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Effect of seaweed saps derived from two marine algae *Kappaphycus* and *Gracilaria* on growth and yield improvement of blackgram

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A field experiment was conducted during the *pre-kharif* season at Muratipur village, Nadia, West Bengal (Latitude: 22°57′ N, Longitude: 88°20′ E) in two consecutive year of 2012 and 2013 to study the effects of seaweed saps on growth and yield improvement of blackgram in new alluvial soil of West Bengal. Foliar spray was applied twice at different concentrations (0, 2.5, 5.0, 7.5, 10.0 and 15.0% v/v) of seaweed extracts (namely *Kappaphycus* and *Gracilaria*) with recommended dose of fertilizer (RDF). Foliar applications of seaweed extract significantly enhanced the growth and yield parameters. Highest grain yield was recorded with the combined applications of 15% *Kappaphykus* sap and RDF, followed by the combined application of 15% *Gracilaria* sap and RDF extract resulting in an increase by 51.06% and 47.15% seed yield respectively compared to the control. Maximum stover yield was also achieved with the application of 15% *Kappaphykus* sap.

[Keywords: Blackgram, *Gracilaria*, Growth, *Kappaphycus*, Seaweed saps, Yield.]

Introduction

Marine bioactive substances extracted from marine algae are used in agricultural and horticultural crops, and many beneficial effects may be achieved in terms of enhancement of yield and quality. Liquid extracts obtained from seaweeds have recently gained importance as foliar sprays for many crops including various cereals, pulses and different vegetable species. Seaweed extracts contain major and minor nutrients, amino acids, vitamins, cytokinins, auxin and abscisic acid like growth promoting substances and have been reported to stimulate the growth and yield of plants, develop tolerance to environment stress[1], increase nutrient uptake from soil[2] and enhance antioxidant properties[3]. Seaweed extracts have proven to accelerate the health and growth of plants. It supplies nitrogen, phosphorous, potash as well as trace minerals like Zn, Mn, Mg, Fe, etc. It also contains natural plant growth substances like auxins, gibberlins and cytokinins[4,5]. Liquid extracts obtained from seaweeds have recently gained importance as foliar sprays for many crops including various grasses, cereals, flowers and vegetable species[6]. In recent years, use of seaweed extracts have gained in popularity due to their potential use in organic and sustainable agriculture[7], especially in rainfed crops, as a means to avoid excessive fertilizer applications and to improve mineral absorption. Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animals and birds[8]. With the advancement of modern agricultural technologies, we somehow achieved food security for our country to feed its ever escalating population. But till today unfortunately we could not achieve nutritional security for our people. If we are to achieve nutritional security we must have to go for crop diversification in cropping pattern introducing crops like pulses e.g. black gram, green gram in *Zaid* (Summer) season and lentil, chickpea, garden pea in *Rabi* (Winter) season. On the other hand to nourish the Protein Energy Malnourished (PEM) people and to maintain soil health properly pulse crops should be included in the cropping system. Keeping this belief in mind a field experiment was conducted to study the effect of different seaweed saps on growth and yield improvement of blackgram.

Materials and Methods

Preparation and composition of liquid seaweed extract

The seaweed extract used in this study was obtained from *Kappaphycus sp.* and *Gracilaria sp*. Algae were handpicked from the coastal area of Rameswaram, T. N., India during September 2012. 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[9]. 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 two and half hours as described in the semi-micro Kjeldahl method[10], and other nutrient elements were analysed by ICP-OES (inductively coupled plasma-optical emission spectroscopy), 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 h and then raise the temperature to about 150 °C[11].

Table 1- Chemical composition of *Kappaphycus* sap

Nutrient	Amount Present	Nutrient	Amount Present
Moisture	94.38 g/100 ml	Iron	8.58 mg/100 ml
Protein	0.085 g/100 ml	Manganese	0.22 mg/100 ml
Fat	0.0024 g/100 ml	Nickel	0.35 mg/100 ml
Crude Fibre	0.01 g/100 ml	Copper	0.077 mg/100 ml
Carbohydrate	1.800 g/100 ml	Zinc	0.474 mg/100 ml
Energy	7.54 Kcal/100ml	Chromium	3.50 mg/100 ml
Sodium	18.10 mg/100 ml	Lead	0.51 mg/100ml
Potassium	358.35 mg/100 ml	Thiamine	0.023 mg/100 ml
Magnesium	116.79 mg/100 ml	Riboflavin	0.010 mg/100 ml
Phosphorous	2.96 mg/100 ml	B-Carotene	0.0 mg/100 ml
Calcium	32.49 mg/100 ml	Iodine	160ng/100ml
Indole acetic acid	23.36 mg/L	Kinetin + Zeatin	31.91 mg/L
Gibberelin GA_3	27.87 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 2- Chemical composition of *Gracilaria* sap[12,13]

Nutrient	Amount Present	Nutrient	Amount Present
Ash	38.91 g/100 g	Calcium	295.50 mg/ 100 g
Crude Protein	9.58 g/100 g	Copper	0.20 mg/ 100 g
Crude Fibre	10.40 g/100 g	Zinc	1.00 mg/ 100 g
Crude lipid	2.00 g/100 g	Iron	67.35 mg/100 g
Saturated fatty acid	48.92 % of total fatty acids	Manganese	4.16 mg/100 g
Total amino acids	889.78 mg/g of protein	Nickel	0.92 mg/100 g
Moisture	88.88 %	Cobalt	0.24 mg/100 g
Vit-C	28.50 mg/ 100 g	Sulphate	106.20 mg/ 100 g
Carbohydrate	45.92 %	Chlorine	1170.00 mg/ 100 g
Potassium	8633.00 mg/ 100 g	Pb	1.11 mg/ 100 g
Magnesium	549.50 mg/ 100 g	Cd	0.14 mg/ 100 g
Phosphorus	278.50 mg/ 100 g	Sodium	158.50 mg/ 100 g

Experimental site and treatment details

The field experiment was conducted during the *pre-kharif* season of 2012 and 2013 on inceptisol at Muratipur village, Kalyani, Nadia. Soil of the site was sandy clay loam with pH 6.45, organic carbon 0.52%, total nitrogen 0.057%, available P_2O_5 28.01 kg ha^{-1} and available K_2O 148.33 kg ha^{-1}. Climate of the region is humid subtropical. The experimental site is located at 22° 57′ N latitude, 88° 20′ E longitude and altitude is 7.8 m. Experiment comprised of ten treatments, viz, T_1 - 2.5% *Kappaphycus* - sap + RDF, T_2 - 5 % *Kappaphycus* - sap + RDF, T_3 - 10% *Kappaphycus* - sap + RDF, T_4 - 15% *Kappaphycus* - sap + RDF, T_5 - 2.5% *Gracilaria* - sap + RDF, T_6 - 5% *Gracilaria* - sap + RDF, T_7 - 10% *Gracilaria* - sap + RDF, T_8 - 15% *Gracilaria* - sap + RDF, T_9 - RDF + Water spray and T_{10} - 7.5% *Kappaphycus* - sap + 50% RDF in RBD replicated thrice. Two sprays of *Kappaphycus* and *Gracilaria* extract were applied, one at the seedling stage (25 days after sowing) and the other at the pre-flowering stage (50 days after sowing). For proper adherence, extracts were mixed with proper surfactant. The total spray volume was 500 L ha^{-1} in each application.

Data were taken through random sampling at 30 DAS, 60 DAS and 90 DAS to measure plant height, dry matter accumulation, crop growth rate and leaf area index. Data on yield attributes were taken randomly before harvesting.

Data were analysed using analysis of variance (ANOVA) following randomized block design[14]. Differences were considered significant at 5% level of probability.

Results

Effect of treatments on growth of blackgram

Foliar application of different sea weed saps along with RDF increased growth attributes of blackgram significantly over control (Table 3). In general, a gradual increase in plant height, dry matter accumulation and LAI was observed with increasing seaweed extract application. Though these parameter are not significantly affected by foliar applications of seaweed extracts up to 5% concentration. Maximum plant height, dry matter accumulation was recorded with 15% *Kappaphycus* - sap + RDF (T_4) treated plots being statistically at par with 15% *Gracilaria* - sap + RDF (T_8) treated plot regarding all the observations taken at different days after sowing. In case of crop growth rate during 30 – 60 DAS the best result (4.37 g m^{-2} day^{-1}) was recorded with the treatment T_4 which was closely followed by T_8. Highest value of leaf area index was recorded with T_4 for all the observations.

Effect of treatments on yield attributes and yields of blackgram

The maximum numbers of branches per plant, pods per plant and seeds per pod were observed under the treatment T_4 (highest dose i.e. foliar application of 15% *Kappaphycus* sap along with RDF) which was closely followed by 15% *Gracilaria* - sap + RDF (T_8). The treatment T_4 (15% *Kappaphycus* - sap + RDF) showed the maximum increase in yield over control to the extent of 51.06% and this treatment was followed by the treatments T_8 (15% *Gracilaria* - sap + RDF), T_3 (10% *Kappaphycus* - sap + RDF), T_7 (10% *Gracilaria* - sap + RDF), T_2 (5 % *Kappaphycus* - sap + RDF) and T_6 (5% *Gracilaria* - sap + RDF) recording 47.15%, 43.69%, 35.08%, 26.48% and 24.58% yield increase respectively over control. Increase in yield was mainly due to the increase in number of pods as well as weight of pods per plant and number of seeds per pod. This is in conformity with the results reported for *Phaseolus aureus*[15]. Increase in yield of several other crops like *Capsicum annuum*[16], blackgram[17] and canola plants (*Brassica napus*)[18] are reported with the foliar application of seaweed extract.

Table 3- Effect of treatments on plant height (cm), dry matter accumulation (g m^{-2}), CGR (g m^{-2} day^{-1}) and LAI

Treatments	Plant height (cm)			Dry matter accumulation (g m^{-2})			CGR (g m^{-2} day^{-1})		LAI		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 – 60 DAS	60 – 90 DAS	30 DAS	60 DAS	90 DAS
T_1	13.33	25.59	31.32	123.25	232.33	341.79	3.64	3.65	1.62	2.89	1.38
T_2	13.91	26.31	32.33	127.31	242.81	351.73	3.85	3.63	1.69	3.21	1.41
T_3	14.87	27.90	34.23	133.67	252.22	359.45	3.95	3.57	1.71	3.31	1.52
T_4	16.97	29.83	36.67	146.29	277.25	391.77	4.37	3.82	1.85	3.47	1.61
T_5	13.21	24.99	29.97	121.33	228.37	332.33	3.57	3.47	1.57	2.99	1.32
T_6	13.67	26.03	30.58	125.34	230.91	348.55	3.51	3.92	1.63	3.12	1.39
T_7	14.13	27.15	33.47	132.80	255.46	351.47	4.09	3.20	1.74	3.38	1.49
T_8	16.13	29.17	35.99	142.37	270.93	383.73	4.29	3.76	1.82	3.49	1.55
T_9	11.75	22.33	27.21	107.25	214.37	325.97	3.57	3.72	1.51	2.89	1.19
T_{10}	13.45	26.78	30.47	128.87	250.39	331.48	4.05	2.70	1.65	3.11	1.37
SEm(±)	1.01	1.13	1.41	5.01	8.78	9.76	0.56	1.25	0.05	0.118	0.06
CD at 5%	2.99	3.36	4.22	14.97	26.32	29.26	1.65	3.69	NS	0.354	0.18

[T_1: 2.5% *Kappaphycus*- sap + RDF; T_2: 5 % *Kappaphycus*- sap + RDF; T_3: 10% *Kappaphycus*- sap + RDF; T_4: 15% *Kappaphycus*- sap + RDF; T_5: 2.5% *Gracilaria* - sap + RDF; T_6: 5% *Gracilaria* - sap + RDF; T_7: 10% *Gracilaria* - sap + RDF; T_8: 15% *Gracilaria* - sap + RDF; T_9: RDF + Water spray; T_{10}: 7.5% *Kappaphycus*- sap + 50% RDF]

Table 4- Effect of treatments on yield components and seed and stover yield of blackgram

Treatments	No of branches $plant^{-1}$	No of pod $plant^{-1}$	No of seed pod^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	% of yield increase over control	Stover yield (kg ha^{-1})	% of yield increase over control
T_1	5.17	11.02	5.42	41.03	1116	24.69	3655	15.88
T_2	5.47	11.83	5.74	41.21	1132	26.48	3879	22.99
T_3	6.24	12.55	6.02	42.12	1286	43.69	4198	33.10
T_4	6.97	13.23	7.17	42.89	1352	51.06	4417	40.04
T_5	5.09	10.59	5.45	41.05	1097	22.57	3594	13.95
T_6	5.37	10.74	5.98	41.36	1115	24.58	3795	20.32
T_7	6.09	12.06	6.13	42.05	1209	35.08	4097	29.91
T_8	6.53	12.98	6.97	42.63	1317	47.15	4333	37.38
T_9	4.95	9.97	5.16	40.02	895	--	3154	--
T_{10}	6.17	11.29	5.93	41.91	1192	33.18	4007	27.05
SEm(±)	0.178	0.36	0.25	0.91	42.2	--	72.1	--
CD at 5%	NS	1.05	0.74	NS	126.5	--	216.1	--

[T_1: 2.5% *Kappaphycus*- sap + RDF; T_2: 5 % *Kappaphycus*- sap + RDF; T_3: 10% *Kappaphycus*- sap + RDF; T_4: 15% *Kappaphycus*- sap + RDF; T_5: 2.5% *Gracilaria* - sap + RDF; T_6: 5% *Gracilaria* - sap + RDF; T_7: 10% *Gracilaria* - sap + RDF; T_8: 15% *Gracilaria* - sap + RDF; T_9: RDF + Water spray; T_{10}: 7.5% *Kappaphycus*- sap + 50% RDF]

Discussion

Seaweed extract a the rich source of several primary nutrients like potassium, phosphorus; secondary nutrients like calcium, magnesium; trace elements like zinc, copper, iron, manganese and beneficial elements like nickel, sodium etc. Sea weed extracts stimulate various aspects of growth and development resulting in around good health of the plants. While deliberating the effect of sea weed extracts on crops the aspects of root development and mineral absorption, shoot growth and photosynthesis and ultimately crop yield, even vegetative propagation can also be taken into consideration. Due to the presence of good amount of Phosphorus in it, the liquid sea weed fertilizers (LSF) proliferate root development, enhance root to shoot ratio, thereby, making the plants more able to mine adequate nutrients from the deeper layer of soil and influence crop maturity as a whole. As Phosphorus is the important constituent of NADP, the niacin component of Vitamin-B complex, it helps in photosystem-I to produce NADPH. As LSF is a very good source of potassium it helps in regulating the water status of the plants, controls the opening and closing of stomata and thereby the photosynthesis to a large extent. The meristematic growth, translocation of photosynthates and disease resistance are also influenced by it due to the manifestation of good impact of potassium. Calcium being present in sea weed extracts helps in enzyme activation, cell elongation and cell stability. LSF is the opulent source of secondary nutrients like Mg; hence it helps in photosynthesis, phloem export, root growth and nitrogen metabolism. It also influences the N-fixation in legumes as it contains Mn. Mn is a constituent of several cation activated enzymes like decarboxylase, kinase, oxidase etc., and hence, essential for the formation of chlorophyll, reduction of nitrates and for respiration. The trace elements like Fe, Cu and Zn being present in considerable amount in seaweed extracts inspire redox reaction of respiration and photosynthesis, promote reduction of nitrates and sulphates and stimulate the cation activated enzymes. The organic constituents of seaweed extract include plant hormones which elicit strong physiological responses in low doses. A panorama of phytohormones and plant growth regulators are found in different seaweed concentrates and marine macroalgal extracts *viz.* Auxins, Gibberellins, Cytokinins etc. which simulate rooting, growth, flower initiation, fruit set, fruit growth, fruit ripening, abscission and senescence when applied exogenously. Seaweeds also contain a diverse range of organic compounds which include several common amino acids *inter alia* aspartic acid, glutamic acid and alanine in commercially important species. Alginic acid, laminarin and mannitol represent nearly half of the total carbohydrate content of commercial seaweed preparations. Seaweeds also contain a wide range of vitamins which might be utilized by the crops. Vitamins C, B, (thiamine), B_2 (riboflavin), B_{12}, D_3, E, K, niacin, pantothenic, folic and folinic acids occur in algae. Although vitamin A is not present, the presences of its precursor carotene and another possible precursor fucoxanthin have been found. Apart from the above organic and inorganic constituents, there is evidence of existence of different other stimulatory and antibiotic substances.

Thus being a wealthy source of versatile plant nutrients, phytohormones, amino acids, vitamins, stimulatory and antibiotic substances the liquid sea weed extract enhances root volume and proliferation, bio-mass accumulation, plant growth, flowering, distribution of photosynthates from vegetative parts to the developing fruits and promotes fruit development, reduces chlorophyll degradation, disease occurrence etc. resulting in improved nutrient uptake, water and nutrient use efficiency causing sound general plant growth and vigor ultimately reflecting higher yield and superior quality of agricultural products.

Conclusion

Thus it can be concluded that the seaweed extracts are effective in increasing the growth parameters, yield attributes and yield of blackgram. The saps also enhance nutrient uptake by this legume food crop. Presence of microelements and plant growth regulators, especially cytokinins in *Kappaphycus* and *Gracilaria* extracts is responsible for the increased yield of blackgram receiving foliar application of the aforesaid two saps.

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References

1 Zhang, X., Ervin, E.H. & Schmidt, E.R., Plant growth regulators can enhance the recovery of Kentucky bluegrass sod from heat injury, *Crop Sci*., 43(2003) 952–956.

2 Turan, M. & Köse, C., Seaweed extracts improve copper uptake of grapevine, *Acta. Agric. Scand. B-S P*, 54(2004) 213–220.

3 Verkleij, F.N., Seaweed extracts in agriculture and horticulture: a review, *Biol. Agric. Hort*., 8(1992) 309–324.

4 Jameson, P.E., Plant hormones in the algae, *Prog. Phycol. Res*., 9(1998) 239-279.

5 Zhang, X. & Ervin, E.H., Impact of seaweed extract-based cytokinins and zeatin riboside on creeping bentgrass heat tolerance, *Crop Sci*., 48(2008) 364-370.

6 Crouch, I.J. & Van Staden, J., Commercial seaweed products as biostimulants in horticulture, *J. Home Con-sumer Hort*., 1(1994) 19–76.

7 Russo, R.O. & Beryln, G.P., The use of organic biostimulants to help low inputs, *J. Sustain. Agr*., 1(1990) 9–42.

8 Dhargalkar, V.K. & Pereira, N., Seaweed: promising plant of the millennium, *Sci. Culture*, 71(2005) 60–66.

9 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. & Tewari, A., Integrated method for production of carrageenan and liquid fertilizer from fresh seaweeds, 2005 United States Patent no. 6893479.

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

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

12 Benjama Ommee & Masniyom Payap., 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(2012) 223-230.

13 Yokoya Nair S., Stirk Wendy A., Van Staden Johannes, Novák Ondřej, Turečková Veronika, Pěnčík Aleš & Strnad Miroslav, Endogenous cytokinins, auxins, and abscisic acid in red algae from Brazil, *J. Phycol*., 6(2010) 1198-1205.

14 Gomez, K.A. & Gomez, A.A., Statistical Procedures for Agricultural Research (John Wiley and Sons, New York) 1984.

15 Bai, N.R., Banu, N.R.L., Prakash, J.W. & Goldi, S.J., Effect of seaweed extracts (SLF) on the growth and yield of *Phaseolus aureus* L., *Indian Hydrobiol*., 11(2008) 113-119.

16 Arthur, G.D., Stirk, W.A. & Van Staden, J, Effect of seaweed concentrates on the growth and yield of three varieties of *Capsicum annuum*, *S. Afr. J. Bot.,* 69(2003) 207-211.

17 Venkataraman, K. & Mohan, V.R., The effect of liquid seaweed fertilizer on black gram, *Phykos*., 36(1997) 43-47.

18 Ferreira, M.I. & Lourens, A.F., The efficacy of liquid seaweed extract on the yield of Canola plants, *S. Afr. J. Plant Soil*., 19(2002) 159-61.