The Bioscan 9(4): 1535-1539, 2014
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

IMPACT OF NATURAL ORGANIC FERTILIZER (SEAWEED SAPS) ON PRODUCTIVITY AND NUTRIENT STATUS OF BLACKGRAM (*PHASEOLUS MUNGO* L.)

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KEYWORDS
Seaweed saps
Kappaphycus
Gracilaria
Blackgram yield
Nutrient uptake

Received on :
16.04.2014

Accepted on :
24.10.2014

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ABSTRACT
A field experiment was conducted during the *Kharif* season of 2013 at Research Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) to study the effects of seaweed saps on growth, yield, nutrient uptake and economic of Blackgram in *Vertisol* of Chhattisgarh. The foliar spray was applied twice at different concentrations (0, 2.5, 5.0, 7.5, 10 and 15% v/v) of seaweed extracts (namely *Kappaphycus* and *Gracilaria*). Foliar applications of seaweed extract significantly enhanced the growth, yield, nutrient uptake and B:C ratio parameters. The highest grain yield was recorded with applications of 15% *Kappaphycus* sap + recommended dose of fertilizer (RDF), followed by 15% *Gracilaria* sap + RDF extract resulting in an increase by 49.2% and 37.8% grain yield, respectively compared to the control (Water spray + RDF). The highest nutrient uptake [nitrogen (N), posphorus (P) and potassium (K)] by crop were observed under 15% K Sap + RDF. The highest net return ('25,244 ha^{-1}) and B: C ratio (1.27) were observed with the application of 15% *Kappaphycus* sap + recommended dose of fertilizer RDF.

INTRODUCTION

Seaweed extract is a new generation of natural organic fertilizers containing highly effective nutritious and promotes faster germination of seeds and increase yield and resistant ability of many crops. Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, nonpolluting and non-hazrdous to humans, animals and birds (Dhargalkar and Pereira, 2005). Liquid seaweed fertilizer is a unique combination of N, P, K, trace elements, alginates and simple sugars that are in dissolved form. These are easily absorbed through roots and leaves, besides releasing trace elements bound to the soil (Chapman and Chapman, 1980; Thivey, 1982). Seen and Skelton, (1969) showed in their experiments that use of seaweed liquid fertilizers on seeds of cereals, crops and vegetables was found to increase the germination capacity. Commercial use of concentrated seaweed extracts as foliar spray, in seed treatments and root dips have increased far more rapidly than use of seaweed meals a soil additive (Metting *et al.*, 1990). Now days, application of biostimulants has become an alternative approach to minimize the use of chemical fertilizers. Seaweeds are the macroscopic marine algae found attached to the bottom in relatively shallow coastal waters. They grow in the intertidal, shallow and deep sea areas up to 180 meter depth and also in estuaries and backwaters on the solid substrate such as rocks, dead corals and pebbles (Thirumaran *et al.*, 2009). Seaweed liquid extract (SLE) which contains macro nutrients, trace elements, organic substances like amino acids and plant growth regulators such as auxin, cytokinin and gibberellins are applied to improve nutritional status, vegetative growth, yield and fruit quality in some plants (Eman *et al.*, 2008; Spinelli *et al.*, 2009). The recent challenge in sustainable food production is due to the increasing occurrence of biotic and abiotic stress as due to climate change, which may lead to reduction of agricultural productivity globally. Under this situation SLF may work as a good inducer for sustainability in agricultural production coupled with maintenance of soil health. In India seaweeds are not used extensively except for production of phycocolloids. But being a rich source of vitamins, minerals and growth promoters, they can be of immense help to the coastal farmers for their use as a source of organic fertilizer. Hence there is a need for popularizing the use of seaweed as health food and liquid organic fertilizer through mass scale field trials and organization of public awareness programmes (Mohanty *et al.*, 2013)

Pulses are the world's major source of plant protein. The productivity of blackgram is declined due to inadequate plant stand, heavy flower drop and immature pod abscission leading to poor seed setting besides unfavorable environment, water and nutrient deficiencies at critical periods. Therefore, the solution to increase the productivity is to develop a method by which improve vegetative growth, flowering and pod filling could be maintained. Biological inputs through seed and foliar nutrition are ideal for improving crop yield and environmentally safe. It is also gaining more attention in recent past years because of its biosafety nature. Hence, it is important to find out the organic sources for seed and foliar treatments, for effective maintenance of vigour and viability. Hence objective of this study was to exploit uses of *Kappaphycus* sap *and Gracilaria* sap in agriculture and as a source of biofertilizer was chosen for crops grown extensively throughout India. Therefore, the objective has been taken towards the balancing nutrients requirement for the optimum productivity of blackgram crop by foliar application of sea weeds sap to enhance growth, yield and nutrient uptake of blackgram.

MATERIALS AND METHODS

Field experiment was carried out during *Kharif* season of 2013 at Research Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). Weekly average meteorological data during the span of experimentation, recorded at meteorological observatory, IGKV, Raipur. The total rainfall of 1206 mm was received during *kharif* season. The maximum temperature ranged in crop seasons was 27.9ºC to 34.4ºC and minimum temperatures during the same season was 23.8ºC to 25.8ºC. The Sun shines hours and wind velocity ranged from 0.7 to 6.2 hr day^{-1} and 2 to 11.8 km hr^{-1}. The Relative humidity throughout the crop season varied between 67 to 95 %. The open pan evaporation mean value ranged from 2.1 to 6.2 mm day^{-1} and the vapour pressure (mm) was recorded between the ranges 21 to 24.6 mm. The experiment comprised of ten treatments, the details of treatments are mentioned in Table 1. Two sprays of *Kappaphycus* and *Gracilaria* extract were applied at different growth stages (30 and 50 DAS) through knapsack sprayer. Spraying of sea weed sap was done in the field as per the treatment. The quantity of water used was 500 liter ha^{-1} with adjuvant. The soil of experiment field was *'Inceptisols'* (sandy loam) which is locally known as *'Matasi'* with pH 7.2, EC 0.35 dsm^{-1}, Organic carbon 0.55%, Available N 263 kg ha^{-1}, P 12.5 kg ha^{-1} and K 338 kg ha^{-1}. The recommended nutrient dose of N, P_2O_5, K_2O and S was applied @ 20:40:20:15 Kg/ha for the blackgram crop. Full dose of nitrogen, phosphorus, potassium and sulphur were applied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively as basal at the time of sowing. The sulphur content available in SSP, provide recommended dose of sulphur through their application. The observations, for growth, yield and yield attributing character were recorded as per the standard method from each plot of each replication separately. Soil and plant samples were drawn from the treated plots and analyzed. The analysis was done by micro kjeldahl, Vanadomolybdophosphoric yellow colour and flame photometric methods for nitrogen, phosphorus and potassium, respectively. The uptake of Nitrogen (N), Phosphorus (P) and Potassium (K) by blackgram crop was computed on the basis of dry matter accumulation and expressed as kg ha^{-1}. During the season, field experiment was laid out in randomized block design (RBD) replicated thrice to evaluate the effect of a seaweed sap product (provided by CSIR-CSMCRI, Bhavnagar Gujarat and chemical composition of the seaweed was given in Table 2 and 3). The data was analyzed by the method of analysis of variance as described by Gomez and Gomez (1984). The level of significance used in "F" test was given at 5%. Both experiments consisted of eight treatments (Table 1).

Table 1: Treatment details

Different doses of spray	Spray interval (days after sowing)
T_1: 2.5% K Sap + RDF	30 and 50 DAS
T_2: 5.0% K Sap + RDF	30 and 50 DAS
T_3: 10.0% K Sap + RDF	30 and 50 DAS
T_4: 15.0% K Sap + RDF	30 and 50 DAS
T_5: 2.5% G Sap + RDF	30 and 50 DAS
T_6: 5.0% G Sap + RDF	30 and 50 DAS
T_7: 10.0% G Sap + RDF	30 and 50 DAS
T_8: 15.0% G Sap + RDF	30 and 50 DAS
T_9: Water Spray+ RDF	30 and 50 DAS
T_{10}: 7.5 % K SAP+50% RDF	30 and 50 DAS

handpicked from the coastal area of Rameswaram, T. N., India during September, 2011. It was washed with seawater to remove unwanted impurities and transported to the field station at Mandapum, Rameswaram. Here, samples were thoroughly washed using tap water. After that, fresh seaweed samples were homogenized by grinder with stainless steel blades at ambient temperature, filtered and stored (Eswaran *et al.*, 2005). The liquid filtrate was taken as 100% concentration of the seaweed extract and further diluted as per the treatments. The nitrogen (N) content of seaweed extract (100% concentrate) was determined by taking 20 ml of filtrate which was oxidized and decomposed by concentrate sulphuric acid (10 ml) with digestion mixture (K_2SO_4 : $CuSO_4$ = 5:1) heated at 400°C temperature for 2½ h as described in the semi-micro Kjeldahl method [AOAC International, 1995, method No. Ba 4b-87(90)], and other nutrient elements were analyzed by inductively coupled plasma-optical emission spectroscopy (ICP-OES), after wet digestion of filtrate (20 ml) with HNO_3-$HClO_4$ (10:4) di-acid mixture (20 ml) and heated at 100°C for 1 hour and then raise the temperature to about 150°C (Richards, 1954).

Table 2: *Chemical composition of Kappaphycus* sap.

Nutrient	Amount present	Nutrient	Amount present
MoistureProtein	94.38 g/100 mL0.085 g/100 mL	IronManganese	8.58 mg/100 mL0.22 mg/100 mL
FatCrude fibre	0.0024 g/100 ml0.01 g/100 mL	NickelCopper	0.35 mg/100 ml0.077 mg/100 mL
CarbohydrateEnergy	1.800 g/100 mL7.54 Kcal/100 mL	ZincChromium	0.474 mg/100 mL3.50 mg/100 mL
SodiumPotassiumMagnesium	18.10 mg/100 mL358.35 mg/100 mL116.79 mg/100 mL	LeadThiamineRiboflavin	0.51 mg/100mL0.023 mg/100 ml0.010 mg/100 mL
PhosphorousCalcium	2.96 mg/100 mL32.49 mg/100 mL	B-CaroteneIodine	0.0 mg/100 mL160 mg/100 mL
Indole acetic acidGibberelin GA	23.36 mg/L27.87 mg/L	Kinetin + Zeatin	31.91 mg/L

Data courtesy: National Institute of Nutrition, Hyderabad, India (except growth hormone data generated by CSMCRI using quantitative MS-MS and LC-MS techniques)

Table 3: Chemical composition of *Gracilaria* sap

Nutrient	Amount present	Nutrient	Amount present
AshCrude protein	38.91 g/100 g9.58 g/100 g	CalciumCopper	295.50 mg/100 g0.20 mg/100 g
Crude fibreCrude lipid	10.40 g/100 g2.00 g/100 g	ZincIron	1.00 mg/100 g67.35 mg/100 g
Saturated fatty acidTotal amino acids	48.92% of total fatty acids 889.78 mg/g of protein	ManganeseNickel	4.16 mg/100 g0.92 mg/100 g
MoistureVitamin CCarbohydrate	88.88%28.50 mg/100 g45.92%	CobaltSulphateChlorine	0.24 mg/100g106.20 mg/100 g1170.00 mg/100g
PotassiumMagnesium Phosphorus	8633.00 mg/100 g549.50 mg/100 g 278.50 mg/100 g	LeadCadmium Sodium	1.11 mg/100 g0.14 mg/100 g 158.50 mg/100 g

Source: (Benjama and Masniyom, 2012). *Gracilaria* extract also contains variable amount of phytohormones like Auxin, Cytokinin, Abscisic acid etc. (Yokoya *et al.*, 2010)

Table 4: Effect of seaweed sap on growth, yield attributes, yield and economics of blackgram crop

Treatment	Plant height (cm)	Dry matter accumulation (g) plant^{-1}	No. branches plant^{-1}	Pods plant^{-1} (No.)	Seeds pod^{-1} (No.)	Seeds plant^{-1} (No.)	100 – seed weight (g)	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)	Net Return (' ha^{-1})	B:C ratio
T_1: 2.5% K Sap + RDF	63.63	13.99	3.13	27.1	6.00	153.40	4.20	7.92	17.48	31.18	18128	1.03
T_2: 5% K Sap + RDF	64.81	14.52	3.20	28.5	6.20	162.67	4.23	8.54	18.04	32.11	20083	1.09
T_3: 10% K Sap + RDF	67.40	15.47	3.40	31.3	6.53	168.60	4.26	8.89	18.77	32.17	20920	1.09
T_4: 15% K Sap + RDF	70.88	17.09	3.80	34.3	6.87	196.07	4.32	10.03	20.33	33.01	25244	1.27
T_5: 2.5% G Sap + RDF	63.43	13.25	2.93	26.0	5.80	150.87	4.20	7.86	17.75	30.69	17897	1.01
T_6: 5% G Sap + RDF	65.87	14.03	3.13	28.1	6.13	160.33	4.21	8.28	18.01	31.50	18985	1.03
T_7: 10% G Sap + RDF	67.01	14.89	3.33	28.6	6.40	166.60	4.23	8:72	18.19	32.40	20124	1.05
T_8: 15% G Sap + RDF	68.36	16.49	3.67	32.3	6.67	182.00	4.27	9.26	19.00	32.79	21812	1.09
T_9: Water Spray + RDF	60.51	12.84	2.87	25.7	5.27	135.27	4.15	6.72	16.87	28.51	13645	0.81
T_{10}: 7.5 % K SAP + 50% RDF	63.07	13.21	2.67	26.8	5.73	149.13	4.16	7.13	17.16	29.41	15635	0.93
SEm±	0.84	0.36	0.11	0.85	0.25	3.88	0.03	0.25	0.44	0.86	-	-
CD (P=0.05)	2.52	1.09	0.32	2.54	0.75	11.53	NS	0.75	1.33	2.56	-	-

Table 5: Effect of seaweed sap on available nutrient and nutrient uptake of blackgram crop

Treatment	Available N kg ha^{-1}	Available P kg ha^{-1}	Available K kg ha^{-1}	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake(kg ha^{-1})		
				Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
T_1: 2.5% K Sap + RDF	133.8	20.31	422.2	25.80	14.01	39.81	2.56	0.99	3.55	7.82	15.74	23.56
T_2: 5% K Sap + RDF	148.4	22.70	534.2	28.53	15.07	43.60	2.83	1.44	4.27	9.11	16.71	25.82
T_3: 10% K Sap + RDF	152.6	23.89	484.2	30.08	16.10	46.18	3.20	1.88	5.08	9.60	18.82	28.41
T_4: 15% K Sap + RDF	156.8	21.21	442.0	34.56	18.42	52.98	4.38	2.23	6.61	11.82	22.56	34.38
T_5: 2.5% G Sap + RDF	131.7	24.79	427.5	28.35	14.04	42.39	3.17	0.89	4.06	8.72	17.22	25.94
T_6: 5% G Sap + RDF	144.3	25.09	441.7	28.36	14.64	43.01	3.25	1.08	4.32	9.07	17.34	26.41
T_7: 10% G Sap + RDF	138.0	20.01	587.3	28.85	15.10	43.95	3.51	1.58	5.09	9.26	18.13	27.39
T_8: 15% G Sap + RDF	145.3	22.40	420.7	30.87	16.61	47.48	3.84	2.09	5.93	10.33	19.82	30.15
T_9: Water Spray + RDF	128.8	19.11	498.0	21.97	13.15	35.11	2.15	1.01	3.16	6.48	15.15	21.62
T_{10}: 7.5 % K SAP + 50% RDF	139.0	18.82	487.9	21.57	12.27	33.84	1.83	0.58	2.41	6.71	14.40	21.11
SEm±	12.02	4.77	41.77	0.69	0.37	0.73	0.21	0.17	0.21	0.37	0.84	0.90
CD (P=0.05)	NS	NS	NS	2.07	1.12	2.18	0.62	0.50	0.62	1.10	2.51	2.69

RESULTS AND DISCUSSION

Growth and yield attributes of blackgram crop

Different concentration of seaweed extract along with recommended dose of fertilizer showed the significant effect on growth and yield attributes *viz.* plant height (cm), dry matter accumulation (g) plant^{-1}, no. of branches plant^{-1}, pods plant^{-1}, seeds pod^{-1} and seeds plant^{-1} which is embodied in Table 4. Data recorded, on plant height (cm), dry matter accumulation (g plant^{-1}), no. of branches (plant^{-1}) and pods plant^{-1} were significantly higher i.e. 70.88 cm, 17.09 g, 3.8 and 34.3, respectively under foliar spray of 15% K Sap + RDF (T_4) then others treatments, however, it was at par with foliar spray of 15% G Sap + RDF (T_8). Seeds pod^{-1} and seeds plant^{-1} were also found significantly higher under foliar spray of 15% K Sap + RDF (T_4) which was found at par with foliar spray of 5% K Sap + RDF (T_2), 10% K Sap + RDF (T_3), 5% G Sap + RDF (T_6), 10% G Sap + RDF (T_7) and 15% G Sap + RDF (T_8) in case of seeds pod^{-1}. All above growth and yield attributing characters were found to be lowest under water spray + RDF (T_9). The foliar spray of seaweed sap during important growth stages of blackgram crop, increased their metabolic activity and it act as growth stimulant for healthy plant development. The increased growth and yield attributes may be due to the presence of some growth promoting substances such as IAA and IBA, gibberellins, cytokinins, micronutrients, vitamins and amino acids (Challen and Hemingway, 1966). Growth hormones like cytokinin and gibberellins have been detected in the extract of K. alvarezii which might be responsible for beneficial effects in the present study. Significant increase in seed yield of blackgram (Venkataraman and Mohan, 1997) and marketable bean by 24% has been reported with the foliar application of seaweed extract (Temple and Bomke, 1989).

Yield of blackgram crop

Seaweed sap of *kapaphycus spp.* and *gracilaria spp.* along with RDF showed the significant effect on yield, due to their application seed yield increase as per the increase dose of seaweed sap (Table 4). It was observed that application of foliar spray 15% K Sap + RDF (T_4) produced significantly higher yield (10.03 q ha^{-1}) as compare to other treatment. However, the data recorded for stover yield, foliar spray of 15% G Sap + RDF (T_8) was significantly at par with highest stover yield (20.33 q ha^{-1}) producing treatment i.e. foliar spray of 15% K Sap + RDF (T_4). As compare to treatment water spray + RDF (T_9), seaweed sap of *Kapphaphycus spp.* foliar spray treatment along with RDF i.e. 2.5% K Sap + RDF (T_1), 5% K Sap + RDF (T_2), 10% K Sap + RDF (T_3), 15% K Sap + RDF (T_4) and 7.5% K Sap + RDF (T_{10}) produced 17.85%, 27.02%, 32.26%, 49.29% and 6.07% more seed yield, respectively. However, seaweed sap of *gracilaria spp.* treatment along with RDF *i.e.* 2.5% G Sap + RDF (T_5), 5% G Sap + RDF (T_6), 10% G Sap + RDF (T_7) and 15% G Sap + RDF (T_8) also produced 16.96%, 23.23%, 29.71% and 37.87% more seed yield as compare with water spray + RDF (T_9), respectively. Growth hormones like cytokinin and gibberellins along with other trace element have been detected in the extract of *Kappaphycus spp.* and *Gracilaria spp.* which might be responsible for beneficial effects in the present study. Foliar application of aqueous extract of gives positive result on the growth and yield of pea and black gram (Ramamoorty *et al.,* 2006 a, Ramamoorty *et al.,* 2006 b and Ramamoorty and Sujata, 2007). Seaweed extracts not only increase the vegetative growth of the plant but it also triggers the early flowering, fruiting in crops and ultimately on seed yield. Zodape *et al.* (2011) also reported that foliar application of liquid extract of *Kappaphycus spp.* increse the yield tomato.

Nutrient status of soil after harvest of crop

Data pertaining to soil status after harvesting of crop was analysed and embodied in Table 5. The available nutrient in soil was non-significantly influenced due to seaweed sap foliar spray along with RDF. Application of recommended dose of fertilizer at basal provide sufficient nutrient for growth but after harvest of crop, nutrient status in soil showed non-significant result. Application of seaweed extract has been shown to enhance the moisture holding capacity of the soil as well nutrient status in soil (Mohanty *et al.*, 2013). Application of seaweeds and seaweed extract triggers the growth of beneficial microbes and secretion of soil conducting substances by these microbes. Due to their microbial substances and soil improvement ability it acts as soil conditioners for several important crops (Thirumaran *et al.,* 2006, Thirumaran *et al.*, 2009a and Thirumaran *et al.,* 2009b).

Nitrogen, phosphorus and potassium uptake of blackgram

The N, P and K uptake by blackgram were influenced significantly due to foliar application of seaweed sap along with RDF; nutrient uptake was increased with increasing doses of seaweed sap (Table 5). Statistically highest and significant amount of nitrogen uptake in seed, stover and total was observed under foliar spray of 15% K Sap + RDF (T_4). In seed, stover and total; phosphorus uptake of blackgram was observed highest under foliar application of 15% K Sap + RDF (T_4) but, it was at par with 10% K Sap + RDF (T_3) and 15% G Sap + RDF (T_8) in case of stover and treatment 15% G Sap + RDF (T_8) also found at par in case of seed. Potassium uptake in seed, stover and total was highest with foliar application of 15% K Sap + RDF (T_4). The lowest nitrogen, phosphorus and potassium uptake in case of seed, stover and total was recorded with 7.5 % K SAP+50% RDF (T_{10}), except in case of potassium uptake in seed. These results are closely similar with findings of Pramanick *et al.* (2013) who noted that the foliar application of seaweed sap improved the nutrient uptake capacity of crop. Presence of marine bioactive substance in seaweed sap improves stomata uptake efficiency in treated plants as compared to non treated ones (Mancuso *et al.,* 2006). The findings of Rathore *et al.* (2009) also confirmed that the foliar application of 15% (v/v) aqueous extracts prepared from fresh *Kappaphycus spp.* resulted in 57% increase of soybean yield compared to the control and intensified nutrient uptake by soybean crop.

Effect of Seaweed sap on economics of blackgram crop

Data related to economics was computed and embodied in Table 4. The cost of cultivation of blackgram varied from ' 16731 to ' 19926 ha^{-1} owing to the use of different levels of foliar spray of seaweed sap along with RDF and showed beneficial effect on monitory return of blackgram production. The application of foliar spray 15% K Sap + RDF (T_4) gave maximum net return (' 25244 ha^{-1}) and B:C ratio of 1.27 as compare with other treatments. However, application of 15% K Sap + RDF (T_4) gave ' 11599 ha^{-1} more net return than that of treatment where water spray + RDF (T_9) was applied. The foliar spray of 15% G Sap + RDF (T_8) also gave ' 8167 ha^{-1} more net return as compared to treatment of water spray + RDF (T_9). Application of seaweed extract enhanced the early growth and yield attribute properties in legume plants and yield return of 12-25% more than that of control (Sethi and Adhikary, 2008). At present, the use of natural seaweed products as substitutes to conventional inorganic fertilizers has gained importance. Seaweed fertilizers are better than other fertilizers and are very economical. Recent, research demonstrated that seaweed fertilizers can compete with other fertilizers and are very economical (Gandhiyappan and Perumal, 2001).

REFERENCES

AOAC International 1995. Official methods of analysis of AOAC international. In: Cunniff, P. (Ed.), Contaminants, Drugs, 16th ed. Agricultural Chemicals, vol. 1. AOAC International, Wilson Boulevard, Virginia, USA.

Benjama, O. and Masniyom, P. 2012. Biochemical composition and physicochemical properties of two red seaweeds (*Gracilaria fisheri* and *G. tenuistipitata*) from the Pattani Bay in Southern Thailand. *J. Sci. Technol.* **34(2):** 223-230.

Challen, S. B. and Hemingway, J. C. 1966. Growth of higher plants in response of feeding with seaweed extracts. *Proc. Fifth Int. Seaw. Symp.* pp. 359-367.

Chapman, V. J. and Chapman, D. J. 1980. Seaweeds and their uses. 3rd edition. Chapman and Hall, USA. p. 334

Dhargalkar, V. K. and Pereira, N. 2005. Seaweed: promising plant of the millennium. *Science and culture.* **71:** 60-66.

Eman, A., Abd El-Moniem and Abd-Allah, A. S. E. 2008. Effect of green algae cells extract as foliar spray on vegetative growth, yield and berries quality of superior grapevines. *Am. Euras. J. Agric. and Environ.*

Sci. **4(4):** 427-433.

Eswaran, K., Ghosh, P. K., Siddhanta, A. K., Patolia, J. S., Periyasamy, C., Mehta, A. S., Mody, K. H., Ramavat, B. K., Prasad. K., Rajyaguru, M. R., Reddy, S. K. C. R., Pandya, J. B. and Tewari, A. 2005. Integrated method for production of carrageenan and liquid fertilizer from fresh seaweeds. United States Patent no. 6893479.

Gandhiyappan, K. and Perumal, P. 2001. Growth promoting effect of seaweed liquid fertilizer (Enteromorpha intestinalis) on the sesame crop plant. *Seaweed Res. Utilization.* **23:** 23-25.

Gomez, K. A. and Gomez, A. A. 1984. Statistical procedures for Agricultural Research. A Willey - Interscience Publication, J. Willey and Sons, New York.

Mancuso, S., Azzarello, E., Mugnai, S. and Briand, X. 2006. Marine bioactive substances (IPA extract) improve foliar ion uptake and water tolerance in potted *Vitisvinifera* plants. *Advances in Hort. Sci.* **20:**156-161.

Metting, B., Zimmermann, W. J., Crouch, I. and Staden Van, J. 1990. Agronomic uses of seaweed and micro algae. In: I. Akatsuka (ed.) Introduction to applied phycology. SPB Academic Publishing. The Netherlands. pp. 589-627.

Mohanty, D., Adhikary, S. P. and Chattopadhyay, G. N. 2013. Seaweed liquid fertilizer (SLF) and its role in agriculture productivity. *The Ecoscan Special issue.* **Vol. III:** 147-155.

Pramanick, B., Brahmachari, K. and Ghosh, A. 2013. Effect of seaweed saps on growth and yield improvement of green gram. *Afri. J. Agric. Res.* **8(13):** 1180-1186.

Ramamoorthy, K. and Sujatha, K. 2007. Effect of seaweed extract on the ageing of black gram seeds. *Seaweed Res. Utiln.* **29:** 119-123.

Ramamoorthy, K., Sujatha, K., Sivasubramaniam, K. and Subburamu, K. 2006 a. Organic priming with Sargassum polycystum extracts on vigour and viability in cowpea (*Vigna unguiculata* L.). *Seaweed Res. Utiln.* **28:** 85-88.

Ramamoorthy, K., Sujatha, K., Sivasubramaniam, K. and Subburamu, K. 2006 b. Utilisation of seaweed extract for enhancing yield in black gram (*Vigna mungo* L.) *Seaweed Res. Utiln.* **29:** 97-100.

Rathore, S. S., Chaudhary, D. R., Boricha, G. N., Ghosh, A., Bhatt B. P., Zodape, S. T. and Patolia, J. S. 2009. Effect of seaweed extract on the growth, yield and nutrient uptake of soybean (*Glycine max*) under rainfed conditions. *South Afri J. Bot.* **75(2):** 351-355.

Richards, L. A. 1954. Diagnosis and Improvement of Saline Alkali Soils. USDA Handbook No. 60. USDA, Washington, D.C.

Seen, T. L. and Skelton, J. 1969. Proc. 66h Int. Seaweed Symp., la Marina Merchante, Madrid, Spain. pp. 723-730.

Sethi, S. K. and Adhikary, S. P. 2008. Effect of seaweed liquid fertilizer on vegetative growth and yield of black gram, brinjal and tomato. *Seaweed Res. Utiln.* **30:** 241-248.

Spinelli, F., Giovanni, F., Massimo, N., Mattia S. and Guglielmo, C. 2009. Perspectives on the use of a seaweed extract to moderate the negative effects of alternate bearing in apple trees. *J. Hort. Sci. Biotech.* **17(1):** 131-137.

Temple, W. D. and Bomke, A. A. 1989. Effects of Kelp (*Macrocystis integrifolia* and *Ecklonia maxima*) foliar applications on bean crop growth. *Plant Soil.* **117:** 85-92.

Thirumaran, G., Arumugam, M., Arumugam, R. and Anantharaman., P. 2009 a. Effect of seaweed liquid fertilizer on growth and pigment concentration of *Cyamopsis tetrogonolaba* (L.) Taub. *Am. Euras. J. Agron.* **2(2):** 50-56.

Thirumaran, G., Arumugam, M., Arumugam, R. and Anantharaman, P. 2009b. Effect of seaweed liquid fertilizer on growth and pigment concentration of *Abelmoschus ensculetus* (L.) medikus. *Am. Euras. J. Agron.* **2(2):** 57-66.

Thirumaran, G., Pratap, K. and Anantharaman, P. 2006. Effect of seaweed extracts used as fertilizer for *Abelmoschus esculentus. J. Ecobiology.* **19(4):** 373-376.

Thivy, F. 1982. On the importance and prospects of seaweed utilization in India. *Seaweed Res. Utiln.* **5(2):** 53-60.

Venkataraman, K. and Mohan, V. R. 1997. The effect of liquid seaweed fertilizer on black gram. *Phykos.* **36:** 43-47.

Yokoya Nair, S., Stirk, W., endy, A., van Staden Johannes, Novak Ondrej, Tureckova Veronika, Pencik, A. and Strnad, M. 2010. Endogenous cytokinins, auxins, and abscisic acid in red algae from Brazil. *J. Phycol.* **6:** 1198-1205.

Zodape, S. T., Gupta, A., Bhandari, S. C., Rawat, U. S., Chaudhari, D. R., Eswaran, K. and Chikara, J. 2011. Foliar application of seaweed sap as biostimulant for enhancement of yield and quality of tomato. *J. Scientific and Indus. Res.* **70:** 215-219.