BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, October 2014. Vol. **11**(Spl. Edn. 1), p. 253-261

Development of Seaweed Liquid Fertilizer (SLF) Consortium for the Enhancement of Agriculturally Important Crop Plants

R. Muthezhilan[1]*, V. Ravikumar[1], R. Karthik and A. Jaffar Hussain[2]

[1]Department of Marine Biotechnology, AMET University (U/S of UGC Act 1956)
Kanathur, Chennai 603112, India.
[2]Centre for Marine Bioprospecting, AMET University (U/S of UGC Act 1956)
Kanathur, Chennai 603112, India.
[3]Department of Biotechnology, AVC College of Arts and Science (Autonomous),
Mannampandal, Mayiladuthurai - 609305, India.

doi: http://dx.doi.org/10.13005/bbra/1418

(Received: 15 August 2014; accepted: 10 October 2014)

Modern agriculture with use of chemical fertilizers and resulted in an increase of food production. The continuous use of chemical fertilizers in agriculture field is toxic in nature and also disturbs the soil living beneficial microorganisms. So, the use of seaweed as a fertilizer in agricultural field will help to maintain the moisture content and are eco-friendly. Keeping this point in mind, the present study was aimed to develop different consortium of seaweed liquid fertilizer (SLF) to enhance crop yield. The seaweeds such as *Ulva fasciata, Sargassum wightii* and *Padina boergesenii* were collected from the rocky shore areas of Mandapam Coast, Rameshwaram District, Tamil Nadu, India. A total of four different consortium of seaweed liquid fertilizer (SLF) were prepared in different concentrations (1%, 2% and 2.5%) to determine their plant growth promoting ability in agriculturally important crop plants such as, Green gram, Black gram, Mustard and Paddy by seed germination and soil drenching methods in both sterilized and unsterilized soil at laboratory scale experimental setups. The 100% of seed germination and the maximum shoot length ((Green gram 33.73±0.64), (Black gram 34.46±0.45), (Mustard 15.96±0.20) and (Paddy 15.36±0.15)) and root length (Green gram 13.63±0.37), (Black gram 10.46±0.20), (Mustard 11.2±0.2) and (Paddy 14.43±0.30) was found high in the plants treated with the consortium of *Padina boergesenii, Sargassum wightii* and *Ulva fasciata* at 0.7% (21ml of seaweed extracts and 71ml of distilled water) concentration followed by consortium of *Padina boergesenii,* and *Sargassum wightii* at 1% (20ml of seaweed extracts and 80ml of distilled water) in unsterilized soil and the work has suggested to use this consortium of seaweed liquid fertilizer (SLF) in agricultural field to enhance the crop production.

Key words: Seaweed Liquid Fertilizer (SLF) Consortium, Crop Plants, Seed germination, Soil drenching, Plant Growth Promotion.

Agriculture faced multiple challenges to produce more food to supply a growing population. Many agriculture-dependent developing countries, adopt more efficient and sustainable production technique to climate change and concerns on environmental pollution coupled with random use of agrochemicals. Abundant use of chemical fertilizer is undesirable because of the production of chemical fertilizer is a expensive process, consumption of non-renewable fossil fuel, considerable pollution is caused through both the production and use of mineral N- fertilizer (Mai *et al.*, 2010; Deshwal *et al.*, 2011a). Moreover the over use of chemical fertilizers in agriculture soil

* To whom all correspondence should be addressed.
E-mail: mycomuthu@gmail.com

will disturbs the nature of the soil and soil living beneficial microbes also it will make health problems in human due to biomagnifications (Comargo and Alonso, 2006). To solve the above problem, there is an emerging need of natural bio fertilizers with low cost in agricultural field to improve the plant growth and to enhance the food production (Ganapathy Selvam and Sivakumar, 2014).

Generally, bio fertilizer improves crop productivity through the processes such as nitrogen fixation, phosphate solubilization and plant hormone produc-tion (Pereira and Verlecar 2005). With increasing demand, availability of organic fertilizers from one or two sources is not sufficient (Zodape, 2001). In normal, the marine ecosystem is the rich place for much natural recourse. Seaweeds are among the important marine living resources with incredible commercial (Sahoo, 2000). It is estimated that, there are about 9,000 species of macro algae broadly classified into three main groups namely green (chlorophyceae),brown (Phaeophyceae) and red (rhodophyceae) based on their pigments such as chlorophylls, carotenoids and phycobiliproteins (Wajahatullah *et al.*, 2009). Most of the seaweeds contains various fine chemicals and micro nutrients and plant growth promoting hormones, Cytokinins, Gibberellins, trace elements, vitamins, aminoacids, antibiotics and micronutrients (Tay *et al*., 1987; Thirumaran *et al*., 2009). Recently, it is assured that the seaweed extract containing highly valuable nutritious and promotes faster germination of seeds and increase yield and resistant ability of many crops (Balakrishnan *et al*., 2007). Moreover compared with chemical fertilizers, the extracts derived from seaweeds are biodegradable, non toxic, non-polluting and non-hazarduos to humans, animals and birds (Dhargalkar, 2005). Keeping this point in mind, the present study was aimed to develop different consortium of seaweed liquid fertilizer (SLF) to enhance crop yield.

MATERIALS AND METHODS

Collection of Seaweeds

The seaweeds such as, *Padina boergesenii*, *Sargassum wightii* and *Ulva fasciata* were collected from Mandapam Coast, Rameshwaram District, Tamil Nadu, India. After the sampling, the seaweeds were immediately washed several times with clean water in order to remove non-algal materials and it was sun dried for and stored in container for further use.

Preparation of consortium of seaweed liquid fertilizer (SLF)

The seaweed liquid fertilizer was prepared by the method of Rama Rao (1990). The coarse powder of all the three seaweeds (separately) was mixed with distilled water in the ratio of 1: 20 (W/V) and the mixture was autoclaved at 121^0C (20 lbs) for 20 minutes. Then, the mixture was filtered through cheese cloth and the filtrate was collected and the supernatant was centrifuged and dried on an oven at 60º C for 48 hours. The obtained filtrate was treated as 100% concentration. Now, the extract was made up into 100ml with distilled water (10%) (Ganapathy Selvam and Sivakumar, 2014). From this, different combination of seaweed extracts were mixed at various concentrations using distilled water in the following manner (Bhosle *et al*., 1975, John Peter Paul and Yuvaraj, 2014).

Collection of crop plants seeds

The crop plants seeds such as, Green gram (*Vigna radiate)*, Black gram (*Vigna mungo)*, Mustard (*Brassica juncea)* and Paddy (*Oryza sativa)* were obtained from local farmers. The uniform size, color and weight of the seeds were selected for seed germination and seedling growth study.

Effect of consortium of seaweed liquid fertilizer (SLF) on Seed germination

The crop plant seeds such as, Green gram, Black gram, Mustard and Paddy were individually soaked in different consortium of seaweed liquid fertilizer (SLF) at various concentrations (Distilled water was used for control) for 12hrs. After 12 hrs of soaking, incubation 25 numbers of (each seed) were placed in tissue paper with respective seaweed liquid fertilizer (SLF) coded including control. Under humid condition, the seed germination was occurred and the percentages of germination in all the four seeds were recorded (Muthezhilan *et al.*, 2012).

Effect of consortium of seaweed liquid fertilizer (SLF) on plant growth

For seedling growth promotion, all the crop plant seeds (such as, Green gram, Black gram, Mustard and Paddy) were individually soaked in different consortium of seaweed liquid fertilizer (SLF) at various concentrations (Distilled water was used for control) for 6 hours. After 6 hrs of soaking, six seeds (from all the treatments and control) were sowed in sterilized garden red soil (250 gm in plastic cup) and another six seeds were sowed in unsterilized garden red soil (250 gm in plastic cup) and labeled and the watering was done once in 2 days. After 15 days of sowing, the root and shoot length of the seedlings in all the control and experimental groups from both the soil treatments were recorded (Muthezhilan *et al.*, 2012). The relative increase was calculated by the following formula.

Seedling vigor = Shoot length + Root length X Germination percentage

RESULT AND DISCUSSIONS

The increasing agricultural practices need more fertilizers for higher yield to satisfy food for human beings. In general, there are many growth hormones, regulators and promoters available to enhance yield attributes. The developed countries utilized such growth hormones in cultivation of crops. . In general, seaweeds have a wide range of plant growth promoting harmones and responses induced by seaweed extracts implies the presence of more than one group of plant growth promoting substances or hormones (Wajahatullah,2009). Moreover, the large quantity of seaweeds has been utilized directly as manure or in the form of compost by coastal peoples in India (Thivy, 1958). The utilization of seaweeds and their extracts as a fertilizer in agriculture will be useful to achieve higher agricultural production in our country (Thirumarann *et al., 2009*). Furthermore, it is reported that, higher concentration of seaweed extracts can also inhibit the development of seedling roots. Some previous authors also stated that, dilute extracts are more effective than the concentrated ones (Bai *et al,* 2011; Kumar *et al,* 2012). In this study, the commercially available seaweeds such as, *Padina boergesenii*, *Sargassum wightii and Ulva fasciata* were collected from Mandapam Coast, Rameshwaram District, Tamil Nadu, India. A total of four different consortium of seaweed liquid fertilizers (SLF) were prepared at different concentrations to check their plant growth promoting ability in agriculturally important four different crop plants plants such as, Green gram (*Vigna radiate)*, Black gram (*Vigna mungo)*, Mustard (*Brassica juncea)* and Paddy (*Oryza sativa)*.

Whereas checking the seed germinating ability of all the consortium of three different Seaweed Liquid Fertilizers (SLF) in various concentrations, the 100% seed germination was founded in all the crop plants seeds soaked with the consortium of *Padina boergesenii*, *Sargassum wightii* and *Ulva fasciata* seaweed extracts at 2.5% concntration followed by *Padina boergesenii* and *Sargassum wightii* extracts respectively. Kalaivanan and Venkatesalu, 2012 observed, germination of black gram was inhibited by *Sargassum myriocystum* extracts in concentration

Table 1. Preparation of consortium of seaweed liquid fertilizer (SLF)

Combination of different Seaweed Extracts	Percentage of Concentration	Extract (ml) Distilled	Water (ml)
Control	-	-	100
Padina boergesenii + Sargassum wightii	1%	20	80
	1.5%	30	70
	2%	40	60
Sargassum wightii + Ulva fasciata	1%	20	80
	1.5%	30	70
	2%	40	60
Ulva fasciata + Padina boergesenii	1%	20	80
	1.5%	30	70
	2%	40	60
Padina boergesenii + Sargassum wightii + Ulva fasciata	0.3%	9	91
	0.5%	15	85
	0.7%	21	79

Table 2. Seed germination and plant growth promoting effect of consortium of different three seaweeds on black gram in unsterilized and sterilized soil conditions

Treatments	Plant growth at different concentration							
	Unsterilized soil				Sterilized soil			
	Shoot length (cm)	Root length (cm)	Seedling Vigor	Seed germination	Shoot length (cm)	Root length (cm)	Seedling vigor	Seed germination
Control	20.83±0.76	7.03±0.15	2479	86	19.52±0.16	6.01±0.11	2271	86
S1 +S2 (1%)	31.53±0.64	12.73±0.37	4636	100	30.33±0.64	11.53±0.37	3636	100
S2 + S3 (1%)	28.63±0.64	11±0.52	3863	89	27.53±0.64	10±0.52	2863	89
S3 + S1 (1%)	28.73±0.64	12±0.52	3873	88	27.63±0.64	11±0.52	3473	88
S1 +S2 + S3 (0.3%)	32.73±0.64	13.63±0.37	4726	100	31.63±0.64	12.63±0.37	3726	100
S1 +S2 (1.5%)	30.73±0.64	10.75±0.52	3773	100	29.43±0.64	9.85±0.52	3673	100
S2 + S3 (1.5%)	29.63±0.64	10.63±0.52	3763	89	28.63±0.64	9.73±0.52	3663	89
S3 + S1 (1.5%)	27.53±0.64	10.53±0.37	4436	88	27.54±0.64	9.63±0.37	4336	88
S1 +S2 + S3 (0.5%)	31.73±0.64	12.63±0.37	4526	100	30.63±0.64	11.63±0.37	4426	100
S1 +S2 (2%)	30.73±0.64	13±0.52	3973	100	28.33±0.64	8.95±0.52	3583	100
S2 + S3 (2%)	29.63±0.64	12±0.52	3963	87	27.83±0.64	8.53±0.52	3553	87
S3 + S1 (2%)	28.53±0.64	11.73±0.37	4536	87	26.34±0.64	7.43±0.37	4226	87
S1 +S2 + S3 (0.7%)	33.73±0.64	13.63±0.37	4926	100	29.53±0.64	10.33±0.37	4316	100

Table 3. Seed germination and plant growth promoting effect of consortium of different three seaweeds on black gram in unsterilized and sterilized soil conditions

Treatments	Plant growth at different concentration							
	Unsterilized soil				Sterilized soil			
	Shoot length (cm)	Root length (cm)	Seedling Vigor	Seed germination	Shoot length (cm)	Root length (cm)	Seedling vigor	Seed germination
Control	24.7±0.60	5.1±0.1	2622	98	21.9±0.42	4.8±0.7	2531	98
S1 +S2 (1%)	31.36±0.45	8.16±0.20	3972	100	30.36±0.45	7.16±0.20	3372	100
S2 + S3 (1%)	27.8±0.26	6.5±0.2	3340	99	26.8±0.26	5.5±0.2	3440	99
S3 + S1 (1%)	29.5±0.26	7.5±0.2	3430	100	28.5±0.26	6.5±0.2	3530	100
S1 +S2 + S3 (0.3%)	33.46±0.45	9.26±0.20	3992	100	32.46±0.45	8.26±0.20	3892	100
S1 +S2 (1.5%)	27.5±0.26	5.5±0.2	3330	98	28.6±0.26	4.4±0.2	3230	98
S2 + S3 (1.5%)	26.8±0.26	5.5±0.2	3340	100	25.8±0.26	3.3±0.2	3210	100
S3 + S1 (1.5%)	30.36±0.45	7.16±0.20	3872	99	27.26±0.45	6.15±0.20	3462	99
S1 +S2 + S3 (0.5%)	31.46±0.45	7.26±0.20	3952	100	30.36±0.45	6.23±0.20	3852	100
S1 +S2 (2%)	30.5±0.26	9.5±0.2	3630	100	27.5±0.26	3.4±0.2	3120	100
S2 + S3 (2%)	29.82±0.26	7.55±0.2	3540	98	24.8±0.26	2.3±0.2	3110	98
S3 + S1 (2%)	29.36±0.45	7.16±0.20	3472	98	26.46±0.45	5.15±0.20	3052	98
S1 +S2 + S3 (0.7%)	34.46±0.45	10.46±0.20	4392	100	29.26±0.45	5.23±0.20	3762	100

Table 4. Seed germination and plant growth promoting effect of consortium of different three seaweeds on mustard in unsterilized and sterilized soil conditions

Treatments	Plant growth at different concentration							
	Unsterilized soil				Sterilized soil			
	Shoot length (cm)	Root length (cm)	Seedling Vigor	Seed germination	Shoot length (cm)	Root length (cm)	Seedling vigor	Seed germination
Control	9.11±0.09	3.28±0.22	1168	96	10.18±0.07	4.26±0.20	1270	96
S1 +S2 (1%)	13.96±0.20	9.1±0.2	2306	100	12.86±0.20	8.1±0.2	2106	100
S2 + S3 (1%)	12.63±0.15	7.9±0.1	2253	99	11.53±0.15	6.9±0.1	2153	99
S3 + S1 (1%)	12.63±0.15	7.9±0.1	2353	96	11.63±0.15	6.9±0.1	2253	96
S1 +S2 + S3 (0.3%)	14.96±0.20	10.1±0.2	2426	100	13.96±0.20	9.1±0.2	2326	100
S1 +S2 (1.5%)	11.63±0.15	6.9±0.1	2053	100	9.63±0.15	5.9±0.1	2153	100
S2 + S3 (1.5%)	11.63±0.15	6.9±0.1	2053	98	9.53±0.15	5.9±0.1	2053	98
S3 + S1 (1.5%)	12.96±0.20	8.1±0.2	2206	96	10.66±0.20	7.1±0.2	2016	96
S1 +S2 + S3 (0.5%)	12.96±0.20	8.1±0.2	2226	100	10.76±0.20	7.1±0.2	2186	100
S1 +S2 (2%)	12.73±0.15	9.9±0.1	2363	100	8.83±0.15	4.7±0.1	2053	100
S2 + S3 (2%)	12.63±0.15	8.7±0.1	2273	97	8.53±0.15	4.8±0.1	2043	97
S3 + S1 (2%)	11.96±0.20	7.8±0.2	2176	98	9.96±0.20	6.5±0.2	2016	98
S1 +S2 + S3 (0.7%)	15.96±0.20	11.2±0.2	2536	100	19.86±0.20	6.2±0.2	2086	100

Table 5. Seed germination and plant growth promoting effect of consortium of different three seaweeds on paddy in unsterilized and sterilized soil conditions

Treatments	Plant growth at different concentration							
	Unsterilized soil				Sterilized soil			
	Shoot length (cm)	Root length (cm)	Seedling Vigor	Seed germination	Shoot length (cm)	Root length (cm)	Seedling vigor	Seed germination
Control	10±0.7	8.1±0.1	1629	94	10.2±0.72	8.93±0.11	1721	94
S1 +S2 (1%)	13.36±0.15	12.33±0.30	2379	100	10.36±0.15	11.13±0.30	2179	100
S2 + S3 (1%)	12.26±0.15	11.1±0.1	2546	98	11.26±0.15	10±0.1	2246	98
S3 + S1 (1%)	11.26±0.15	11.1±0.1	2436	94	10.26±0.15	10.1±0.1	2336	94
S1 +S2 + S3 (0.3%)	14.36±0.15	13.43±0.30	2679	100	13.36±0.15	12.23±0.30	2579	100
S1 +S2 (1.5%)	12.26±0.15	10.1±0.1	2236	100	10.26±0.15	9.11±0.1	2236	100
S2 + S3 (1.5%)	11.26±0.15	10.1±0.1	2246	97	10.16±0.15	9.1±0.1	2246	97
S3 + S1 (1.5%)	12.36±0.15	10.33±0.30	2379	93	9.76±0.15	9.33±0.30	2379	93
S1 +S2 + S3 (0.5%)	13.36±0.15	11.43±0.30	2479	100	11.26±0.15	12.33±0.30	2479	100
S1 +S2 (2%)	13.48±0.15	13.1±0.1	2746	100	9.26±0.15	8.1±0.1	2176	100
S2 + S3 (2%)	13.36±0.15	12.21±0.1	2636	97	9.16±0.15	8.1±0.1	2156	97
S3 + S1 (2%)	12.36±0.15	11.33±0.30	2489	93	8.56±0.15	8.23±0.30	2269	93
S1 +S2 + S3 (0.7%)	15.36±0.15	14.43±0.30	2798	100	10.36±0.15	11.43±0.30	2359	100

more than 10%. Kalaivanan et al., 2012, also observed that, the lower concentration of SLF of *Caulerpa scalpelliformis* (25%) enhanced the percentage of germination, shoot length, root length and biochemical constituents such as amino acids, reducing sugars, total sugar contents, and amylase activities of shoot and root. Kumar *et al,* 2012, reported that, in their studies the seeds soaked in 0.5 and 1% of *Sargassum wightii* hot water extract (1 : 20 w/v) showed faster germination in compare with seeds that were soaked at higher concentration (2%) . In general, the value of seaweeds as fertilizer is not from mineral contents but from their trace elements and the metabolites similar to cytokinin, auxin, gibberellins and other related growth hormones. Therefore, the beneficial effect of consortium of seaweed extracts on seed germination and growth of plants may be due to the presence of plant growth promoting substances or hormones present in the seaweed extracts (Blunden *et al*., 2010; Anisimov *et al*., 2013).

Erulan *et al*., 2009 also have suggested that, the seaweed liquid fertilizer (SLF) at low concentrations will enhance the some plant growth parameters such as, shoot length, root length, leaf area, fresh weight, dry weight and moisture content. So, in this study, different consortium of Seaweed Liquid Fertilizers (SLF) was prepared using three different seaweeds at different lower concentrations. Whereas analyzing plant growth promoting effect of all the four different consortium of seaweed liquid fertilizer (SLF) at different concentration in both sterilized and unsterilized soil, after 15 days of sowing, the shoot and root length of all the four crop plants from all the experimental and control groups were measured and from which the seedling vigor was determined. The maximum shoot length ((Green gram 33.73±0.64), (Black gram 34.46±0.45), (Mustard 15.96±0.20) and (Paddy 15.36±0.15)) and root length (Green gram 13.63±0.37), (Black gram 10.46±0.20), (Mustard 11.2±0.2) and (Paddy 14.43±0.30) was found high in the plants treated with the consortium of *Padina boergesenii, Sargassum wightii* and *Ulva fasciata* at 0.7% (21ml of seaweed extracts and 71ml of distilled water) concentration followed by consortium of *Padina boergesenii*, and *Sargassum wightii* at 1% (20ml of seaweed extracts and 80ml of distilled water) in unsterilized soil (Table 1-4). Similar results were reported by Jothinayagi and Anbazhagan (2009) who studied the effect of *Sargassum wightii* on the growth of *Abelmoschus esculentus* and concluded that 20% SLF of *Sargassum wightii* is more effective than the control and 100% SLF of *Sargassum wightii*. Moreover, Thirumaran *et al*. (2009a) also reported that the SLF treatment of *Sargassum wightii* increased total chlorophyll and carotenoids content of both the test plants at lower concentration (20%) of SLF with or without chemical fertilizer. Kalidass *et al*., 2010 also stated that, the different concentrations of liquid extract of *Ulva lacuta, Caulerpa scalpelliformis, Padina tetrastromatica* and *Sargassum linearifolium* increased the amount of protein, carbohydrate and aminoacid of *Brassica nigra*. The results of the present study was clearly demonstrated the plant growth promoting effect of consortium of seaweed liquid fertilizer (SLF) and suggested to use this consortium in agriculture to enhance the crop production in ecofriendly manner.

REFERENCES

1. Anisimov M.M, E.L. Chaikina , A.G. Klykov , V.A. Rasskazov., Effect of Seaweeds Extracts on the Growth of Seedling Roots of Buckwheat (Fagopyrum esculentum Moench) is depended on the Season of Algae Collection Agriculture Science Developments, 2013; **2**(8): 67-75 2306-7527
2. Arnon DI. Copper enzymes in isolated chloroplasts, polyphenol oxidase in Beta vulgaris. *Plant Physiol*., 1949; **2**:1-15
3. Balakrishnan C, Venkataraman Kumar P, Mohan VR. Studies on the effect of crude seaweed extract on seedling growth and biochemical parameters in Peninsetum typhoides (Burn. F.) Stapf C.E. Hubbard. Seaweed Res Utiln 2007; **29**(1&2): 89-96.
4. Blunden, G., P. F. Morse., I. Mathe., J. Hohmann., A. T. Critchley., S. Morrell., Betaine yields from marine algal species utilized in the preparation of seaweed extracts used in agriculture. *Nat. Prod. Commun*. 2010; **5**: 581 – 585
5. Bhosle, N.B., A.G. Untawale and V.K. Dhargalkar., Effects of seaweed extract on the growth of Phaseolus vulgaris L. *Indian Journal of Marine Science*, 1975; **4**: 208-210.
6. Deshwal, V.K., Reena, Sharma, P., Gupta, S., Chakraborty, M. and Chatterji, T. Phosphorous

Solubilizing *Pseudomonas Aeruginosa* PMV-14 Enhance Productivity in Rice Crop. *Int. J. Appl. Agri. Res*. 2011d; **6**(1): 29-33.

7. Dhargalkar VK, N. Pereira., Seaweed: promising plant of the millennium. *Science*; 2005; **71**(3-4): 60-66.
8. Erulan, V. S. P., Thirumaran, G. and Ananthan, G.., Studies on the effect of Sargassum polycystum extract on the growth and biochemical composition of Cajanus cajan L. *J. Agri. Environ. Sci*. 2009; **6**: 392-399.
9. Ganapathy Selvam.G, K. Sivakumar *et al.*, Influence of seaweed extract as an organic fertilizer on the growth and yield of Arachis hypogea L. and their elemental composition using SEM– Energy Dispersive Spectroscopic analysis . *Asian Pacific Journal of Reproduction* 2014; 18-22.
10. Ganapathy Selvam G, M. Balamurugan ,T. Thinakaran, K. Sivakumar., Developmental changes in the germination, growth and chlorophyllase activity of Vigna mungo L. using seaweed extract of Ulva reticulata Forsskal. *Intn Res J Pharm*; 2013; **4**(1): 252-254.
11. Peter Paul J and Yuvaraj, P.. Effect of Seaweed Liquid Fertilizer of Colpomenia sinuosa (Mert. ex Roth) Derbes & Solier (Brown Seaweed) on Vigna radiata (L.) R. Wilczek. In Koothankuzhi, Tirunelveli district, Tamil Nadu, *India. Int. J. Pure App. Biosci.* 2014; **2**(3): 177-184.
12. Jothinayagi N and C.Anbazhagan., Effect of Seaweed Liquid Fertilizer of Sargassum wightii on the growth and biochemical characteristics of Abelmoschus esculentus (L.) Medikus. *Recent Research in Science and Technology*, 2009; **1**(4):155-158.
13. Jeswani K D., We want to provide farmers updated technology in the field of agriculture, chem. *Eng world* 1999; **34**: 23-25
14. Mai, M.A.B., Shamsuddin, Z.H., Wahab, Z. and Marziah, M., Effect of plant growth and nitrogen incorporation of tissue-cultured Musa plantlets under nitrogen free hydroponics condition. *Aus. J. Crop Sci.* 2010; **4**(2): 85-90.
15. Muthezhilan, R.; Sindhuja, B.S.; Jaffar Hussain, A. and Jayaprakashvel, M., Efficacy of Plant Growth Promoting Rhizobacteria Isolated From Sand Dunes of Chennai Coastal Area. *Pakistan Journal of Biological Sciences* 2012; **15:** 795-799.
16. Kalidass C, S. Jayarani and M. Glory., Effect of seaweed liquid fertilizers on growth and biochemical constituents of Brassica nigra (L.). *Int J Agric Environ Biol*., 2010; **3**: 307-311
17. Rama Rao, K., Preparation, Properties and use of liquid seaweed fertilizer from Sargassum. Workshop on Algal Products, Seaweed Research and Utilisation Association, 1990; 7-8.
18. Tay, A. A. B., Palni, L. M. S. and Mac Lead, J. K., Identification of cytokinin glusides in a seaweed extracts. *J. Plant Growth Regul*. 1987; **5**: 133.
19. Thirumaran G,M. Arumugam ,R. Arumugam and P.Anantharaman., Effect of Seaweed Liquid Fertilizer on growth and pigment concentration of Cyamopsis tetrogonolaba (L). *Taub. Am. Euras J Agron.*, 2009; **2**(2):50 -56
20. Thivy, F., Ecnomic seaweeds. Int. fisheries of West coast of India. (S. Jones, Editor), 1958; 1-8.
21. Wajahatullah Khan P.Usha, Rayirath Sowmyalakshmi Subramanian N.Mundaya, Jithesh D.Prasanth Rayorath, T. Mark Hodges Alan, S. Critchley James, S. Craigie Jeff Norrie J.Balakrishan Prithiviraj ., *Plant Growth Regul* 2009; **28**: 386–399.
22. ST Zodape Seaweed as a biofertilizer journal of scientific and industrial research vol 60, may 2001; 378- 382.
23. Zodape, S.T., V. J. Kawarkhe., J. S. Patolia., A. D. Warade., Effect of liquid seaweed fertilizer on yield and quality of okra (Abelmoschus esculentus L.). *J. Sci. Ind. Res*. 2008; **67**: 1115 – 1117
24. Kumar, N.A., B. Vanlalzarzova., S. Sridhar., M. Baluswami., Effect of liquid seaweed fertilizer of Sargassum wightii Grev. on the growth and biochemical content of green gram (Vigna radiata (L.) R. Wilczek). *Rec. Res. Sci. Technol.* 2012; **4**: 40 – 45.
25. Bai, N. R., R. M. Christi., T. C. Kala., Effect of seaweed concentrate of Padina pavonia on the growth and yield of a pulse crop. *Plant Archives.* 2011; **11**: 117 – 120.
26. Kalaivanan, C., V. Venkatesalu., Utilization of seaweed Sargassum myriocystum extracts as a stimulant on seedlings of Vigna mundo (L.) Hepper. *Spanish J. Agric. Res.* 2012; **10**: 466 – 470.
27. Pereira, N and Verlecar, X.N., Role of marine algae in organic farming. *Current Science*, 2005; **89**: 593-594.
28. Camargo, J.A.; Alonso, A. Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment .Environment International, 2006; **32**: 831-849.
29. Sahoo D., Farming the Ocean: seaweeds cultivation and utilization. Aravali Books International, New Delhi, India. 2000; XI±44.