

Influence of foliar application seaweed (*Kappaphycus* and *Gracilaria*) saps in rice (*Oryza sativa*)–potato (*Solanum tuberosum*)–blackgram (*Vigna mungo*) sequence

BISWAJIT PRAMANICK¹, KOUSHIK BRAHMACHARI², DIBAKAR GHOSH³ AND P.S. BERA⁴

Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741 252

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ABSTRACT

A field experiment was conducted during 2011–12 and 2012–13 on sandy loam soil at Uttar Chandamari village (22°57' N, 88° 20' E), Kalyani, District Nadia, West Bengal, to study the effect of seaweed (*Kappaphycus* and *Gracilaria*) saps on crop growth, yield and nutrient uptake and monetary advantages in rice (*Oryza sativa* L.)–potato (*Solanum tuberosum* L.)–blackgram [*Vigna mungo* (L.) Hepper] sequence. Pooled results indicated that foliar application of seaweed extracts at different concentrations (2.5, 5.0, 10.0 and 15.0% V/V) significantly enhanced the growth, yield and nutrient uptake of all the crops. Application of 15% *Kappaphycus* sap with 75% recommended dose of fertilizer (RDF) resulted in the highest productivity in terms of rice-equivalent yield (REY) with annual net monetary returns of ₹231,686/ha and benefit: cost ratio of 2.61. The highest N, P, K uptake in all the crops was also observed in the same combination.

Key words: Foliar nutrient management, Rice–potato–blackgram cropping systems, Seaweed sap

In eastern fraction of the Indo-Gangetic Plain (IGP) and parallel areas, many studies have been carried out in the past to find out important cropping systems in terms of productivity, profitability, energy efficiency, soil fertility and nutrient balances. Rice–wheat–jute system was found most productive but had the lowest benefit: cost ratio, whereas rice–Indian mustard–sesame was least productive but had a high benefit: cost ratio. In a similar study, rice–potato–jute was the most productive and profitable cropping sequence (Biswas *et al.*, 2006). Mukhopadhyaya and Roy (2000) reported potato–jute–rice as a more productive system than other systems such as potato–greengram–jute, potato–maize–rice and wheat–jute–rice. Adoption of proper crop sequence involving crops like pulses and vegetables in cereal-based system to sustain food security and nutritional security simultaneously. Rice is the staple cereal food crop of India, providing 43% of calorie requirement for more than 70% of Indian population. A short-duration crop like potato produces more dry matter, edible protein/unit land and time than many other major crops

like wheat and rice. Moreover, to nourish the protein energy malnourished (PEM) people and to maintain soil health properly pulse crops can be included in the cropping system. Any improvement in agricultural system that improves crop production should have less negative impact on environment and should enhance the sustainability of the system. During post Green Revolution era, to increase production per unit area per unit time for maintaining food security of the entire nation, an unsystematic exploitation of chemical fertilizers, pesticides, herbicides along with natural resources was made putting the entire environment vis-à-vis overall ecological balance in danger (Nellemann *et al.*, 2009 and Lee, 2017). So, it is the high time for reshaping our present package of practices by introducing some alternative approaches which can mitigate the hazards and sustain the production. The use of biostimulants can enhance the effectiveness of conventional mineral fertilizers (Pramanick *et al.*, 2013). The bioactive substances extracted from marine algae are used in agricultural and horticultural crops, and many beneficial effects may be attained 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. It supplies nitrogen, phosphorus, potassium as well as trace minerals like Zn, Mn, Mg, Fe, etc. It also contains natural plant-growth substances like auxins, gib-

¹Corresponding author's Email: bipra.its4u@gmail.com

¹Assistant Professor (Agronomy), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145;

²Professor (Agronomy), Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741 252; ³Scientist (Agronomy), ICAR-Directorate of Weed Research, Jabalpur, Madhya Pradesh 482 001

berellins and cytokinins. One such source is foliar application and direct assimilation through crop foliage and canopy. Hence a field experiment was carried out to study the effect of different seaweed saps on growth and yield of crops in rice-potato-blackgram sequence, nutrient uptake and monetary advantages.

MATERIALS AND METHODS

The field experiment was conducted during 2011–12 and 2012–13 in sub-tropical humid on Inceptisols located at 22° 57' N latitude, 88° 20' E longitude and 7.8 m altitude in Uttar Chandamari village of Nadia district of West Bengal in India. The soil was sandy clay loam, having pH 6.45, total nitrogen 115%, available P 27.0 kg/ha and available K 146.0 kg/ha. Ten treatments, viz. 2.5% *Kappaphycus* (K) sap + 75% recommended dose of fertilizer (RDF), 5% *Kappaphycus* sap + 75% RDF, 10% *Kappaphycus* sap + 75% RDF, 15% *Kappaphycus*- sap + 75% RDF, 2.5% *Gracilaria* (G) sap + 75% RDF, 5% *Gracilaria* sap + 75% RDF, 10% *Gracilaria* - sap + 75% RDF, 15% *Gracilaria* - sap + 75% RDF, 75% RDF + water spray and 100% RDF), were tested in randomized block design with 4 replications in rice-potato-blackgram system. Three sprays of *Kappaphycus* and *Gracilaria* extract were applied in case of rice [20, 40 and 60 days after transplanting (DAT)], and potato [20, 35 and 50 days after planting (DAP)], whereas 2 sprays were applied to blackgram [20 and 40 days after sowing (DAS)]. Chemical compositions of *Kappaphycus* and *Gracilaria* extract are given in Table 1. Extracts were mixed with proper surfactant (active 80 @ 0.5 mL/L water) at the time of spray-

ing. The total spray volume was 550 L/ha in each application. The net plot size was 5 m × 6 m. The recommended dose of N, P₂O₅ and K₂O was applied through urea, single superphosphate and muriate of potash respectively. The RDF of rice, potato and blackgram was 60 : 30 : 30, 180 : 120 : 120 and 20 : 40 : 20 kg/ha N : P₂O₅ : K₂O respectively. Irrigations were applied as and when required. 'Satabdi', 'Kufri Jyoti' and 'Sarada' varieties were used for rice, potato and blackgram respectively. Standard package of practices were applied except nutrient-management practices. Growth, yield attributes, yield and nutrient uptake were studied as per standard protocols. Data were taken through random sampling at harvesting to measure plant height, dry-matter accumulation. The prevailing market prices taken for calculation (₹/t) were ₹13,000 for rice, ₹10,000 for potato and ₹35,000 for blackgram. Price of rice straw and blackgram stover was considered ₹2,500/t for each. Common costs of cultivation for rice, potato and blackgram were ₹38,045, 80,500 and 18,100/ha respectively. Rate of seaweed saps derived from *Kappaphycus* and *Gracilaria* was ₹15/L. The yields of crops grown during different seasons were converted into rice-equivalent yields (REY) for comparison. The statistical analysis of data was done using SAS Windows Version 9.3. The effect of the years was non-significant and there were no significant interactions between treatments and years. Treatment means were separated with the use of Tukey's Honestly Significant Difference test at the 5% level of significance.

RESULTS AND DISCUSSION

Growth and yield attributes of crops in the sequence

Response of vegetative growth of different crops in the sequence was found to be increased with the application of seaweed extraction compared to 75% RDF + water spray and 100% RDF. In general, gradual increase in plant height, dry-matter accumulation and leaf-area index (LAI) was observed with increasing seaweed extract application in all the 3 crops in the system (Tables 2, 3 and 4). The highest values of all the growth parameters of rice, viz. plant height (93.3 cm), DMA (449 g/m²), no. of tillers/m² (356), LAI (4.29) and yield attributes such as, panicles/m² (349), length of panicle (29 cm), filled grains/panicle (100.8), test weight (21.2) were recorded with the application of 15% K-sap + 75% RDF and this treatment was statistically at par with the application of 15% G-sap+75% RDF in most of the occasions (Table 2). Combined application of 15% K-sap + 75% RDF increased the plant height, DMA, tillers/ m², LAI, panicles/m², filled grains/panicle of rice to the tune of 13, 11, 18, 24, 18 and 26% over conventional 100% RDF. In case of 2 other crops in the system, viz. potato and blackgram, the application of

Table 1. Chemical compositions of *Kappaphycus* sap and *Gracilaria* sap

Chemical analysis of seaweed sap	<i>Kappaphycus</i> -sap	<i>Gracilaria</i> -sap
Organic carbon (%)	0.71	0.62
Total nitrogen (%)	0.10	0.04
Total phosphorus (%)	0.01	0.002
Total potassium (%)	11.1	5.97
Total calcium (%)	13.5	5.45
Total magnesium (%)	9.29	6.67
Cu (mg/g)	0.36	0.37
Zn (mg/g)	0.01	0.12
Mn (mg/g)	0.40	0.19
Fe (mg/g)	0.63	0.67
IAA (mg/L)	23.4	20.2
Gibberellin GA ₃ (mg/L)	27.9	22.6
Kinetin + Zeatin (mg/L)	31.91	25.33

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

15% *K*-sap + 75% RDF and 15% *G*-sap + 75% RDF showed promising result over all other treatments concerning growth and yield attributes. These 2 treatments increased the growth and yield attributes of potato to the tune of 11–20% over 100% RDF only. Regarding blackgram also these treatments augmented the growth attributes to the tune of 10–24% and yield attributes almost 18–39% over conventional 100% RDF. These results are in agreement with the view of Jeannin *et al.* (1991), who opined that the foliar application of seaweed extract (Goemar GA₁₄) increased total fresh-matter production of cereal maize seedlings by 15–25% over the control. Physiological responses owing to application of seaweed extracts gave rise to nutrient mobilization as well as partitioning, growth of a strong root-system, increased chloro-

phyll content and leaf area and senescence retardation in the plant system (Akila and Jeyadoss, 2010). All these factors ultimately improved the plant height, DMA, LAI, and varied yield-attributing characters of a crop.

Total yield may be considered to be the mirror of all growth and yield-attributing features. Spraying of *Kappaphycus* extract @ 15% thrice along with 75% RDF resulted in the highest values of yield attributes for rice, potato and blackgram. The highest grain and straw yields of rice, tuber yield of potato and seed and stover yields of blackgram were concomitant with using the higher level of seaweed extract as the best treatment (Tables 2, 3 and 4). Per cent increment of the grain yield through the application of 15% *K*-sap + 75% RDF and 15% *G*-sap + 75% RDF was almost 27 and 26% respectively over 100%

Table 2. Effect of different concentration of seaweeds extracts of *Kappaphycus* and *Gracilaria* on growth, yield attributes and yields of rice receiving (pooled data of 2 years)

Treatment	Plant height (cm)	Dyr-matter accumulation (g/m ²)	Tillers/m ²	Leaf-area index at 60 DAT	Panicles/m ²	Length of panicle (cm)	Filled grains/panicle	1,000-seeds weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
2.5% <i>K</i> -sap + 75% RDF	88.1	414	309	3.43	300	28.0	80.0	20.4	3.99	4.22
5% <i>K</i> -sap + 75% RDF	88.8	416	313	3.55	306	28.1	81.2	20.5	4.02	4.33
10% <i>K</i> -sap + 75% RDF	90.2	428	334	3.97	324	28.1	90.5	20.8	4.77	4.99
15% <i>K</i> -sap + 75% RDF	93.3	449	356	4.29	349	29.0	100.8	21.2	5.01	5.67
2.5% <i>G</i> -sap + 75% RDF	87.1	408	301	3.29	298	27.8	77.7	20.1	3.96	4.19
5% <i>G</i> -sap + 75% RDF	88.1	410	311	3.50	301	27.9	81.1	20.2	3.99	4.30
10% <i>G</i> -sap + 75% RDF	89.3	420	330	3.88	320	28.1	89.5	20.9	4.67	4.89
15% <i>G</i> -sap + 75% RDF	92.4	440	350	4.11	340	28.6	95.9	21.1	4.95	5.55
75% RDF + water spray	72.3	389	278	2.95	267	27.1	70.0	20.1	3.77	4.00
100% RDF	82.4	406	301	3.45	295	28.6	80.1	20.3	3.93	4.25
SEm±	1.53	6.5	6.6	0.11	6.6	0.45	4.29	0.58	0.16	0.20
CD (P=0.05)	4.59	19	20	0.33	20	NS	12.8	NS	0.48	0.61

DMA, Dry-matter accumulation; *K*-sap, *Kappaphycus*-sap; *G*-sap, *Gracilaria*-sap; RDF, recommended dose of fertilizer

Table 3. Effect of *Kappaphycus* and *Gracilaria* seaweed extracts on growth, yield attributes and yields of potato (pooled data of 2 years)

Treatment	Plant height (cm)	Dyr-matter accumulation (g/m ²)	Leaf-area index at 60 DAP	Tuber dry weight (g/m ²)	Tuber bulking rate (g/m ² /day)	Tubers/m ²	Tuber yield (t/ha)
2.5% <i>K</i> -sap + 75% RDF	62.8	125.3	2.97	2106	26.9	40.6	18.2
5% <i>K</i> -sap + 75% RDF	64.6	131.3	3.01	2134	27.0	41.7	18.8
10% <i>K</i> -sap + 75% RDF	67.9	141.0	3.23	2204	27.6	44.8	20.8
15% <i>K</i> -sap + 75% RDF	71.3	145.1	3.41	2353	30.5	47.3	23.9
2.5% <i>G</i> -sap + 75% RDF	62.2	125.0	2.93	2100	26.9	40.9	18.2
5% <i>G</i> -sap + 75% RDF	63.7	129.7	2.99	2156	27.0	41.1	18.3
10% <i>G</i> -sap + 75% RDF	66.0	135.3	3.15	2200	27.7	44.1	20.1
15% <i>G</i> -sap + 75% RDF	70.0	143.9	3.33	2325	30.1	47.3	23.5
75% RDF + water spray	56.8	101.4	2.67	2020	23.0	35.0	16.3
100% RDF	60.7	121.4	2.99	2090	26.0	41.0	18.1
SEm±	1.11	2.0	0.09	11	1.21	1.66	1.12
CD (P=0.05)	3.3	6.0	0.25	33	3.17	4.95	3.33

K-sap, *Kappaphycus*- sap; *G*-sap, *Gracilaria*-sap; RDF, recommended dose of fertilizer

RDF. In case of potato and blackgram, application of 15% *K*-sap + 75% RDF showed approx 30 and 45% more tuber and seed yields correspondingly over conventional practice, i.e. 100% RDF. However, there was not much improvement in the yield of the different crops in the system when seaweed extract concentration was increased from 2.5% (V/V) to 5% (V/V). While, the sap concentration was 10% or more, a significant augmentation in the economic yield of the crops was recorded. Such increment might be owing to the fact that seaweed extract is a bio-stimulant, which provides the crops with macro and micro-nutrients and significant amounts of cytokinins, auxins and betaines ultimately increasing the chlorophyll production by boosting the photosynthetic process, thereby stimulating vegetative growth (Blunden, 1991). Thus, the overall plant performance would be enhanced accordingly and finally reflecting through an escalated productivity. These results corroborate the findings of Bai *et al.* (2008) on *Phaseolus aureus* and Abdel-Mawgoud *et al.* (2010) on watermelon, Pramanick *et al.* (2013, 2017) on greengram and potato.

Nutrient uptake by crops in the sequence

The use of the seaweed extracts at higher concentrations (10% and above) increased N, P and K uptake in the grains, seeds and tubers of respective crops significantly and the uptake reached the maximum level at 15% of both the 2 seaweed extracts compared with the treatments having only inorganic sources of nutrients (Tables 5, 6 and 7). The maximum values of N, P and K uptake in grain/tuber/seed as well as straw/stover of different crops were recorded with the application of 15% *K*-sap + 75% RDF being statistically at par with the application of 15% *G*-sap

+ 75% RDF, while the minimum values were observed under 75% RDF+water spray (Table 5). Application of 15% *K*-sap + 75% RDF resulted in 49, 74 and 36% more N, P and K uptake in rice grain respectively; 11, 20 and 12% more N, P and K uptake in potato tuber and 42, 88 and 45% more N, P and K uptake in blackgram seed than that of under conventional practice. It was already observed that combined application of both *K* and *G*-sap @ 10% or more (v/v) with 75% RDF increased the yield of rice, potato and blackgram to a great extent. So, ultimately higher nutrient uptake was also observed with these sap application. These results confirm the findings of Crouch *et al.* (1990), who noted increased uptake of Mg, K and Ca in lettuce with application of seaweed concentrate. Turan and Köse (2004) and Mancuso *et al.* (2006) also observed increased uptake of N, P, K and Mg in grapevines and cucumber with application of seaweed extract. The presence of marine bioactive substances in seaweed extract improves stomata uptake efficiency in treated plants compared to non-treated plants (Mancuso *et al.* 2006). Seaweed sap is proved to increase root size and vigour, root: shoot ratios and biomass accumulation by stimulating root growth. All these indicate that the components in seaweed, particularly having a good amount of phosphorus as well as auxin, had a considerable effect on root growth and development (Jeannin *et al.*, 1991).

System productivity and economics

The highest values of system productivity (30.25 t/ha/year) and REY (38.88 t/ha/year) were evident with the application of 15% *Kappaphycus*-sap along with 75% RDF and it was statistically at par with the application of 15% *Gracilaria*-sap along with 75% RDF (Table 6). The

Table 4. Growth, yield attributes and yields of blackgram receiving different concentration of seaweed *Kappaphycus* and *Gracilaria* extracts (pooled data of 2 years)

Treatment	Plant height (cm)	Dry-matter accumulation (g/m ²)	Nodules/plant	Leaf-area index at 60 DAS	Branches/plant	Pods/plant	Seeds/pod	1,000-seed weight (g)	Seed yield (t/ha)	Stover yield (t/ha)
2.5% <i>K</i> -sap + 75% RDF	31.3	342	18.5	2.89	5.17	11.02	5.42	41.0	0.92	3.46
5% <i>K</i> -sap + 75% RDF	32.3	352	19.3	3.21	5.47	11.83	5.74	41.2	0.96	3.48
10% <i>K</i> -sap + 75% RDF	34.2	359	20.2	3.31	6.24	12.55	6.02	42.1	1.19	4.00
15% <i>K</i> -sap + 75% RDF	36.7	392	23.1	3.47	6.97	13.23	7.17	42.9	1.35	4.02
2.5% <i>G</i> -sap + 75% RDF	30.0	332	17.8	2.99	5.09	10.59	5.45	41.1	0.91	3.40
5% <i>G</i> -sap + 75% RDF	30.6	349	18.3	3.12	5.37	10.74	5.98	41.4	0.93	3.45
10% <i>G</i> -sap + 75% RDF	33.5	351	19.2	3.38	6.09	12.06	6.13	42.1	1.17	3.90
15% <i>G</i> -sap + 75% RDF	36.0	384	22.9	3.49	6.53	12.98	6.97	42.6	1.32	4.00
75% RDF + water spray	25.2	326	16.8	2.77	4.55	8.67	4.89	40.0	0.86	3.05
100% RDF	29.9	351	18.7	2.89	5.05	10.97	5.16	41.1	0.91	3.15
SEm±	1.41	6.7	1.26	0.18	0.4	1.7	0.4	1.26	0.80	0.90
CD (P=0.05)	4.18	20	3.74	0.53	1.2	5.1	NS	NS	2.37	2.69

K-sap, *Kappaphycus*- sap; *G*-sap, *Gracilaria*-sap; RDF, recommended dose of fertilizer

Table 5. Effect of different concentrations of *Kappaphycus* and *Gracilaria* seaweeds extract on nutrient uptake in grain/tuber/seed and straw/stover of rice, potato and blackgram (pooled data of 2 years)

Treatment	Grain/tuber/seed uptake (kg/ha)						Straw/stover uptake (kg/ha)						
	N		P		K		N		P		K		
	Rice	Black-gram	Potato	Black-gram	Rice	Black-gram	Potato	Black-gram	Rice	Black-gram	Rice	Black-gram	
2.5% K-sap + 75% RDF	53.7	45.3	9.21	28.9	3.35	56.1	201	17.9	85.5	13.83	4.33	180.1	58.4
5% K-sap + 75% RDF	54.9	46.3	9.85	29.3	3.89	57.3	209	18.1	91.9	14.55	4.67	60.1	60.1
10% K-sap + 75% RDF	59.3	51.0	11.07	31.5	4.51	60.2	217	19.7	101.7	15.23	5.67	70.7	70.7
15% K-sap + 75% RDF	64.2	57.7	13.68	32.6	5.85	65.7	222	23.0	143.3	17.05	7.83	81.0	81.0
2.5% G-sap + 75% RDF	51.7	41.7	8.95	28.5	3.22	54.6	200	16.9	81.2	12.9	4.03	55.5	55.5
5% G-sap + 75% RDF	53.1	45.2	9.33	29.0	3.51	56.4	206	17.5	89.8	13.93	4.52	59.8	59.8
10% G-sap + 75% RDF	56.9	48.8	10.27	30.0	3.93	58.8	212	18.0	98.1	14.87	5.25	66.9	66.9
15% G-sap + 75% RDF	61.6	55.1	12.99	31.0	5.21	63.3	218	21.7	133.3	16.74	6.93	76.6	76.6
75% RDF + water spray	40.6	38.1	7.03	25.1	2.5	46.7	189	14.4	71.0	10.33	3.25	48.7	48.7
100% RDF	43.2	40.7	7.83	27.1	3.11	48.3	199	15.9	85.0	12.05	3.99	53.6	53.6
SEm±	2.19	1.72	0.45	1.42	0.33	1.71	3.6	1.41	4.89	0.72	0.27	1.76	1.76
CD (P=0.05)	6.6	5.47	1.34	3.84	0.97	5.15	10	4.13	14.5	2.15	0.85	5.3	5.3

K-sap, *Kappaphycus*-sap; G-sap, *Gracilaria*-sap; RDF, recommended dose of fertilizer

maximum net monetary return ($\text{₹}231.7 \times 10^3/\text{ha}/\text{year}$) and benefit: cost ratio (2.61) were also observed in the same combination. Though the application of foliar extracts over 75% RDF increased the cost of cultivation to the tune of ₹700 to 7,300 under 5, 10 and 15% (V/V) sap concentration over conventional 100% RDF, the significant yield augmentation owing to the application of these extracts escalated the net monetary return and ultimately the benefit: cost ratio over conventional method of cultivation. Being a wealthy source of versatile plant nutrients especially potassium (K), phosphorus (P), calcium (Ca), iron (Fe), manganese (Mg) etc., phytohormones especially cytokinin, auxin and gibberellins; amino acids; vitamins; stimulatory and antibiotic substances the liquid seaweed extract enhances root volume and proliferation, biomass 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 vigour ultimately reflecting higher yield and superior quality of agricultural products.

Thus it can be concluded that the seaweed extracts are effective in increasing the growth parameters, yield attributes, yield *vis-à-vis* economics of the cropping system. The saps also enhance nutrient uptake by different crops. Presence of microelements and plant-growth regulators, especially cytokinins (Zodape *et al.*, 2009) in *Kappaphycus* and *Gracilaria* extracts is responsible for the increased yield and improved nutrition of different crops receiving foliar application of the aforesaid 2 saps.

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Table 6. System productivity, rice-equivalent yield (REY) and economics of different treatments of seaweed extracts (pooled data of 2 years)

Treatment	System productivity (t/ha/year)	REY of system (t/ha/year)	Cost of cultivation ($\times 10^3$ ₹/ha/year)	Gross returns ($\times 10^3$ ₹/ha/yr)	Net returns ($\times 10^3$ ₹/ha/year)	Benefit: cost ratio
2.5% <i>K</i> -sap + 75% RDF	23.10	29.82	135.6	285.2	149.6	2.10
5% <i>K</i> -sap + 75% RDF	23.76	30.50	137.3	293.0	155.7	2.13
10% <i>K</i> -sap + 75% RDF	26.73	35.09	140.6	333.8	193.2	2.37
15% <i>K</i> -sap + 75% RDF	30.25	38.88	143.9	375.6	231.7	2.61
2.5% <i>G</i> -sap + 75% RDF	23.02	29.66	135.6	283.8	148.1	2.09
5% <i>G</i> -sap + 75% RDF	23.25	29.97	137.3	287.2	149.9	2.09
10% <i>G</i> -sap + 75% RDF	25.90	34.14	140.6	324.2	183.7	2.31
15% <i>G</i> -sap + 75% RDF	29.72	38.23	143.9	368.8	224.9	2.56
75% RDF + water spray	20.96	26.31	134.0	259.9	125.9	1.94
100% RDF	22.95	29.52	136.6	282.4	145.7	2.07
SEm±	0.66	1.09	1.32	11.4	5.55	0.037
CD (P=0.05)	1.95	3.20	3.91	33.7	16.8	0.11

K-sap, *Kappaphycus*-sap; *G*-sap, *Gracilaria*-sap; RDF, recommended dose of fertilizer

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