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Research Article

BENEFICIAL EFFECT OF SLF OF SARGASSUM WIGHTII ON THE GROWTH AND BIOCHEMICAL CHARACTERISTICS OF OKRA

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ABSTRACT

The application of Seaweed Liquid Fertilizer (SLF) of *Sargassum wightii* has significant effect on the growth of Okra (*Abelmoschus esculentus* (L.) Moench). The growth characters such as seed germination, seedling vigour index, shoot length, root length, plant fresh weight and plant dry weight were significantly higher in plants treated with different concentration of SLF (1%, 2%, 3%, 4%, 5%, 6% and 7%). The effect was varied with the concentration of SLF. Among them, the growth response was superior in the plants treated with 5.0% of SLF of *Sargassum wightii* over the control plants. The SLF treatment has positive effect on the biochemical characters of Okra such as total chlorophyll, protein, aminoacids, glucose content and NR activity. These biochemical characters were significantly higher in plants treated with 5.0% SLF. The results revealed that the optimum concentration for the production/synthesis of biochemical characters of Okra was found to be 5.0% SLF of *Sargassum wightii.* Above this concentration (5.0%), there was gradual decrease in all the biochemical characters.

INTRODUCTION

Green Revolution (GR) technologies are known to have enhanced agricultural production and productivity. The technologies greatly helped to address the food security of India, farmers using these technologies have to depend upon the purchased inputs. The small farmers, who by cash flow definition are short of cash, are therefore found to lag behind large farmers in the adoption of technologies. The manufactures of fertilizers and pesticides, the two major inputs of GR technologies, need fossil fuels and/or expensive energy and are associated with serious environmental and health problems (Suresh Reddy, 2010).

Modern agricultural farming practices, along with irrational use of chemical inputs over the past four decades have resulted in not only loss of natural habitat balance and soil health (Ram, 2003). In this context, the alternative farm techniques and strategies for growing crops ought to be found in the larger interest. In India, cropping system involves the usage of inorganic and organic fertilizers to improve soil health and soil fertility. However, the mismanagement and excessive use of inorganic fertilizers creates problems in soil fertility and the environment. Hence, a widespread need has arisen to go in for organic farming and cultivation. The efficiency of sole organic inputs in nutrient management should be studied through the use of different types of organic manures. Organic farming is a productive system, which reduces or avoids entirely the use of chemical fertilizers, pesticides, growth regulators and other agricultural chemicals. The system relies on crop rotation, organic manure and biofertilizers for nutrient supply, biopesticides and biocontrol for pest and disease control and innovative crop husbandry practices for maintaining soil productivity.

Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health including biodiversity, biological cycles and soil biological activity. Thus, farmers are switching over to organic fertilizers for sustainable agriculture. Unlike chemical fertilizer, manure derived from living resources is biodegradable, non-toxic, non-polluting and non-hazardous to soil ecosystem (Dhargalkar and Pereira, 2005). Consequently, farmers began to shift from chemical-based conventional farming methods towards organic, alternative, or low input sustainable agriculture. With increasing demand, availability of organic fertilizers from one or two sources was not adequate. To meet the increasing demand many viable options have to be explored and one such option is the use of seaweed extracts as fertilizer (Mukesh, 2013).

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Seaweed Fertilizer

The seaweed suspensions or extracts obtained from algae gain a commercial importance. The seaweed suspensions can be an alternative treatment especially for organic farming (Crouch *et al*., 1990). The application of seaweed fertilizers for different crop plants is of great importance to substitute/supplementary to the inorganic fertilizers and to reduce the cost of production. The current research indicates that the extract from seaweeds are found to be superior to chemical fertilizers due to high level of organic matter, micro and macro elements, vitamins, fatty acids and growth regulators. The phyto hormones identified in seaweed extracts are auxins, cytokinins, gibberellins, abscisic acid and ethylene.

The application of seaweed liquid extract stimulate different aspects of plant like good health, development of root system, absorption of mineral, enlargement of shoot, increased rate of photosynthesis and crop yield (Sridhar and Rengasamy, 2010). Seaweed liquid extract have newly gained importance as foliar spray for lots of crops including various variety of grasses, flowers, cereals, vegetables and spices (Pramanick *et al*. 2014). Further, Zodape (2001) tried various modes of seaweed extract application such as a foliar spray, application to soil and soaking of seeds before sowing and reported that extract not only enhances the germination of seeds but also increases uptake of plant nutrients and gives resistance to frost and fungal diseases (Jameson, 1993).

MATERIAL AND METHODS

Collection of seaweed

The marine algae *Sargassum wightii* was freshly collected from the coastal area of Rameshwaram, Tamil Nadu, India. The collected sea weeds were washed thoroughly with seawater to remove all the unwanted impurities, adhering sand particles and epiphytes. Then, the samples were washed thoroughly using fresh water to remove the surface salt and then blotted to remove excess water. The shade dried seaweeds were cut into small pieces and powdered in a mixer grinder and stored in air tight container for further use.

Preparation of Seaweed Liquid Fertilizer (SLF)

Seaweeds were shade-dried for four days, followed by oven-drying for 24 hours at 60°C. The dried seaweeds were used for the preparation of Seaweed Liquid Fertilizer (SLF) following the method of Rama Rao (1990). The filtrate thus obtained was considered as 100% SLF, from which different concentrations (1% to 7%) were prepared by distilled water.

Nursery experiment

A nursery experiment was conducted to study the nursery performance SLF of *Sargassum wightii* in Okra (*Abelmoschus esculentus* (L.) Moench). The seeds with uniform size, colour and weight were chosen for the experimental purpose and surface sterilized with 0.1% $HgCl_2$ for 1 minute and thoroughly washed with distilled water 3-5 times. Seeds were pre-soaked for 12 hours in distilled water and were sown in sterilized soil mixture. The soil mixture was prepared by mixing black soil, red soil and sand in the ratio of 1:1:1. Eight treatments were given to the nursery plants by the soil application of 1%, 2%, 3%, 4%, 5% 6% and 7% of SLF. In each treatment, 100 mL aqueous extract was applied. The first spray treatment was given to 10-day-old seedlings. Thereafter, three treatments at the intervals of 10th days each were given up to 30^{th} days. The control set was treated only with distilled water. To study the nursery performance of SLF of *Sargassum wightii*, the growth characters such as seed germination, germination index, seedling vigour index I (SVI I) and II (SVI II), shoot length, root length, number of leaves, fresh weight and dry weight were studied.

Table 1 Effect of SLF of *Sargassum wightii* on the seedling growth of Okra

S. No.	Treatment	Seed Germination (%)	Germination Index	Seedling Vigour Index I	Seedling Vigour Index II
1	Control	74^{e} ±0.07 (100)	0.53^{f} ±0.01 (100)	14.8^{h} ±0.08 (100)	0.25^{e} ±0.01 (100)
2	SLF – 1%	90^{d} ±0.08 (121)	0.96^{e} ±0.03 (181)	19.8^{g} ±0.08 (133)	0.34^{de} ±0.03 (136)
3	SLF – 2%	92^{c} ±0.05 (124)	1.25^{d} ±0.07 (235)	21.6^{f} ±0.15 (145)	0.43^{cd} ±0.04 (172)
4	SLF – 3%	93^{c} ±0.03 (125)	1.28^{d} ±0.04 (241)	23.9^{e} ±0.11 (161)	0.44^{c} ±0.01 (176)
5	SLF – 4%	95^{b} ±0.06 (128)	1.32^{c} ±0.01 (249)	26.1^{c} ±0.57 (176)	0.63^{b} ±0.05 (252)
6	SLF – 5%	98^{a} ±0.04 (132)	1.42^{a} ±0.04 (267)	32.0^{a} ±0.33 (216)	1.05^{a} ±0.02 (420)
7	SLF – 6%	94^{b} ±0.05 (127)	1.32^{c} ±0.02 (249)	27.2^{b} ±0.06 (183)	0.67^{b} ±0.04 (268)
8	SLF – 7%	95^{b} ±0.01 (128)	1.39^{b} ±0.06 (262)	25.1^{d} ±0.01 (170)	0.65^{b} ±0.04 (260)
CD P = 0.05 %		0.415	0.541	0.308	0.112

The biochemical parameters such as chlorophyll, glucose, protein, free amino acids and nitrate reductase activity were also studied.

Statistical analysis

The data were reported as mean ± SE and in the figure parentheses represent the percent activity. The data obtained were subjected to analysis variance (ANOVA) and the significant means were segregated by critical difference (CD) at 0.05% level of significance.

RESULTS

The use SLF of *Sargassum wightii* significantly promoted the growth characters and biochemical characters of Okra. There was a noticeable increase in growth and biochemical parameters when 5.0% of SLF of *S. wightii* applied to Okra plant. Higher concentrations (6.0 % and above) were found to show inhibiting effect on all the growth as well as biochemical characters studied. The positive effect of SLF also reflected in nutrient status and microbial dynamics of SLF treated soil.

Effect of SLF on the Growth Characters

There was a significant difference was observed in the rate of seed germination of Okra**.** The germination rate was higher in the plants treatment with SLF of *S. wightii* over the control plants. Among different concentrations tested, 5.0% concentration of SLF was superior to others. The germination index varied according to concentration of SLF of *S. wightii*. Little difference was shown in germination index among different concentration of SLF but the effect was higher to the control. The values of the vigour index of the Okra also varied according to the concentration of SLF. The highest value of seedling vigour index was for the application of soil to 5.0% SLF and lowest seedling vigour index was shown in the control plants. The trend was similar in both in SVI- I and SVI- II.

The SV-I was based on the value obtained in seedling length and percentage of seed germination and in the case of SV-II was based on the seedling dry weight and percentage of seed germination (Table 1).

The results further revealed that the SLF treatment improved the shoot length of Okra compared to the control. The shoot length of okra plants enhanced when 5.0% concentration of SLF was applied. The retarding effect in seedling length was corresponding to increase in the concentrations (6.0% and 7.0%). The application of SLF of *S. wightii* highly influenced the root length also. Plants treated with different concentration of SLF responded better than control plants. The root length was higher in 5.0% of SLF (16.9cm) than control plants (9.8cm). The number of leaves per plant was significantly influenced by SLF of *S. wightii* and plants produced more number of leaves and the highest number of leaves was found in plants treated with 5.0% SLF. There was a reduction in the number of leaves in plants treated with 6.0% and 7.0% of SLF. The results clearly indicated that the application of SLF of *S. wightii* significantly increased the plant fresh and dry weight over the control plants. There was an increase of biomass of Okra with increase the concentration of SLF up to 5.0% and then there was a gradual reduction in the biomass production in the 6.0% and 7.0% of SLF (Table 2).

Effect of SLF on the Biochemical Characters

The maximum pigment production (Total chlorophyll) was noted (3.32mg/g LFW) at 5.0% concentration of SLF over the control (1.50 mg/g LFW). But, slight reduction was observed in 6.0% (2.56 mg/g LFW) and 7.0% (2.32 mg/g LFW) concentration of SLF. The result revealed that there was a marked difference observed in the glucose content among treatments. It was higher in plants treated with 5.0% concentration of SLF (123%). Among treatments, the least glucose content was noticed in plants treated with 1% of SLF (20.39%) and 7.0% of SLF (25.96%).

Table 2 Effect of SLF of *Sargassum wightii* on the plant biomass production of Okra

S.No.	Treatment	Shoot Length (cm)	Root Length (cm)	Number of leaves (per plant)	Fresh Weight (g)	Dry Weight (g)
1	Control	20.1^{h} ±0.03 (100)	9.8^{g} ±0.01 (100)	12^{g} ±0.88 (100)	8.25^{g} ±0.04 (100)	1.33^{f} ±0.03 (100)
2	SLF – 1%	22.1^{g} ±0.01 (109)	10.7^{f} ±0.04 (109)	17^{f} ±1.15 (141)	10.71^{f} ±0.24 (129)	1.83^{e} ±0.02 (111)
3	SLF – 2%	23.5^{f} ±0.03 (116)	11.3^{d} ±0.05 (115)	20^{e} ±1.45 (166)	13.07^{e} ±0.56 (158)	2.17^{d} ±0.01 (138)
4	SLF – 3%	25.8^{e} ±0.04 (128)	13.9^{c} ±0.04 (141)	22^{d} ±0.57 (183)	14.87^{d} ±0.48 (180)	2.25^{d} ±0.02 (141)
5	SLF – 4%	27.5^{c} ±0.05 (136)	14.0^{b} ±0.03 (142)	25^{cd} ±1.53 (208)	16.47^{c} ±0.45 (199)	2.50^{c} ±0.03 (197)
6	SLF – 5%	32.7^{a} ±0.03 (162)	16.9^{a} ± 0.04 (172)	30^{a} ±1.20 (250)	18.26^{a} ±0.28 (221)	3.17^{a} ±0.01 (317)
7	SLF – 6%	29.0^{b} ±0.02 (144)	14.0^{b} ±0.03 (142)	27^{b} ±0.88 (225)	17.32^{b} ±0.12 (209)	3.0^{b} ±0.04 (208)
8	SLF – 7%	26.5^{d} ±0.02 (131)	10.8^{e} ±0.02 (110)	24^{c} ±0.57 (200)	15.12^{c} ±0.04 (183)	2.50^{c} ±0.04 (202)
CD P = 0.05 %		0.041	0.71	1.58	0.649	0.062

The SLF treatment significantly increased the aminoacids over the control plants, 1% (50%), 2.0% (68%), 3.0% (137%), 4.0% (217%), 5.0% (391%), 6.0% (279%) and 7.0% (166%). The increment of aminoacid content directly correlated with the protein content also. The positive effect of SLF on the protein content was similar with that of aminoacid content. All the SLF treatments recorded maximum activity of nitrate reductase when compared to the control plants. Among the treatments, 5.0% of SLF was found to be superior in registering the maximum activity of nitrate reductase. NR activity was increased from 1% of SLF up to 5.0% then there was a decline in the NR activity (Table 3).

related to seaweed components such as macro and microelement nutrients, amino acid, vitamins, cytokinins, auxins, and abscisic acid (ABA) like growth substances. These compounds were enhanced the growth and crop yield (Durand *et al*., 2003). Ramya *et al.* (2010) used liquid extracts of marine algae as soil drench to cluster bean plant and noticed maximum influence on growth parameters such as shoot length, root length, total fresh and dry weight and leaf area. The growth enhancing potential of seaweed might be attributed to the presence of carbohydrate, micro and macro elements.

Table 3 Effect of SLF of *Sargassum wightii* on the biochemical characters of Okra

S.No.	Treatment	Total Chlorophyll (mg/g LFW)	Glucose (mg/g LFW)	Aminoacid (mg/g LFW)	Protein (mg/g LFW)	NRA (µmol NO_2 formed/ g/LFW/h)
1	Control	1.50[g] ±0.01 (100)	20.39[h] ±0.03 (100)	1.22[h] ±0.01 (100)	1.89[g] ±0.02 (100)	1.28[g] ±0.01 (100)
2	SLF – 1%	1.82[f] ±0.03 (121)	25.70[g] ±0.05 (126)	1.78[g] 0.02 (150)	2.50[f] ±0.02 (132)	2.13[f] ±0.01 (166)
3	SLF – 2%	2.34[de] ±0.01 (156)	28.95[e] ±0.02 (142)	2.05[f] ±0.01 (168)	3.57[e] ±0.01 (189)	2.85[e] ±0.01 (223)
4	SLF – 3%	2.47[c] ±0.03 (165)	31.47[d] ±0.02 (154)	2.89[e] ±0.02 (237)	3.76[d] ±0.01 (199)	3.63[d] ±0.01 (284)
5	SLF – 4%	2.85[b] ±0.11 (190)	34.83[c] ±0.01 (171)	3.87[c] ±0.02 (317)	4.41[c] ±0.05 (233)	4.01[c] ±0.06 (313)
6	SLF – 5%	3.32[a] ±0.02 (221)	45.42[a] ±0.06 (223)	5.99[a] ±0.01 (491)	6.73[a] ±0.01 (356)	5.72[a] ±0.01 (447)
7	SLF – 6%	2.56[cd] ±0.03 (171)	37.59[b] ±0.03 (184)	4.63[b] ±0.01 (379)	5.48[b] ±0.02 (290)	4.87[b] ±0.02 (380)
8	SLF – 7%	2.32[e] ±0.06 (155)	25.96[f] ±0.02 (127)	3.25[d] ±0.01 (266)	3.70[d] ±0.01 (196)	3.90[c] ±0.01 (305)
CD P = 0.05 %		0.131	1.751	0.022	0.080	0.06

DISCUSSION

The nursery soil treated with Seaweed Liquid Fertilizer (SLF) of *S. wightii* at different concentrations (1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0% and 7.0%) had a positive effect on the crop response. The results indicated that the SLF significantly increased crop response of Okra with reference to growth attributes and biochemical attributes.

Effect of SLF on the Growth Attributes

The increased seedling growth may be due to the presence of phenyl acetic acid and other micro nutrients and trace elements in the seaweed liquid fertilizers as well as the presence of other growth promoting substances in *Sargassum wightii*, *Padina boergesenii* and *Ulva fasciata*. Among three seaweeds, the maximum effect was found in *Sargassum wightii* in all the experimental studies (Taylor and Wilkinson, 1997). The increase in plant height with seaweed liquid fertilizer may be due to its stimulation effect on growth and development resulting in good health of plants, while deliberating the effect of seaweed liquid fertilizer on crops the aspects of root development and shoot growth of the plant system (Pramanick *et al*., 2013). The enhancing of vegetative growth can be

Seaweeds are known to contain appreciable quantities of plant growth regulators (Mooney and Van Staden, 1985), cytokinins (Smith and Van staden, 1984), IAA (Abe *et al*., 1972), gibberellins and gibberellins-like substances. The application of seaweed extracts not only promote growth and yield of plants but also enhance the disease resistance capacity in horticulture crops (Sekar *et al.*, 1995).

Chemical analysis of the algal extracts showed the presence in them a whole range of types of plant growth regulators auxins, cytokinins, gibberellins, abscisic acid, etc. (Prasad *et al*., 2010; Yokoya *et al*., 2010), which have high concentrations of inhibitory, while low a stimulating effect on the growth of plants (Crouch and van Staden, 1993). (Vijayanand *et al.* 2004) reported that lower concentration of SLF from *Stoechospermum marginatum* promoted the growth of brinjal. The increase in the growth variables at lower concentration of the SLF treated plant may be due to the uptake of magnesium, phosphorus, potassium, nitrate and iron from the seaweed extract (Dhargalkar and Pereira, 2005). The seedlings treated with low concentration of SLF showed better results in growth parameters which may be directly attributed by the presence of essential macro, micro nutrients, phenyl acetic acid (PAA) and other closely related compounds like growth regulators at an optimum level (Genard *et al*., 1991).

Effect of SLF on the Biochemical Attributes

Latique *et al.* (2013) reported that the foliar application of SLF increased leaf pigment (particularly chlorophyll a) and protein content. But at high proportion of seaweed extract in medium culture decreased these parameters. Blunden *et al*. (1997) found that seaweed applied at low concentration of *Ascophyllum nodosum* extract to soil or on foliage of tomatoes produced leaves with higher chlorophyll content than those of untreated controls. This increase in chlorophyll content was a result of reduction in chlorophyll degradation, which might be caused in part by betaines in the seaweed extract. The application of SLFs increased chlorophyll a, b and xanthophyll pigments content in most of the concentration tested. Seaweed liquid fertilizer of *U. fasciata* and *S. swartzii* enhanced the synthesis of biochemical constituents such as photosynthetic pigments, soluble sugar, soluble protein and lipid in C 3 plants (Menon and Srivastava, 1984).

Zodape *et al.* (2010) observed that SLF treated *Vigna radiata* showed increase protein content in both leaves and seeds. Norrie and Hiltz (1999) reported that the SLF of *Ulva lactuca* improved the accumulation of total carbohydrate, total protein and total lipid with 1.0% SLF on marigold. Such a rise in protein content may be attributed to the increased availability and absorption of necessary elements (Ca, Na, Mg, Cd and Zn) present in the aqueous extract that enhanced the efficiency of leaves. The increase in protein content at lower concentrations of liquid extract may be due to absorption of most of the necessary elements by the seedling (Anantharaj and Venkatesalu, 2001).

In comparison to control plants treated with aqueous seaweed extracts showed a significant increase in total soluble sugars and reducing sugars. This may be considered indicative of the fact that seaweed extracts stimulate various biological processes that increase the carbohydrate levels in tomato plants. In *V. sinensis*, the sugar content increased up to 20% with *S. wightii* liquid extract but showed a decline at higher concentrations (Sivasankari *et al.*, 2006). With respect to nitrate reductase activity, the foliar application of seaweed extract increased this enzymatic activity. *Ulva rigida* extract was found more effective than *Fucus spiralis*. When SLE of *Ulva rigida* extract incorporated in medium culture we noted an important decrease of nitrate reductase activity. However the incorporation of *Fucus spiralis* extract in medium culture showed a remarkable increased of nitrate reductase activity particularly at proportion (50% and 75% of *Fucus spiralis* extract) while a high proportion of this extract (100% of *Fucus spiralis* extract) decrease the nitrate reductase activity. Gurusaravanan *et al.* (2011) found that the effect of seaweed liquid extract of *Turbinaria decurrens* at 1.5% showed more *in vivo* NR activity and NR activity decreased correspondingly with increase in the seaweed extract concentration.

The seaweed extract prepared from *S. wightii* and *U. lactuca* was found to be promising in possessing fertilizer activity. Hence, this simple practice of application of eco-friendly seaweed liquid fertilizers to vegetables is recommended to the farmers for attaining better growth and yield over chemical fertilizers. Seaweed extracts can be recommended as biofertilizer to be used alone or in combinations with other biofertilizers and applied to either soil or foliage for improved growth. With abundant distribution, great regeneration potential and easy mass cultivation, the seaweed biofertilizer seems a feasible substitute to synthetic fertilizers. If such seaweeds extracts are used for organic farming, our dependence on chemical fertilizers can be reduced (Divya and Niranjana Reddi, 2017).

CONCLUSION

The present investigation revealed that the Plant growth and biochemical characters of Okra were significantly increased with increased concentration of SLF of *Sargassum wightii*. The positive effect was differed with reference to concentration of SLF of *Sargassum wightii*. Among different concentration tested, 5.0% of SLF was superior to other concentrations. The SLF from *Sargassum wightii* is best suit for Okra plants especially at 5.0% concentration of SLF. In conclusion, considering the above important findings, the seaweed extracts derived from *Sargassum* act as an effective Seaweed Liquid Fertilizer (SLF) in increasing the growth and biochemical characters. Hence, this simple practice of application of eco-friendly seaweed liquid fertilizers to economically important plants like Okra of South India is recommended to the growers for attaining better growth and yield.

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