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Effect of liquid seaweed sap on yield and economics of summer rice

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ABSTRACT

The experiment was conducted during 2011 and 2012 to study the efficacy of liquid seaweed sap of Kappaphycus alvarezii and Gracilaria edulis on growth and yield performance of summer rice in a lowland field at Gerua, Assam.The treatments consisted of Kappaphycus (K) sap and Gracilaria(G) sap, each in four different doses viz., 2.5%, 5%, 10% and 15% in combination with recommended doses of fertilizer (RDF); and were compared with RDF in combination with water spray, and, also with the 7.5% K sap+50% RDF. A total of 10 treatments were evaluated and the results indicated that rice grain yield was increased by 13.8% and 10.3% in the treatments 5% K sap+ RDF and 5%G sap+ RDF, respectively, as compared to RDF + water spray. The increase in yield was attributed to increase in the number of panicles per unit area, number of filled grains panicle^{-1} and test weight. Highest net return (₹ 29751ha^{-1}) and benefit: cost ratio(1.75) was obtained under 5%K sap+RDF with 20% increase in net return as compared to RDF + water spray. Application of 5% K or G sap in combination with RDF increased grain and straw yield, net income and benefit:cost ratio of summer rice.

Key words: *summer rice, liquid seaweed sap, yield, economics, lowland*

The demand for rice in India is increasing because of population growth and an expected diet change (Joshi *et al*., 2009). To meet the increasing demand, farmers are using chemical fertilizers to enhance their crop production. Declining trend in productivity due to continuous use of chemical fertilizers alone has been observed in several long term experiments all over India. Therefore, emphasis should be given to optimize the use of chemical fertilizers and to improve their use efficiency. Integrated nutrient management by combining chemical fertilizers with organic manures and bio fertilizers is important for improving and sustaining the crop productivity and profitability of dry season rice (Hegde, 1998).

Seaweed extracts, as foliar nutrient spray,have been used in horticulture for several decades (Blunden,1991; Turan and Kose, 2004) and being organic and bio degradable, it is important in sustainable agriculture (Cassan *et al*., 1992).Seaweed extracts are effective fertilizer in many crops including vegetables, trees, flowering plants and grain crops (Ferreira and Lourens, 2002; Strik *et al*., 2004; Zodape *et al*., 2008; Shah *et al*., 2013). Central Salt and Marine Chemical Research Institute (CSMCRI), Bhavnagar introduced the commercially important seaweed *Kappaphycus alvarezii* in India. The liquid seaweed sap prepared through liquefaction of fresh *Kappaphycus alvareziiis* is rich in plant nutrients (micro and macro) as well as plant growth regulators (Table 1). It has proven to be very effective in increasing the productivity of various crops, reducing insect and disease incidents, as evidenced from limited scale exploratory trials (Zodape, 2011). Recently sap of another fast growing algae-*Gracilaria edulis* whose cultivation technology has been optimized by CSMCRI, have given encouraging results as liquid fertilizer in sugarcane (Zodape, 2011). Thus, it may be very useful in achieving high incremental biomass and grain yield in rice.Hence, the present study was undertaken to study the efficacy of liquid seaweed sap from *Kappaphycus alvarezii* and *Gracilaria edulis* as foliar spray on growth and productivity of summer rice.

MATERIALS AND METHODS

A field experiment was conducted during the summer season (*boro*) of 2011-12 and 2012-13 at Gerua, Assam to study the efficacy of liquid seaweed sap of *Kappaphycus alvarezii* and *Gracilaria edulis* on growth and yield performance of rice. The soil of the experimental field was alluvial with clay loam texture, acidic reaction (pH 6.0), high in organic carbon (0.81%), medium in available nitrogen (284 kg ha^{-1}) and P_2O_5(40.4 kg ha^{-1}), and high in available K_2O (353 kg ha^{-1}). The experimental field comes under shallow lowland with assured irrigation facilities. The treatments consisted of *Kappaphycus* (K) sap in four different doses *viz.*, 2.5%, 5%, 10% and 15% in combination with recommended dose of fertilizer (RDF); *Gracilaria* (G) sap in four different doses *viz.*, 2.5%, 5%, 10% and 15% in combination with RDF. These 8 treatments were compared with RDF + water spray, and 7.5% K Sap+50% RDF. Thus, a total of 10 treatments were evaluated in a randomized complete block design with three replications.

The sprouted seeds of the test variety 'Chandrama' (165 days duration) were sown in wet nursery in November end in both the years of experimentation. Sixty days old seedlings were transplanted at 20 cm x 15 cm spacing with 2 to 3 seedlings $hill^{-1}$. The crops were raised with RDF of 80: 40: 40 kg N, P_2O_5 and K_2O ha^{-1}. Half of the fertilizer N, full dose of P_2O_5 and half of K_2O were applied at final land preparation. The rest half of the N and K_2O fertilizer were applied in 2 equal splits *viz.*, at active tillering (45 days after transplanting (DAT)) and panicle initiation stage (75 DAT). The experimental field was kept saturated during first 5- 7 days, and then standing water level of 3-5 cm was maintained till 15 days prior to maturity. Two hand weeding were done at 30 and 60 DAT.Recommended agronomic and plant protection measures were adopted. The sea weed saps of *Kappaphycus alvarezii* and *Gracilaria edulis* were received from Aqua Agri Processing Private Limited, Manamadurai, Tamil Nadu and Marine Algal Research Station, Mandapam camp of CSMCRI. These liquid fertilizers were sprayed three times at an early tillering stage (30 DAT), maximum tillering stage (60 DAT) and at Panicle initiation stage (75 DAT) using knapsack sprayer fitted with flat fan nozzle at spray volume of 500 l ha^{-1}.The mean maximum and minimum temperature recorded during the crop period was 33.4 ^{O}C and 8.7 ^{O}C, respectively. The crop received more than 200 mm rainfall during reproductive stage of the crop.

Weed species associated with the crop were recorded at the time of 1st weeding (30 DAT).The growth parameters were recorded at different growth stages. Days to flower initiation, days to 50% flowering and days to 100% flowering were recorded plot wise by visual observations.The crops were harvested at maturity.Grain and straw yield (t ha^{-1}) of rice along with other yield attributing characters *viz.*, plant height (cm), tiller numbers m^{-2}, panicles m^{-2}, grains $panicle^{-1}$,

Table 1. Chemical Constitution of Neat Sap of *Kappaphycus alvarezii* after ultra filtration

Nutrient	Amount present
Moisture	94.38g $100ml^{-1}$
protein	0.085g $100ml^{-1}$
Fat	0.0024g $100ml^{-1}$
Crude Fibre	0.0g $100ml^{-1}$
Carbohydrate	1.800 g $100ml^{-1}$
Energy	7.54 K cal 100 ml^{-1}
Sodium	18.10 mg 100 ml^{-1}
Potassium	358.35 mg 100 ml^{-1}
Magnesium	116.79 mg 100 ml^{-1}
Phosphorous	2.96 mg $100ml^{-1}$
Calcium	32.49 mg $100ml^{-1}$
Indole acetic acid	23.36 mg L^{-1}
Gibberelin GA3	27.87 mg L^{-1}
Iron	8.58 mg $100ml^{-1}$
Manganese	0.22 mg $100ml^{-1}$
Nickel	0.35 mg $100ml^{-1}$
Copper	0.077mg $100ml^{-1}$
Zinc	0.474mg $100ml^{-1}$
Chromium	3.5microg $100ml^{-1}$
Lead	0.51microg $100ml^{-1}$
Thiamine	0.023mg $100ml^{-1}$
Riboflavin	0.010mg $100ml^{-1}$
B-Carotene	0.0mg $100ml^{-1}$
Iodine	160microg $100ml^{-1}$
Kinetin+Zeatin	31.91mg L^{-1}

Data courtesy National Institute of Nutrition, Hyderabad, India (except growth hormone data generated at CSMCRI using quantitative MS-MS and LC-MS techniques); Sap is stable for 1 year when stored with preservative; Note that normal sap used for agriculture is only subjected to coarse filtration and not ultra filtration.

1000 grain weight (g) were recorded at harvest. The grain and straw were dried under sun and, subsequently, yields were recorded at 14% and 10% moisture, respectively. The data related to growth and yield parameters were analyzed applying analysis of variance. Significance of treatments was tested by F-test (Gomez and Gomez, 1984) and the Least Significant Difference (LSD) was calculated at 5% probability. Maximum and minimum temperature, relative humidity, rainfall, and pan evaporation were recorded during crop growth period. Economics were calculated following standard technique.

RESULTS AND DISCUSSION

In both the years, semi-aquatic weeds were observed during early crop growth period. The dominant weed species observed in the experimental field were *Monochoria vaginalis* (Burm. F.), *Echinochloa glabrescens* (Murno ex Hook.f.), *Cyperus difformis* L, *Schoenoplectus articulatus* (L.), *Ludwigia adscendens* (L.) and *Fimbristylis mileacea* (L.).

It was observed that the vegetative growth of the crop was better in the plots treated with different doses of K and G sap in combination with RDF (Table 2). Among the K sap treated plots, 15% K sap+ RDF recorded significantly higher plant height (94.2 cm) than RDF + water spray. However, other treatment combinations of K sap have no significant effect on plant height. Among the G sap treated plots, 15%G sap+RDF and 10%G sap +RDF significantly increased plant height as compared to RDF + water spray. The plant height was reduced significantly in plots treated with 7.5% K sap+50% RDF. The number of tillers m^{-2} increased significantly in the plots treated with different doses of K and G sap except in the lower dose (2.5% K sap+RDF and 2.5% G sap+RDF). Plots treated with 15% Ksap+RDF recorded highest number of tillers m^{-2} (412) and similar tillers(410) were recorded under10% G sap+RDF. The plots treated with 7.5% K sap+50% RDF recorded significantly less tillers than RDF + water spray. The days to 50% flowering was not affected under different doses of K and G sap, except in plots treated with 2.5% K sap+RDF. The days to 50% flowering was prolonged significantly under this treatment.

The grain and straw yield of summerrice increased under the treatments with 5% and 10%K and G sap + RDF as compared to RDF + water spray (Table 3). The plots treated with 5%K sap + RDF registered 13.6% increase in grain yield over the plots treated with RDF+water spray. A similar yieldincrease of 10.3% was recorded under 5% G sap + RDF. When 15% concentration was used, there was no beneficial effect on yield. Lower concentration (2.5%) was not effective in improving grain yield over RDF +water spray. In case of K sap, yields were low due to infestation with sheath rot disease. The increases in grain yield under 5% and 10% concentrations of K and G sap were due to more number of panicles per unit area, filled grains $panicle^{-1}$ and test weight. The

Table 2. Growth and attributes of summer rice under different treatments

Treatment	Plant height (cm)	Tillers m^{-2}	Days to 50% flowering	Panicle length (cm)	Spikelets $Panicle^{-1}$	Grain Filling (%)
2.5% K Sap + RDF	91.4	372	157.9	22.8	120.7	73.2
5% K Sap + RDF	95.7	406	153.2	24.3	142.8	79.0
10 % K Sap + RDF	96.8	400	153.9	23.9	138.5	79.4
15% K Sap + RDF	95.9	412	154.2	24.0	131.0	77.0
2.5% G Sap + RDF	92.8	380	152.7	23.3	131.3	75.6
5% G Sap + RDF	95.0	396	153.7	24.1	140.7	77.0
10% G Sap + RDF	95.7	410	152.7	24.0	139.8	77.2
15% GSap + RDF	96.0	404	152.0	23.4	134.2	78.3
RDF+Water spray	92.5	408	153.4	22.8	119.9	75.1
7.5% K Sap + 50% RDF	91.1	362	153.3	23.1	118.0	73.2
CD (P<0.05)	3.09	26.4	1.96	0.96	7.39	2.1

K sap - *Kappaphycus* sap, G sap - *Gracilaria* sap, RDF - Recommended doses of fertilizer

treatment 7.5% K sap + 50%RDF yielded less as compared to RDF due to significantly reduction in numbers of panicles per unit area. Reduced fertilizer dose by 50% was responsible for decrease in plant height and panicles per unit area leading to less grain and straw yield.

The highest net return (₹ 29751 ha^{-1}) was obtained in the plots treated with 5% K sap + RDF (Table 4). It was due to relatively higher yield obtained from this treatment coupled with less investment in K sap application. The highest benefit: cost ratio *i.e.*, income per rupee investment (1.75) was also recorded under this treatment with 20% increase in net income over the plots treated with RDF +water spray. Though highest gross return (₹ 69675 ha^{-1}) was registered in plots treated with 10% K sap+ RDF, it was not reflected in terms of net return, due to more cost involved in application of K sap (double dose).Among the G sap treated plots, 5% G sap+RDF recoded highest net return of (₹ 27749 ha^{-1}) and B:C ratio (1.70).The plots receiving 7.5% sap+50% RDF recorded less net return and B:C ratio as compared to plots receiving RDF +water spray. This decrease in net income was due to decrease in grain yield.

Based on the experimental findings, it is concluded that 5%K or G sap in combination with recommended dose of fertilizer helped to increase in grain and straw yield, net income and benefit:cost ratio of summer rice.

Table 4. Economics of summer rice under different treatments of seaweed sap

Treatments	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C
2.5% K Sap + RDF	55460.00	16780.00	1.42
5% K Sap + RDF	69556.00	29751.00	1.75
10% K Sap + RDF	69675.00	27620.00	1.65
15% K Sap + RDF	64855.00	20600.00	1.46
2.5% G Sap + RDF	63810.00	25130.00	1.65
5% G Sap + RDF	67554.00	27749.00	1.70
10% G Sap + RDF	67563.00	25508.00	1.61
15% G Sap + RDF	66553.00	22223.00	1.50
RDF + water spray	61442.00	24742.00	1.67
7.5% K Sap + RDF	55083.00	16265.00	1.42

Table 3. Yield and yield attributes of summer rice under different treatments

Treatments	Panicles (m^2)	Grains $Panicle^{-1}$	Panicle wt (g)	Test wt (g)	Grain yield t ha^{-1}	Straw yield t ha^{-1}	Harvest index
2.5% K Sap + RDF	216.8	88.1	2.5	22.8	4.61	5.33	46.2
5% K Sap + RDF	283.8	112.2	3.5	24.3	5.86	6.39	48.2
10 % K Sap + RDF	274.3	109.6	3.4	23.8	5.87	6.24	48.4
15% K Sap + RDF	279.8	100.8	3.2	23.7	5.44	6.05	47.3
2.5% G Sap + RDF	266.0	98.9	3.1	23.6	5.38	6.15	46.7
5% G Sap + RDF	275.1	110.2	3.4	24.0	5.69	6.22	47.8
10% G Sap + RDF	285.6	107.2	3.4	23.7	5.68	6.32	47.4
15% G Sap + RDF	268.2	97.4	3.1	23.7	5.59	6.14	47.6
RDF+Water spray	246.7	89.9	2.9	23.3	5.16	5.74	47.3
7.5% K Sap + 50% RDF	209.5	85.7	2.6	22.9	4.62	5.24	45.8
CD (P<0.05)	20.5	6.0	0.34	0.38	0.41	0.40	0.80

K sap - *Kappaphycus* sap, G sap - *Gracilaria* sap, RDF - Recommended doses of fertilizer

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