mays*) is the most important cereal crop. Maize is one of the three most important cereal crops in the world. Maize is high yielding, easy to process, readily digested and cheaper than other crops. Every part of the maize plant has economic value which the grain, leaves, stalk, tassel and cob can all be used to produce a large variety of food and non food production, (IITA, 2006). Oceans and seas are the greatest store for algae, which are good sources for foods, folders and biofertilizers. Morever, marine algae exhibit antiviral, hypocholesterolemic, hypotensive, antibacterial, anticoagulant, antihelmintic, anticancer, antialgal, cytotoxic and antifungal activities (Saleh *et al*., 1993). Seaweeds are excellent source of vitamins A, B1, B12, C, D and A, riboflavin, niacin, pantothenic and folic acid. Thirumaran *et al*. (2009) reported that seaweed liquid fertilizer (SLF) contained macro nutrients, trace elements, organic substances like amino acids and plant growth regulators such as auxin, cytokinin and gibberellins. Verklejj (1992) stated that application of that seaweed liquid fertilizer (SLF) enhanced the water retention capacity of soil. Seaweed extracts are known to enhance seed germination, improve plant growth, induce resistance to frost, fungal and insect attack and increase nutrient uptake from soil (Mohan *et al*., 1994; Venkataraman *et al*., 1993). Thirumaran *et al*. (2009) stated that recent researches proved that seaweed fertilizers are preferred not only due to their nitrogen, phosphorus and potash content but also because of the presence of trace elements and metabolite similar to plant growth regulators. Recently, seaweed extracts as liquid fertilizers (SLF) has come in the market for the simple reason that they contain many growth promoting hormones like auxin, gibberellin, trace elements, vitamins, amino acids and micronutrients. Dhargalkarand and Untawale (1983) studied the effect of seaweed extracts on grown chillies and turnip to found that lower concentrations of SLF enhanced the rate of seed germination. Strik *et al*. (2004), reported that the seaweeds extracts are effective fertilizers in many crops. El-Barody *et al*. (2007) found that addition of different successive extracts of *Asparogopsis taxiformis* thallus powder to the soil, as a biofertilizer, gave significant increase in the growth of *Vicia faba*. Lozano *et al.* (1999) stated that the application of an extract from algae to soil or foliage increased ash, protein and carbohydrate content of potatoes. Sabh *et al.* (2008) found that NPK in plants treated with *Sargassum* sp., reached four folds the negative control. Thamida Begum *et al*. (2011) showed that the agronomic characters and yield components of rice in algalized plots were statistically identical to the treatment with recommended dose of urea-N. The present study aimed to assess the effect of three red algae species, i.e. *Laurencia obtusa*, *Corallina elongata* and *Jania rubens* on Maize growth and sugar content.

Materials and Methods

Algae collection and preparation:

Laurencia obtusa was collected in May, 2012 from shallow water beside the shore of Red Sea of Safaga,

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Corallina elongata and *Jania rubens* were collected in May, 2012 from shallow water beside the shore of Meditrenean Sea at Abou Quair coast in Egypt. After collection, algae were washed with fresh sea water to remove the epiphytes, sand and other extraneous matter then they were dried in shadow open air and completing the drying process in the oven at 60ºC for 5 hours. Then, dried algae were ground to fine powder by mechanic grinder. The algae were applied as a soil treatment at the rate of 3 gm powdered algae/ Kg soil seven days before planting and watered twice daily.

Plant material

Seeds of maize (*Zea mays* L.) cv. K-8 were surface sterilized with ethanol 70% and washed by sterile distilled water, then dried in shadow open air. The seeds were planted in 30 cm diameter earthen pots containing mixture of 1:1 autoclaved peat and sand soil. Every pot contained 4 seeds. They watered every week.

Growth measurements

Plant height and number of leaves were recorded at different growth stages. At the end of the experiment; plant height, plant fresh weight, plant dry weight, NPK content and sugar content were recorded.

The treatments

Control, 2- *Laurencia obtusa*, 3- *Corallina elongata*, 4- *Jania rubens*, 5- *Laurencia obtusa* + *Jania rubens*, 6- *Laurencia obtusa* + *Corallina elongata*, 7- *Jania rubens* + *Corallina elongata*, 8- *Laurencia obtusa* + *Jania rubens* + *Corallina elongata*.

Chemical analysis

Phosphorus was extracted and determined spectrophotometrically as mentioned by Watanab and Olsen (1965). Potassium was extracted and determined using Flame photometric method (APHA, 1992). The determination of total nitrogen was carried out with Micro-Kjeldahel method. (A.O.A.C., 1990). Obtained data were subjected to analysis of variance, and the means were compared using the "Least Significant Differences (LSD)" test at the 0.05 level, as recommended by Snedecor and Cohran (1982).

Results and Discussion

Laurencia obtusa, *Corallina elongata* and *Jania rubens* were used to study their effect as algal biofertilizers on the growth and production of maize plants (*Zea mays*). *In Vivo* studies (Table 1) showed that the application of *Laurencia obtusa* + *Jania rubens* caused significant increase in the shoot length after 15 and 45 days from planting and the application of *Corallina elongata*, gave the same result after 15 days, while there was non significant increase in shoot length after 25 and 35 days.

Table 1. Effect of some algal treatments on the shoot length and leaves number of Maize plants at early stage from sowing

Treatments	Shoot length (cm)				Leaves numbers			
	15 days	25 days	35 days	45 days	15 days	25 days	35 days	45 days
Control	10.5	32.9	32.9	41.6	3.0	4.6	5.9	6.8
Lo	11.7	34.5	39.1	43.6	3.4	5.2	6.1	7.1
Jr	12.1	35.2	45.9	51.6	3.1	5.3	6.3	7.3
Ce	12.6	39.2	46.4	53.1	3.8	5.5	6.5	7.5
Lo+Jr	12.6	43.7	45.9	53.8	4.0	5.5	6.6	7.6
Ce+Lo	11.3	35.3	43.2	49.7	3.2	5.0	5.9	7.2
Jr+Ce	11.5	37.3	44.0	48.5	3.0	4.6	6.0	7.2
Jr+Lo+Ce	15.6	33.4	47.5	48.7	4.0	5.1	6.4	7.4
$LSD_{0.05}$	0.002***	0.054^{ns}	0.113^{ns}	0.006***	0.000***	0.111^{ns}	0.051^{ns}	0.157^{ns}

Lo: *Laurencia*; **Jr**: *Jania*; **Ce**: *Corallina*;
***:high significant; ns: non-significant

The leaves number was counted after 15, 25, 35 and 45 days as shown in the same table, which indicate that application of *Laurencia obtusa* + *Jania rubens* and *Laurencia obtusa* + *Jania rubens* + *Corallina elongata* gave the highest increase in plant growth after 15 days. Generally, it could be concluded that the treatment of *Laurencia obtusa* + *Jania rubens* was the best treatment on the growth of the plants during the early stages from planting. The criteria based on weight, length and chemical analysis were calculated after 60 days from planting.

The length of shoots, roots and total plants was shown in Table 2 which clear that all the treatments caused noticeable increase in total plant length ranged between (6.25-48.21), application of *Laurencia obtusa* + *Jania rubens* caused the highest increase of shoots and whole plant length and gave 48.21% increase in whole plant length and followed by the treatment of *Laurencia obtusa* + *Jania rubens* + *Corallina elongata* which caused the best increasing of roots and gave 40.17% increase in whole plant length and the lowest one was *Laurencia obtusa*.

Table 2. Effect of some algal treatments on the Maize plants length (cm) after 60 days from sowing

Treatments	Shoots	Roots	Total plants	
	Length (cm)	Length (cm)	Length (cm)	Increasing %
Control	41.6	14.4	56.0	-
Lo	43.6	15.9	59.5	6.25
Jr	51.6	15.8	67.4	13.28
Ce	53.1	21.9	75.0	33.92
Lo+Jr	53.8	29.2	83.0	48.21
Ce+Lo	49.7	27.2	76.9	37.32
Jr+Ce	48.5	28.2	76.7	36.96
Jr+Lo+Ce	48.7	29.8	78.5	40.17
$LSD_{0.05}$	0.006***	0.000***	0.000***	

Lo: *Laurencia*; **Jr**: *Jania*; **Ce**: *Corallina*;
***:high significant

Table 3. Effect of some algal treatments on the Maize plants fresh weight and dry weight (gm) after 60 days from sowing

Treatments	Fresh weight (gm)				Dry weight (gm)			
	Shoots	Roots	Whole plants	Increasing %	Shoots	Roots	Whole plants	Increasing %
Control	31.6	8.9	40.5	-	2.5	0.4	2.9	-
Lo	35.3	17.2	52.5	29.6	2.7	0.4	3.1	6.89
Jr	40.2	11.9	52.1	28.6	2.8	0.6	3.4	17.24
Ce	41.8	15.2	47.0	16.04	2.9	1.2	4.1	41.37
Lo+Jr	42.1	23.9	66.0	62.96	3.1	1.1	4.2	44.82
Ce+Lo	48.6	28.7	77.3	90.86	3.4	0.9	4.3	48.27
Jr+Ce	34.3	23.5	57.8	42.71	2.7	0.9	3.6	24.13
Jr+Lo+Ce	35.0	31.0	66.0	62.96	3.6	1.4	5.0	72.41
$LSD_{0.05}$	0.332 ns	0.047*	0.176 ns		0.492 ns	0.034*	0.610 ns	

Lo: *Laurencia*; **Jr**: *Jania*; **Ce**: *Corallina*;
*:high significant; ns: non-significant

Table 3 showed that all the treatments increased the whole plant fresh weight which ranged between 28.6-90.86%, while the treatment of *Corallina elongata* + *Laurencia obtusa* gave the best result of total plant fresh weight but the treatment with *Corallina elongata* alone gave the lowest one.

The same result was shown in the previous table which studied the plant dry weight. All the treatments caused increase in plant dry weight ranged between 10.3-68.9%. The treatment of *Jania rubens* caused the best result while *Laurencia obtusa* caused the lowest one. Data in Table 3 also showed that all the treatments caused increasing in Maize plants dry weight ranged between (6.89-72.41%). The treatment of *Laurencia obtusa* + *Jania rubens* + *Corallina elongata* caused the highest increasing (72.41%) while the treatment of *Laurencia obtusa* alone caused the lowest increasing.

Table (4-A) 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. 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 4-A. The macro elements contents in different macroalgae (as dry weight)

Algae	N-content %	P- content %	K-Content %
Laurencia obtuse	0.39	0.38	0.2
Corallina elongate	0.34	0.38	0.16
Jania rubens	0.4	0.35	0.16

N: nitrogen; P: phosphorus; K: potasium

The data in Table 4-B showed that all the algal treatments caused increasing in the nitrogen content of Maize plants after 60 days. The increasing ranged between (47.69-129.23%). The treatment of *Jania rubens* caused the best result while the treatment of *Corallina elongata* + *Laurencia obtusa* caused the lowest one.

Data in the same table showed that all the treatments caused increase in the phosphorus content

Table 4-B. Effect of some algal treatments on the NPK-content % of Maize plants after 60 days from sowing

Treatments	N-content%				P- content%				K-Content%			
	Shoots	Roots	Whole plant	Increasing %	Shoots	Roots	Whole plant	Increasing %	Shoots	Roots	Whole plant	Increasing %
Control	0.36	0.29	0.65	-	0.36	0.37	0.73	-	2.60	0.44	3.04	-
Lo	0.86	0.32	1.18	81.53	0.50	0.50	1.00	36.98	3.24	0.80	4.04	32.89
Jr	1.08	0.41	1.49	129.23	0.56	0.43	0.99	35.61	3.56	0.84	4.40	44.73
Ce	0.77	0.29	1.06	63.07	0.58	0.39	0.97	32.87	3.48	0.60	4.08	34.21
Lo+Jr	0.79	0.32	1.11	70.76	0.56	0.45	1.01	38.35	3.80	1.12	4.92	61.84
Ce+Lo	0.61	0.35	0.96	47.69	0.59	0.45	1.04	42.46	3.64	0.92	4.56	50.00
Jr+Ce	0.77	0.32	1.09	67.69	0.64	0.39	1.03	41.09	3.28	0.68	3.96	30.26
Jr+Lo+Ce	0.56	0.44	1.0	53.84	0.58	0.69	1.27	73.97	3.16	1.52	4.68	53.94

Lo: Laurencia; Jr: Jania; Ce: Corallina; N: nitrogen; P: phosphorus; K: potasium

of Maize plants after 60 days ranged between 32.87-73.97%. *Laurencia obtusa* + *Jania rubens* + *Corallina elongata* caused the highest increase while *Corallina elongata* caused the lowest effect.

The data presented also showed that there is an increase in the potassium content of Maize plants after 60 days ranged between 30.26-61.84%. The treatment of *Laurencia obtusa* + *Jania rubens* caused the best result and *Jania rubens* + *Corallina elongata* caused the lowest one.

The effect of the red algal treatments on the sugar contents of Maize plants after 60 days is illustrated in Figure 1. The treatment of *Jania rubens* + *Corallina elongata* caused the highest sugar content (32.42%).

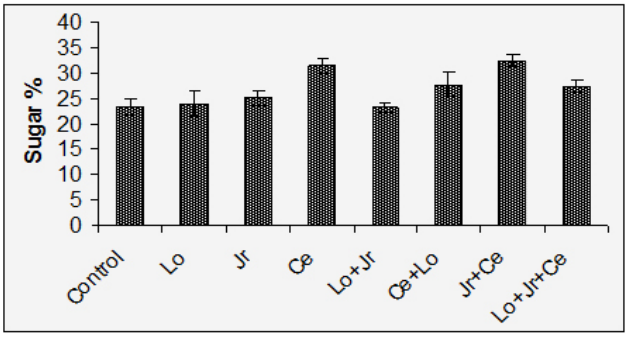

Figure 1. Effect of some algal treatments on the sugar content of Maize plants after 60 days from sowing
Lo: *Laurencia*; Jr: *Jania*; Ce: *Corallina*

The results of the present study indicate that *Laurencia obtusa*, *Jania rubens*, *Corallina elongata* either singley, and their combinations have significant potential as biofertilizers agents to enhance growth of Maize plants. These results were also reported by Strik *et al.* (2004) and Thamida Begum *et al.* (2011). At the early growth stages, all the treatments increased the leaves number and plant height. These results in agreement with those reported by El-Barody *et al.* (2007) and Haroun and Hussein (2003). After 60 days from planting, all treatments increased the plant fresh and dry weight. These results were reported by Faheed and Abd-El Fattah (2008). In the present study, all the retreatment improved NPK% content in plants. These results were also obtained by

Haroun and Hussein (2003), Adam (1999), Lozano *et al.* (1999), Subramaniyan and Malliga (2011) and Saleh *et al.* (2008). All the treatments increased the carbohydrates content of plants as reported by Haroun and Hussein (2003) and Lozano *et al.* (1999).

Conclusion

Laurencia obtusa + *Jania rubens* was the best treatment to enhance growth of maize plants during the early stages from planting and also caused the highest increase of shoots and whole plant length and gave 48.21% increase in total plant length after 60 days of planting. Thus, using algae as biofertilizers improved the vegetative characters of Maize plants.

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