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EFFECT OF SEAWEED SAPS ON GROWTH AND YIELD IMPROVEMENT OF TRANSPLANTED RICE IN OLD ALLUVIAL SOIL OF WEST BENGAL

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Abstract

On summer rice, foliar spray was applied thrice at different concentrations (0, 2.5, 5.0, 7.5, 10.0 and 15.0%, v/v) of seaweed extracts (namely, *Kappaphycus* sp. and *Gracilaria* sp.) along with the recommended dose of fertilizer (RDF). The highest grain yield was recorded with the applications of 15% *Kappaphykus* sap + RDF, followed by 15% *Gracilaria* sap + RDF extract resulting in 41.47 and 34.99% increases, respectively compared to the control. The maximum straw yield was also achieved with 15% seaweed extract application. Improved nutrient uptake (N, P and K) was also observed with seaweed extract applications.

Introduction

Nationwide, the need for N, P and K fertilizers increased from 96,116 tons in 2006 to 739,271 tons in 2007 (Pusri 2008). The increase tends to be caused by the dosage increase of fertilizer used in per unit area. Facts show that farmers use about 150 - 200 kg of urea/hectare of rice, and about 200 - 250 kg/hectare to plant vegetables and fruits. This condition certainly not only increases production costs, but also reduces soil fertility vis-à-vis soil health and causes environmental pollution. Ironically, the increase in fertilizer costs, coupled with a variety of economic losses due to excessive fertilizer application, is not followed with the increase in farmers' income. Therefore, the efforts to maximize the absorption of nutrients by spraying extracts of natural products that contain stimulants, is a strategic move to overcome the ill effects of the use of excessive doses of inorganic fertilizer. Results of previous studies reported that some liquid fertilizer products made from raw seaweeds are proven to increase the absorption of nutrients, which can enhance growth, development and production of various species of agricultural crops (Tay *et al*. 1987, Hankins and Hockey 1990). However, there is insufficient information on the effect of tropical water seaweed extract on the growth and yield of rice. Given the aforementioned facts, the study aims to determine the effect of several types of seaweed extracts on growth and yield of rice.

Materials and Methods

The field experiment was conducted during the *rabi* season of 2010-11 and 2011-12 on inceptisol at Bankapasi village, Bardhaman. The soil of the site was sandy clay loam with pH 6.50, organic carbon 0.51%, total nitrogen 0.057%, available P_2O_5 24.89 kg/ha and available K_2O 158.13 kg/ha. The climate of the region is humid subtropical. The experimental site is located at 23° 35′ N and 88° 01′ E. The experiment comprised 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 design replicated thrice. Three sprays of *Kappaphycus* and *Gracilaria* extract were applied. For proper adherence, extracts were mixed with

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with proper surfactant. The total spray volume was 650 l/ha in each application. Data were taken through random sampling at 30, 45, 60 and 75 DAT to measure plant height, dry matter accumulation, no. of tillers/m^2 and leaf area index. Data on yield attributes were taken randomly before harvesting. At maturity, rice grain and straw samples were collected from each plot, oven-dried at 70°C to constant weight and ground to pass through a 0.5 mm sieve for chemical analysis. The N content was determined by the semi-micro Kjeldahl method [AOAC International, 1995, method No. Ba 4b-87(90)], after the plant tissues (0.2 g) were oxidized and decomposed by concentrated sulphuric acid (10 ml) with digestion mixture (K_2SO_4 : $CuSO_4$ = 5 : 1) heated at 400°C for two and a half hours. P content was determined by the vanado-molybdate yellow method (Jackson 1973), K content by flame photometry (Jackson 1973). Uptake of nutrient (kg/ha) by rice grain and straw was calculated by multiplying the percentage of concentration of concerned nutrient of rice grain and straw with the respective grain and straw yield (kg/ha) [Nutrient uptake (kg/ha) = Nutrient Concentration (%) × Yield (kg/ha)]. Data were analysed using ANOVA following RBD (Gomez and Gomez 1984). Differences were considered significant at 5% level of probability.

Results and Discussion

Observations on growth attributes *viz.,* plant height, number of tillers/m^2 and dry matter production were recorded at different DAT. Response of vegetative growth of rice was found to be increased following seaweed extract spray compared to control treatment. These increments were again enhanced and significant when higher sap concentrations were used (Table 1). Maximum plant height, LAI and dry matter production were recorded with 15% *Kappaphycus*-sap + RDF (T_4) which was statistically at par with 15% *Gracilaria*-sap + RDF (T_8). Control (water spray along with RDF) recorded the lowest plant height and dry matter production. In case of number of tillers/m^2, 15% *Kappaphycus*-sap + RDF (T_4) showed the best result at different DAT over all other treatments. Seaweed extract increased total fresh matter production of cereal maize seedlings by 15 - 25% over the control as observed by Jeannin *et al*. (1991) when Goemar GA_{14} was applied as a foliar spray.

Total yield may be considered to be the mirror of all growth features. Spraying of *Kappaphycus* extract at the rate of 15% thrice along with RDF recorded highest yield attributes *viz.,* number of panicles/m^2 (507.60), filled grains/panicle (143.83), panicle length (28.97 cm) and 1000 grain weight (21.23 g) and thereby highest grain yield (6.55 t/ha) and straw yield (8.25 t/ha) followed by spraying of 15% *Gracilaria* - sap along with RDF (Table 3). Spraying of 15% *Kappaphycus* - sap thrice recorded 41.37% higher grain yield and 53.66% higher straw yield when compared to control (Table 2). The treatment T_8 i.e. 15% *Gracilaria* - sap + RDF and T_3 i.e. 10% *Kappaphycus* - sap + RDF also exhibited promising increase in grain and straw yield over control. The highest grain and straw yield were concomitant with using the higher level of seaweed extract as the best treatment, which significantly overcome control treatment. Such increment might be due to the fact that seaweed extract is a biostimulant, which provide the rice plant with micro, macro nutrients and significant amounts of cytokinins, auxins and betaines (Blunden 1991) ultimately increasing the chlorophyll production by boosting the photosynthetic process, thereby stimulating vegetative growth. Thus, an overall plant performance would be enhanced accordingly and finally reflecting through an escalated productivity. However, these results agree with those of Blunden and Wildgoose (1977) on potato, Featonby and Van Staden (1983) and Beckett *et al.* (1994) on tepary bean, Arthur *et al.* (2003) on pepper, Zodape *et al*. (2008) on okra, Gajewski *et al*. (2008) on Chinese cabbage and Abdel-Mawgoud *et al*. (2010) on water melon.

Table 1. Effect of seaweed sap treatments on plant height, dry matter accumulation, no. of tillers/m^2 and LAI (pooled data of two years).

Treatments	Plant height (cm)				Dry matter accumulation (g/m^2)				No. of tillers/m^2				LAI			
	30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT
T_1	53.33	62.67	78.17	88.08	47.93	101.63	198.33	413.87	404.33	447.90	465.67	468.77	0.70	1.35	2.03	1.58
T_2	54.75	63.97	78.93	88.79	48.77	102.07	200.40	415.67	411.63	449.67	472.33	473.48	0.75	1.44	2.09	1.61
T_3	55.59	65.53	79.67	90.21	48.99	104.91	209.97	428.33	433.21	467.33	479.65	488.65	0.91	1.65	2.27	1.88
T_4	59.30	68.63	81.33	93.33	52.33	120.23	230.44	448.73	478.83	500.40	511.23	516.37	1.01	1.91	3.29	2.26
T_5	51.97	60.03	76.23	87.07	46.67	100.83	196.77	408.11	383.89	433.63	453.37	459.90	0.65	1.21	1.99	1.49
T_6	52.24	61.16	77.07	88.11	47.43	101.23	199.57	410.40	400.20	439.68	467.61	471.75	0.67	1.29	2.01	1.51
T_7	54.17	64.24	79.90	89.33	49.67	103.47	204.63	420.39	419.97	455.53	482.47	484.43	0.85	1.59	2.19	1.63
T_8	58.55	68.07	79.33	92.35	51.67	117.67	222.45	439.91	463.67	488.98	497.67	504.09	0.97	1.84	3.01	2.11
T_9	45.46	56.67	60.33	72.35	38.93	93.88	167.33	331.83	363.33	390.57	399.99	411.23	0.53	1.14	1.86	1.13
T_{10}	54.79	64.48	79.63	90.33	49.97	109.67	207.47	417.77	417.45	451.23	460.35	477.75	0.79	1.49	2.15	1.52
SEm (±)	0.98	1.49	1.16	1.53	1.29	3.17	6.1	6.5	10.51	8.10	9.92	6.58	0.05	0.04	0.06	0.02
CD at 5%	2.98	4.53	3.52	4.59	3.90	9.45	18.0	19.2	31.21	24.22	29.36	19.59	0.15	0.12	0.18	0.06

Table 2. Effect of seaweed sap treatments on yield components and yield of rice (pooled data of two years).

Treatment	No. of panicles/m^2	Length of panicle (cm)	No. of filled grains/panicle	Test weight (g)	Grain yield (t/ha)	Yield increase over control (%)	Straw yield (t/ha)	Yield increase over control (%)	Harvest index (%)
T_1	461.32	28.03	94.97	20.38	5.38	16.21	6.35	18.20	45.87
T_2	473.63	28.07	105.22	20.50	5.54	19.65	6.76	25.84	45.04
T_3	488.75	28.13	119.51	20.79	5.97	28.94	7.40	37.83	44.65
T_4	507.60	28.97	143.83	21.23	6.55	41.47	8.25	53.66	44.26
T_5	455.67	27.83	91.66	20.11	5.23	12.96	6.01	11.99	46.53
T_6	465.93	27.87	101.17	20.21	5.47	18.14	6.51	21.20	45.66
T_7	479.33	28.07	115.47	20.93	5.85	26.35	7.02	30.71	45.45
T_8	499.86	28.57	137.93	21.07	6.25	34.99	7.81	45.46	44.45
T_9	445.05	27.63	79.70	20.02	4.63	-	5.37	-	46.30
T_{10}	471.77	27.99	110.33	20.65	5.80	25.27	7.02	30.71	45.24
SEm(±)	6.59	0.45	4.29	0.58	0.16	-	0.20	-	-
CD at 5%	19.77	NS	12.78	NS	0.48	-	0.61	-	-

The use of the seaweed extracts increased significantly N, P and K uptake by grains at higher concentrations (10% and above) and reached maximum at 15% seaweed extract compared with control (Table 3). The highest N and P uptake by grain was recorded with the 15% *Kappaphycus*-sap + RDF which was statistically at par with 15% *Gracilaria* - sap + RDF and 10% *Kappaphycus*-sap + RDF. 15% *Kappaphycus*-sap + RDF showed maximum uptake of P by grain which shows no significant difference with 15% *Gracilaria*-sap + RDF. 7.5% and above concentration of *Kappaphycus*-sap and 15 % *Gracilaria*-sap gave significant increase of N and P uptake by rice straw over control and other treatments. Whereas 15% *Kappaphycus*-sap + RDF showed the maximum uptake of P by straw and this treatment was statistically at par with the treatment T_8. These results confirm those previously reported by Crouch *et al.* (1990) who noted increased uptake of Mg, K and Ca in lettuce with seaweed concentrate application. Turan and Köse (2004), Nelson and Van Staden (1984), and Mancuso *et al*. (2006) also observed increased uptake of N, P, K and Mg in grapevines and cucumber with the application of seaweed extract. The presence of marine bioactive substances in seaweed extract improves stomata uptake efficiency in the treated plants compared to the non-treated plants (Mancuso *et al*. 2006).

Table 3. Effect of seaweed sap treatments on nutrient uptake by grain and straw of rice (pooled data of two years).

Treatments	Grain uptake (kg/ha)			Straw uptake (kg/ha)		
	N	P	K	N	P	K
T_1	53.67	9.21	56.07	41.33	13.83	180.11
T_2	54.85	9.85	57.33	42.57	14.55	185.67
T_3	59.33	11.07	60.23	45.67	15.23	192.35
T_4	64.23	13.68	65.67	49.12	17.05	209.22
T_5	51.71	8.95	54.55	41.01	12.90	177.39
T_6	53.06	9.33	56.37	41.99	13.93	184.05
T_7	56.89	10.27	58.81	44.23	14.87	190.57
T_8	61.62	12.99	63.29	47.95	16.74	202.13
T_9	43.15	7.83	47.13	36.71	10.33	158.82
T_{10}	56.24	9.97	58.95	44.05	14.73	181.19
SEm(±)	2.19	0.45	1.71	1.29	0.72	4.13
CD at 5%	6.59	1.34	5.15	3.88	2.15	11.97

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

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References

Abdel-Mawgoud AMR, Tantawy AS, Hafez MM and Hoda AM 2010. Seaweed extract improves growth, yield and quality of different watermelon hybrids Research. J. Agri. Biol. Sci. **6**(2): 161-186.

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.

Arthur GD, Stirk WA and Van Staden J 2003. Effect of seaweed concentrates on the growth and yield of three varieties of *Capsium annuum.* S. Afr. J. Bot. **69**: 207-211.

Beckett RP, Mathegka AD and Van Staden J 1994. Effect of seaweed concentrate on yield of nutrient stressed tepary bean (*Phaseolus acutifolius* Gray). J. Appl. Phycol. **6**: 429-430.

Blunden G 1991. Agricultural uses of seaweeds and seaweed extracts. *In:* Guiry MD and Blunden G (eds) Seaweed resources in Europe. Uses and potential. Wiley, Chichester, pp. 65-81.

Blunden G and Wildgoose PB 1977. The effect of aqueous seaweed extract and kinetin on potato yield. J. Sci. Food Agr. **28**: 121-125.

Crouch IJ, Beckett RP and Van Stade J 1990. Effect of seaweed concentrate on the growth and mineral nutrition of nutrient stress lettuce. J. Appl. Phycol. **2**: 269-272.

Featonby SBC and Van Stadena J 1983. The effect of sea weed concentrate on the growth of tomato plants in nematode – infested soil. Sci. Hortic. **20**: 137-146.

Gajewski M, Katarzyna G and Bobruk J 2008. The influence of Goëmar Goteo biostimulator on yield and quality of two Chinese cabbage cultivars. Conf. of biostimulators in modern agriculture "vegetable crops". Warsaw pp. 23-27.

Gomez KA and Gomez AA 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York.

Hankins SD and Hockey HP 1990. The effect of liquid seaweed extract from *Ascophyllum nodosum* (Fucales, Phaephyta) on the two-spotted red spider mite Tetranychus urticae. Hydrobiol. **205**: 555-559.

Jackson ML 1973. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India.

Jeannin I, Lescure JC and Morot-Gaudry JF 1991. The effects of aqueous seaweed sprays on the growth of maize. Bot. Marina. **34**(6): 469-473.

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

Nelson WR and Van Staden J 1984. The effect of seaweed concentrate on wheat culms. J. Plant. Physiol. **115**: 433-437.

Pusri 2008. Data realization of production, consumption, export and import of fertilizer. www. APPI.or.id. [Indonesia].

Tay SAB, Palni LMS and MacLeod JK 1986. Identification of cytokinin in a seaweed extract. J. Plant. Growth Regul. **5**: 133-138.

Turan K and Kose M 2004. Seaweed extract improve copper uptake of Grapevine (*Vitis vinifera*). Acta. Agr. Scand. B-S P. **54**: 213- 220.

Zodape ST, Kawarkhe VJ, Patolia JS and Warade AD 2008. Effect of liquid seaweed fertlizer on yield and quality of okra (*Abelmoschus esulentus* L.). J. Sci. Ind. Res. **67**: 1115-1117.

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