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Effect of Seaweed Liquid Fertilizer of *Sargassum wightii* on the Yield Characters of *Abelmoschus esculentus* (L.) Moench)

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ABSTRACT: The yield characters of Okra (*Abelmoschus esculentus* (L.) Moench) was significantly increased when plants treated with Seaweed Liquid Fertilizer (SLF) of *Sargassum wightii*. The SLF was treated with various concentrations such as 1%, 2%, 3%, 4%, 5%, 6% and 7%. The beneficial effect was varied with respect to concentration of SLF. The yield characters such fruit length, weight and harvest were significantly increased with increasing the concentration of SLF. From the results, it was observed that the optimum concentration for optimum yield at the 5% of SLF. There was a gradual increase in the yield characters up to 5% and then there was a decrease in the 6 and 7% of SLF. Further, the application of SLF greatly influenced the soil microbial dynamics. The population dynamics of both bacteria and fungi was increased with the concentration of SLF. The increased concentration of SLF also facilitated the population build up in the treated soil. The results also indicated that the application of SLF of *Sargassum* significantly affected the soil macro as well as micro nutrients. The response of SLF was superior in the plants treated with 5.0%.

KEYWORDS: *Sargassum*, SLF, Okra, yield, soil nutrients

I. INTRODUCTION

Vegetable cultivation is one of the major enterprises in horticulture which is becoming more popular due to the greater appreciation of their food values, vitamins and minerals. Okra, *Abelmoschus esculentus* (L.) Moench is herbaceous annual that belongs to the family Malvaceae. It is principally used as vegetable and cultivated for its fresh fruits in both tropical and sub-tropical countries. The stem yield is useful as fiber, the leaves are considered good cattle feed and are consumed sometimes and the seeds can be roasted and used as substitute for coffee (Farinde, 2007). The fruit is rich source of vitamins A and C, calcium, thiamine and riboflavin. In general, the cultivation Okra is by the application chemical fertilizers such as urea, diammonium phosphate, zinc sulphate *etc.* The application of conventional fertilizers increased the yield of Okra. But this may affect the soil physical and biological properties and directly affected the soil fertility and soil health when continuous use of chemical fertilizers. With a view to identify a better nutrient management technique should be economical as well as ecologically efficient one.

Now-a-days, seaweed suspensions or extracts obtained from algae gain a commercial importance and the seaweed suspension can be an alternative treatment especially for organic farming. In the experimental studies it was shown that growth of seedlings was stimulated by the crude extracts of green (*Cladophora dalmatica, Entromorpha intestinalis, Ulva lactuca, Caulerpa chemnitzia*), brown (*Sargassum wightii*) and red algae (*Corallina mediterranea, Jania rubens, Pterocladia pinnate*) (El- Sheekh and El- Saled (2000). Craigie (2011) reported that seaweed extracts act as biostimulants mainly due to the presence of plant hormones. Main phytohormones identified in seaweed extracts are auxins, cytokinins, gibberellins, abscisic acid and ethylene. Thirumaran *et al*. (2009) reported that seaweed liquid fertilizer (SLF) contained macro nutrients, trace elements and organic substances.

The seaweeds resources are intensively used to improve harvest quantity and quality in agriculture and horticulture. The beneficial effects of seaweed products on the cultured plants are well documented. They improve seeds germination, seedlings development, increase plant tolerance to environmental stresses (Zhang *et al.*, 2003) and enhance plant growth and yield (Khan *et al*., 2009). More over seaweeds are used as soil amendment and plant disease

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Vol. 4, Issue 9 , September 2017

management (Jayaraj *et al*., 2008). Sutharsan *et al.* (2014) found that the foliar application of seaweed (*Sargassum crassifolium*) extract increased the shoot dry weight, root dry weight, fruit number, fruit yield per hectare along with total soluble solids and total acidity content of fruit significantly over the control. The present study is aimed at to study effect of SLF of *Sargassum wightii* with reference to yield characters of Okra. Further, the population dynamics of general microflora (Bacteria and Fungi) and nutrient status were also studied in SLF treated and untreated control soil.

II. MATERIAL AND METHODS

A) Nursery Experiment

The marine algae *Sargassum wightii* was freshly collected from the coastal area of Rameshwaram, Tamil Nadu, India. The seaweeds were shade-dried and 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. A nursery experiment was conducted to study the nursery performance Seaweed Liquid Fertilizer (SLF) of *Sargassum wightii* in Okra (*Abelmoschus esculentus* (L.) Moench) with reference to yield characters. Further, the effect SLF on the soil nutrient content and soil microorganism were also studied. The seeds Okra the soil mixture was prepared by mixing black soil, red soil and sand in the ratio of 1:1:1. The healthy seeds uses sown and irrigated properly. The SLF (1%, 2%, 3%, 4%, 5% 6% and 7%) was treated as soil application. The first treatment was given to 10-days-old seedlings. Thereafter, three treatments were given up to 30th days.

B) Yield Characters

The yield characters such as number of flowers and fruits, fruit length, fruit weight and harvest index were studied. The numbers of flowers and fruits in the plants were counted in both control and treated plants. The length of okra fruits were measured from the base to the tip of the fruit in centimetres by meter scale. The harvested fruits were weighed with the help of electronic balance and expressed in gram. The harvest index (Gomez and Gomez, 1984) was worked out from the data of total dry matter production and fruit biomass.

C) Soil Analysis

The effect of SLF of *Sargassum* on the soil microbial dynamics was studied. Rhizosphere soils were collected from the treated and control plants. The soil samples were air dried under shade and used for the isolation and enumeration of bacteria and fungi. Isolation and enumeration of bacterial cells was carried out by dilution plate technique using nutrient agar medium. For the isolation, the soil samples were serially diluted up to 10^8 dilutions and plated on petri plates and incubated at 35±2ºC for three days. At the end of incubation, the bacterial colonies were counted. For the isolation and enumeration of fungal colonies, the soil samples were serially diluted in PDA medium up to 10^8 dilutions and plated on petri plates and incubated at 35±2ºC for three to five days. At the end of incubation, the fungal colonies were counted. Soil macronutrients such as total nitrogen (N), available phosphorus (P) and potassium (K); micronutrients such as Fe, Mn, Zn and Cu were analyzed in the treated and untreated soil samples in Agricultural Research Station, Virudhunagar, Tamil Nadu, India.

D) 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.

ISSN: 2350-0328
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Vol. 4, Issue 9 , September 2017

III. RESULTS

A) Yield Characters

The different concentration of SLF of *S. wightii* (1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0% and 7.0%) have been influenced the flower and fruit formation. Among different concentration tested, the plants treated 5.0% of SLF produced maximum number of flowers and fruits. There was a gradual reduction in the formation of flowers and fruits with increasing the concentration of SLF (6% and 7%). The effect was least in untreated control plants. The results revealed that the yield character of Okra such as fruit length and fruit weight were significantly increased in plants treated with different concentration of SLF of *S. wightii*. The optimum concentration of SLF for the highest value in the fruit length and fruit weight was found to be 5.0%. Beyond the optimum concentration, there was a gradual decrease in the fruit length and fruit weight. From the results, it was clear that SLF had significant positive effect on the harvest index of Okra also. With increase the concentration of SLF, there was a gradual increase in the harvest index up to 5.0% and then there was gradual reduction in the harvest index in the 6.0% and 7.0% of SLF. The maximum harvest index was obtained with 5.0% of SLF (Table 1).

B) Soil Microbial Dynamics

It was observed that the bacterial and fungal population level was greatly affected by the SLF treatment. In the treated soil, the bacterial and fungal populations were significantly higher with respect to all the concentration of SLF. Population dynamics of bacteria and fungi were increased with increasing of concentration of SLF. In contrast, the microbial dynamics was not at all affected by increased concentration of SLF (Table 2).

C) Soil Nutrient Status

The present study revealed that the soil treated with different concentration of SLF significantly increased macronutrients such as total nitrogen (N), available phosphorus (P) and potassium (K). The micronutrients such as Fe, Mn, Zn and Cu were also significantly increased with increasing the concentration of SLF of *S. wightii* (Table 3).

IV. DISCUSSION

A) Effect of SLF on Yield Characters

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 promoted growth and yield of horticulture crops (Sekar *et al.*, 1995); increased the seed germination, resistance to frost, fungal and insect attacks, uptake of inorganic constituents (Thirumal Thangam *et al.*, 2003). Promising increased crop yield, nutrient uptake, resistance to frost and stress, improved seed germination of reduced incidents of fungal and insect attack have been resulted by application of seaweed extracts.

Durand *et al*. (2003) found that the liquid extract obtained from seaweeds has recently gained much interest as foliar spray for inducing growth and yield in cereal crops, vegetables, fruits, orchards and horticultural plants. The extracts obtained from marine algae enhanced the growth and yield of various crops (Turan and Kose 2004; Stirk *et al.*, 2004). Bioactive substances extracted from marine algae are used in agricultural and horticultural crops as bio-fertilizers to improve their yield and quality and to reduce the negative environmental impact (Houssien *et al*., 2011). Seaweeds provide an excellent source of bioactive compounds such as essential fatty acids, vitamins, aminoacids, minerals and growth promoting substances. Bhasker and Miyashita (2005) have also been reported to stimulate the growth and yield of plants, enhance antioxidant properties and develop tolerance to drought stress.

ISSN: 2350-0328
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Vol. 4, Issue 9 , September 2017

B) Effect of SLF on the Soil Microbial Dynamics

The application of seaweed extracts triggers the growth of beneficial soil microbes and secretion of soil conditioning substances by these microbes. The SLF affected the soil properties and encouraged the growth of beneficial microorganisms. Ishii *et al.,* (2000) observed that extract from brown algae, significantly stimulated hyphal growth and elongation of Arbuscular Mycorrhizal (AM) fungi and triggered their infectivity on trifoliate orange seedlings. Extracts of various marine brown algae (*Laminaria japonica Areschoug* and *Undaria pinnatifida*) could be used as an AM fungus growth promoter (Kuwada *et al.*, 2006). The application of red and green algae considerably improved *in vitro* hyphal growth of AM fungi more than the control treatment.

Kuwada *et al.* (1999) showed that extracts of brown algae promoted *in vitro* AM hyphal growth as well as improved root colonization by AM fungi. Indigenous AM fungi demonstrated a 27% improvement in root colonization, while spore number was increased about 21% over the controls when liquid fertilizer was applied *via* a sprinkler system in a citrus orchard. Genard (1991) recorded that addition of seaweed manure in soil enhances the symbiotic relationship between microorganisms in the soil. Crop cultivation using organic fertilizers has contributed for deposition of residues, improving physical and chemical properties of soil that is important for biological development (Galbiattia *et al*., 2007).

C) Effect of SLF on the Soil Nutrient Status

Besides eliciting a growth-promoting effect on plants, seaweeds also affect the chemical properties of soil which in turn influence plant growth. Seaweed extracts enhance soil health by improving moisture-holding capacity and by promoting the growth of beneficial soil microbes (Cardozo *et al.,* 2007). Eris *et al.* (2008) found that seaweed of extract *Ascophyllum nodosum* sprayed on pepper plants lead to increase the concentration of nutrient elements significantly. The increase in growth characters might also due to the macronutrients content in seaweed extracts. Macronutrients have a great role in plant nutrition like nitrogen, potassium and phosphorous which are very essential for the growth and development of the plant. Seaweed extract provide the N, P and readily available micronutrients compared to most animal manures. Applications of chemical fertilizers certainly compensate the deficiency of nutrients in soil. Whereas, in excess it affects soil and plants in due course. Recent researchers proved that seaweed fertilizers since they are very economic, cheap and eco-friendly. Seaweed liquid fertilizer prepared from the brown alga, *Rosenvingea intricata*, applied to crop plant gave better results in soil nutrient content (Kannan and Selvan, 1987).

Seaweed fertilizers are preferred not only due to their nitrogen, phosphorus and potash content but also because of the presence of trace elements. The application of seaweed fertilizers for different crops was of great importance to substitute the commercial chemical fertilizers and to reduce the cost of production. Liquid fertilizers derived from seaweeds are found to be superior to chemical fertilizers due to high level of organic matter, micro and macroelements, vitamins, fattyacids and growth regulators. It was observed that the seaweed liquid fertilizers prepared from the red algae, *Gracilaria corticata* when applied to crop plants gave better results in soil nutrient contents when compared to the seaweed liquid fertilizer prepared from the green algae, *Caulerpa peltata* (Chitra and Sreeja, 2013). Seaweed liquid fertilizer prepared from the brown alga, *Rosenvingea intricata*, applied to crop plant gave better results in soil nutrient content when compared to the seaweed fertilizer of green alga. It is probably due to the presence nutrients in more quantities in the brown alga than in other groups of algae, seaweed liquid fertilizer can be applied to various crop plants in order to enrich the nutrient content of the soil and intern to increase the growth and yield of cultivable plants (Kannan and Selvan, 1987).

V. CONCLUSION

The present investigation revealed that the yield characters of Okra were significantly increased with increased concentration of SLF of *Sargassum wightii*. Further, the positive response was also reflected in the microbial dynamics as well as nutrient status of the treated soil. 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 population builds up and soil nutrient status was collectively responsible the yield characters of Okra. Hence, the fertilizer from *Sargassum wightii* is best suit for Okra plants especially at 5.0% concentration of SLF.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 9 , September 2017

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International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 9 , September 2017

Table 1: Effect of SLF of *Sargassum wightii* on the yield characters

S. No.	Treatment	Number of flowers (per plant)	Number of fruits (per plant)	Fruit length (cm/fruit)	Fruit weight (g/fruit)	Harvest Index
1	Control	5^{h} ±0.02 (100)	3^{h} ±0.01 (100)	9.2^{f} ±0.05 (100)	3.81^{h} ±0.01 (100)	15.08^{h} ±0.02 (100)
2	SLF – 1%	7^{g} ±0.02 (140)	6^{g} ±0.02 (200)	10.1^{e} ±0.03 (109)	3.92^{g} ±0.01 (102)	17.97^{g} ±0.01 (119)
3	SLF – 2%	9^{f} ±0.01 (180)	7^{f} ±0.01 (233)	10.3^{e} ±0.08 (111)	4.45^{f} ±0.01 (116)	18.43^{f} ±0.03 (122)
4	SLF – 3%	12^{e} ±0.01 (240)	11^{e} ±0.02 (367)	10.5^{d} ± 0.08 (114)	4.61^{e} ±0.02 (120)	19.78^{e} ±0.02 (131)
5	SLF – 4%	15^{d} ±0.02 (300)	14^{c} ±0.02 (467)	10.7^{c} ±0.08 (116)	4.82^{d} ±0.01 (126)	22.10^{c} ±0.03 (146)
6	SLF – 5%	22^{a} ±0.02 (440)	20^{a} ±0.01 (667)	11.9^{a} ±0.01 (129)	5.50^{a} ±0.01 (144)	25.24^{a} ±0.01 (167)
7	SLF – 6%	18^{b} ±0.01 (360)	16^{b} ±0.03 (533)	10.8^{b} ±0.06 (117)	5.11^{d} ±0.02 (134)	23.11^{b} ±0.02 (153)
8	SLF – 7%	16^{c} ±0.01 (320)	13^{d} ±0.06 (433)	10.6^{c} ±0.03 (115)	5.04^{c} ±0.01 (132)	21.52^{d} ±0.02 (142)
CD P = 0.05 %		0.054	0.078	0.162	0.037	0.053

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International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 9 , September 2017

Table 2: Effect of SLF on the population dynamics of bacteria and fungi

S. No.	Treatment	Population level ($\times 10^7$/g. soil dry weight)	
		Bacteria	**Fungi**
1.	Control	0.8^f ±0.02 (100)	0.3^g ±0.03 (100)
2.	SLF – 1%	2.1^e ±0.03 (262)	0.5^f ±0.05 (167)
3.	SLF – 2%	2.4^d ±0.09 (300)	0.8^e ±0.02 (267)
4.	SLF – 3%	2.7^c ±0.06 (337)	1.0^d ±0.03 (333)
5.	SLF – 4%	2.9^c ±0.07 (363)	1.3^c ±0.01 (433)
6	SLF – 5%	3.4^b ±0.09 (425)	1.5^b ±0.05 (500)
7	SLF – 6%	3.7^a ±0.06 (462)	1.6^b ±0.08 (533)
8	SLF – 7%	3.8^a ±0.01 (475)	1.7^a ±0.06 (567)
CD P = 0.05 %		0.248	0.111

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International Journal of Advanced Research in Science, Engineering and Technology
Vol. 4, Issue 9 , September 2017

Table 3: Effect of SLF of *Sargassum wightii* on the soil nutrient content

S. No.	Treatment	Macronutrients (ppm)			Micronutrients (ppm)			
		N	P	K	Fe	Mn	Zn	Cu
1	Control	28.6^{h} ±0.08 (100)	0.9^{g} ±0.02 (100)	60^{h} ±0.05 (100)	1.3^{g} ±0.01 (100)	3.2^{h} ±0.01 (100)	0.3^{g} ±0.05 (100)	0.4^{g} ±0.04 (100)
2	SLF – 1%	30.8^{g} ±0.07 (108)	1.0^{g} ±0.05 (111)	63^{g} ±0.05 (105)	1.6^{f} ±0.02 (123)	4.8^{g} ±0.05 (150)	0.4^{f} ±0.01 (133)	0.6^{fg} ±0.08 (150)
3	SLF – 2%	35.2^{f} ±0.01 (123)	1.5^{f} ±0.05 (167)	65^{f} ±0.09 (108)	1.8^{e} ±0.03 (138)	5.2^{f} ±0.03 (163)	0.4^{f} ±0.02 (167)	0.7^{ef} ±0.05 (175)
4	SLF – 3%	37.8^{e} ±0.05 (132)	1.7^{e} ±0.03 (189)	70^{e} ±0.09 (117)	1.9^{d} ±0.02 (146)	5.6^{e} ±0.08 (175)	0.6^{e} ±0.02 (200)	0.8^{de} ±0.06 (200)
5	SLF – 4%	42.5^{d} ±0.08 (149)	1.8^{d} ±0.01 (200)	82^{d} ±0.02 (137)	2.1^{c} ±0.01 (162)	6.6^{d} ±0.04 (206)	0.7^{d} ±0.02 (200)	0.9^{cd} ±0.06 (225)
6	SLF – 5%	49.6^{c} ±0.08 (173)	2.0^{c} ±0.04 (222)	85^{c} ±0.02 (142)	2.2^{c} ±0.06 (169)	6.8^{c} ±0.08 (213)	0.8^{c} ±0.01 (233)	1.0^{ab} ±0.07 (250)
7	SLF – 6%	57.4^{b} ±0.09 (201)	2.2^{b} ±0.01 (244)	88^{b} ±0.08 (147)	2.4^{b} ±0.01 (185)	7.2^{b} ±0.05 (225)	0.9^{b} ±0.04 (267)	1.1^{bc} ±0.06 (275)
8	SLF – 7%	60.8^{a} ±0.04 (213)	2.5^{a} ±0.02 (278)	90^{a} ±0.02 (150)	2.6^{a} ±0.04 (200)	7.9^{a} ±0.09 (245)	1.0^{a} ±0.05 (333)	1.3^{a} ±0.09 (325)
CD P = 0.05 %		0.124	0.056	0.019	0.057	0.111	0.058	0.166