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Effect of Seaweed Saps *Kappaphycus alvarezii* and *Gracilaria* on Growth, Yield and Quality of Rice

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Abstract

A field experiment was conducted during 2013 to study the fertilizer potential of seaweed saps (*Kappaphycus alvarezii* and *Gracilaria*) on growth, yield, quality and chlorophyll response of rice var. ADT 43. Foliar sprays of both saps at the rate of 2.5, 5.0, 7.5, 10 and 15% were sprayed on foliage of rice at 35, 45 and 60 days after transplanting along with control (no spray). Foliar spraying of seaweed extract on foliage of rice significantly influenced the growth, yield attributes, grain yield, quality and chlorophyll content. Results revealed that spraying of seaweed extract @ 15% K sap with 100% RDF recorded significantly higher growth, yield attributes and chlorophyll content that were followed by spraying of seaweed extract @ 15% G sap with 100% RDF. It was found that yield of grain was increased significantly by 11.80% and 9.52% for plants receiving 15% concentrations of both K sap and G sap respectively, over control.

Key words: Chlorophyll Content, Growth, Quality, Rice, Seaweed Sap, Yield

1. Introduction

In the last decades, environmental pollution, chemical treatment and upgrading food using additive substances create a new dimension to the problem of rational nutrition, with direct implications on human health. It has become vital and necessary to promote organic farming techniques. Use of seaweed extract in organic farming technique is one of the safest ways to conserve environmental resources, avoid pollution and obtain food and agriculture crops. Seaweeds are organic and biodegradable in nature[1]. Seaweed extracts have proven to accelerate the health and growth of plants. Seaweed extracts supplies nitrogen, phosphorous, potash as well as trace minerals like Zn, Mn, Mg, Fe, etc[2]. Its extract contains natural plant growth substances like auxins, gibberlins and cytokinins[3]. This trace elements present in seaweed extract are in naturally chelated form and are readily available to plants. It accelerates photosynthesis and further develops healthy foliage[4]. Foliar spraying of seaweed sap to crops, vegetables, trees increased growth, grain and yield of plants[5]. It is essential to explore the extent of applicability of seaweeds extract in organic farming techniques. Hence, in present investigation possibilities were explored to study the effect of foliar applications of *Kappaphycus alvarezii* and *Gracilaria* sp. on growth, yield and quality improvement of rice.

2. Materials and Methods

2.1 Experimental Sites and Treatment Details

For the present study experiment was carried out during rabi season at Sugarcane research station, Cuddalore, Tamil Nadu. Experimental site is located at 11.46'N and 79.48'E having altitude of 4.6 m MSL. Experimental soil texture was found to be clay loam with organic carbon content as high as 0.66%. Available N, P_2O_5 and K_2O are 126.8, 12.3 and 206 kg ha^{-1}. Rice variety ADT 43 was used as test crop. Sowing of rice crop was done during rabi season, 2013 and after 30 days after planting transplanting was done. Experiment was laid out in a randomized block design with three replications Seaweed saps were given

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foliar spray at 35, 45 and 60 days after transplanting. The following treatments were included in the study.

T_1 :100%RDF (Recommended dose of fertilizer)
T_2 :100%RDF+ Water spray
T_3 :50% RDF +7.5% K sap
T_4 :100%RDF+2.5% K sap
T_5 :100%RDF+5% K sap
T_6 :100%RDF+10% K sap
T_7 :100%RDF+15% K sap
T_8 :100%RDF+2.5% G sap
T_9 :100%RDF+5% G sap
T_{10} :100%RDF+10% G sap
T_{11} :100%RDF+15% G sap
T_{12} :50% RDF +7.5% G sap

2.2 Observations

Randomly five plants were tagged in each plot for recording observations. Plant height was recorded at 30, 45 and 90 Days After Transplanting (DAT). No. of productive tillers m^{-2}, No. of productive tillers per hill, Panicle length, 1000 grain weight, yield, dry matter accumulation, crop growth rate and leaf area index were recorded. Grain yield and straw yield were determined at the time of harvest. Rice grains were used for analyzing quality parameters. Total carbohydrate and starch in rice grain samples were estimated by Anthrone method[6] Amylose was estimated by calorimetry method using Iodine reagent[7] and reducing sugar was estimated by Nelson Somogyl method[8]. Fresh 3rd plant leaf was collected for the analysis of chlorophyll content of different treatments. Chlorophyll is extracted by 80% ethanol and further measured at spectro photometer at wavelength 645nm and 663nm[9].

2.3 Statistical Analysis

Experimental data collected from the present study were statistically analysed for analysis of variance using statistical analysis software, Agress. Significant differences between treatment means were compared using Critical Difference (CD) and were worked out at 5% significant.

3. Results and Discussion

Plant growth and yield attributes of plants, yield of grains, quality of rice as well as chlorophyll content were greatly influenced by foliar application of seaweed sap. Chemical properties of seaweed saps were given in Table 1.

Table 1. Chemical Properties of Seaweed Sap

Chemical analysis of seaweed sap	*Kappaphycus sap*	*Gracilaria sap*
pH	6.75	4.79
EC (dS/m)	6.15	5.47
Organic carbon %	0.71	0.62
Total Nitrogen %	0.103	0.038
Total Phosphorus%	0.007	0.002
Total Potassium%	11.099	5.968
Total Calcium %	13.473	5.446
Total Magnesium %	9.288	6.673
Cu (mg/g)	0.359	0.371
Zn (mg/g)	0.012	0.123
Mn (mg/g)	0.395	0.187
Fe (mg/g)	0.630	0.674

3.1 Effect of Seaweed Saps on Plant Height, LAI, Dry Matter Production and Crop Growth Rate of Rice

The experimental results depicted that foliar application of both seaweed saps increased plant height, LAI, dry matter production and crop growth rate of rice over control at all different growth stages (Table 2). Maximum plant height was increased at T_7 by 9.5%, 31.7% and 17.0% at 30, 60 and 90 DAT respectively over the control. This increase might be due to the existence of plant growth regulators, i.e., cytokinin, gibberellin, trace elements, vitamins and microelements in the extract[11]. LAI was recorded higher at 100% RDF with 15% K and G sap by 5.78 and 5.55 respectively. Dry matter production was maximum at T_7 (100%RDF+15% K sap) by 10729 kg ha^{-1}. Crop growth rate was measured at different growth stages and it was higher at T_7 with 12.98, 15.99 and 10.64 g m^{-1} day^{-1} respectively. This physiological responds was due to foliar application of seaweed sap that improved nutrient mobilization, and partitioning in increase leaf area, dry matter production and crop growth rate[12].

3.2 Effect of Seaweed Saps on Yield Attributes

Significant increased in yield attributes such as number of productive tillers m^{-2}, numbers of productive tillers per hill, panicle length, yield and straw were increased with the application of saps. Results revealed that maximum foliar application of 10% K sap with 100% RDF had increased the yield attributes which was followed by foliar application of 10% G sap with 100% RDF in all growth stages (Table 3). Highest number

Table 2. Effect of Seaweed Saps on Plant Height at Different Stages of Rice (Cm)

Treatments	Plant height (cm)			LAI	Dry matter production (kg ha^{-1})	Crop growth rate (g m^{-2} day^{-1})		
	30 DAT	60 DAT	90 DAT			30 DAT	60 DAT	90 DAT
T_1:RDF	43.9	53.9	75.4	3.37	9127	10.61	14.7	9.21
T_2:RDF+ Water spray	44.0	54.6	75.9	3.35	9137	10.82	14.8	9.24
T_3:50% RDF +7.5% K sap	40.9	45.5	71.3	2.76	7629	10.33	13.62	8.99
T_4:RDF+2.5% K sap	44.6	54.9	79.7	4.28	9252	11.83	15.38	9.97
T_5:RDF+5% K sap	46.9	56.8	80.9	4.38	9668	12.25	15.61	10.27
T_6:RDF+10% K sap	48.5	65.4	83.2	4.84	9892	12.83	15.91	10.38
T_7:RDF+15% K sap	54.6	78.9	90.8	5.78	10729	12.98	15.99	10.64
T_8:RDF+2.5% G sap	43.6	54.7	78.2	3.87	9192	11.96	15.18	9.24
T_9:RDF+5% G sap	44.5	56.1	78.9	4.33	9298	12.19	15.39	10.14
T_{10}:RDF+10% G sap	45.9	64.2	82.6	4.49	9735	12.78	15.73	10.3
T_{11}:RDF+15% G sap	49.3	73.3	84.3	5.55	10448	12.91	15.79	10.54
T_{12}:50% RDF +7.5% G sap	40.8	45.7	69.8	2.67	8987	10.32	13.57	8.93
SE(d)	0.33	1.46	3.30	0.2	310	0.55	0.39	0.38
Cd	0.70	3.05	6.90	0.42	644	1.15	0.8	0.78

Table 3. Effect of Seaweed Saps on Yield Attributes of Rice

Treatments	No. of productive tillers m^{-2}	No. of productive tillers per hill	Panicle length (cm)	1000 grain weight (gm)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1:RDF	176.3	12.67	21.36	18.39	5470	6167
T_2:RDF+ Water spray	200.0	12.00	21.57	18.48	5481	6391
T_3:50% RDF +7.5% K sap	172.3	9.00	17.00	18.27	4484	380
T_4:RDF+2.5% K sap	212.6	10.01	23.37	19.50	5611	6291
T_5:RDF+5% K sap	254.3	11.66	24.15	19.83	5857	6647
T_6:RDF+10% K sap	266.7	15.02	25.13	20.06	5980	7202
T_7:RDF+15% K sap	277.0	18.34	26.20	21.27	6202	7716
T_8:RDF+2.5% G sap	204.7	9.67	22.24	19.13	5567	6429
T_9:RDF+5% G sap	259.3	10.66	23.25	19.67	5622	6635
T_{10}:RDF+10% G sap	264.0	14.67	24.17	19.86	5881	7095
T_{11}:RDF+15% G sap	269.3	17.01	25.83	20.48	6046	7283
T_{12}:50% RDF +7.5% G sap	172.3	9.33	17.60	18.03	4345	5377
SE(d)	9.919	0.663	0.570	0.294	31.55	69.48
Cd	20.704	1.384	1.190	0.615	65.85	145.02

of productive tillers m^{-2} (277.0 and 269.3 nos.), no. of productive tillers per hill (18.34 and 17.01 nos.), panicle length (26.20 and 25.83 cm) and 1000 grain weight (21.27 and 20.48 g) respectively were recorded at T_7 and T_{11}. The lowest values of yield attributes were recorded at 50%RDF+7.5% K and G sap in all growth stages. This is in conformity that foliar spraying of seaweed extract significantly increased higher growth and yield attributes of rice[4]. Presence of plant growth regulators, trace elements, vitamins and micronutrients in seaweed extract enhanced the growth and yield contributing characters like number, weight and length of spike as well as grain weight[13]. Grain yield recorded highest at T_7 (100%RDF+15% K sap) with 6202 kg ha^{-1} which was followed by T_{11}. Highest straw yield was 7716 kg ha^{-1} at T_7 which was on par with T_{11} (100% RDF+15% G sap) with 7283 kg ha^{-1}. Percentage of grain yield increase was 11.80% and 9.52 % for the treatment T_7 (100%RDF+15%

K sap) and T_{11} (100%RDF+15% G sap) respectively over control. Spraying seaweed extract on the foliage of rice significantly influenced the yield attributes and grain yield. This was due to presence of readily available nutrients like nitrogen, phosphorous, potash as well as trace mineral which helps in increasing yield[4].

3.3 Effect of Seaweed Sap on Quality Parameters of Rice

Increment of quality parameters of rice were recorded with the combined application of seaweed saps and fertilizer than control (Table 4). Plants sprayed with 15% K sap with 100% RDF followed by 15% G sap with 100% RDF showed increased in nutritional quality of rice by starch, 91.64 and 90.00%; carbohydrate, 81.19 and 77.79 %; reducing sugar, 33.83 and 33.25%; and amylose, 38.40 and 38.17 % respectively. Lowest starch, carbohydrates, reducing sugar and amylose content of rice were observed at T_3 and T_{12} which was even lower than control. Such increase in starch, carbohydrates, reducing sugar and amylose may be attributed to the increased availability and absorption of necessary elements (Ca, Na, K, Mg, N and Zn) present in seaweed extracts[14,15].

Table 4. Effect of Seaweed Saps on Quality Parameters of Rice

	Treatment	Starch (%)	Carbohydrates (%)	Reducing sugar (%)	Amylose (%)
T_1	RDF	53.81	67.34	30.61	23.25
T_2	RDF+ Water spray	61.05	67.54	32.16	23.46
T_3	50% RDF +7.5% K sap	42.07	58.99	26.81	17.66
T_4	RDF+2.5% K sap	74.23	70.47	28.19	24.70
T_5	RDF+5% K sap	83.25	71.96	31.28	28.22
T_6	RDF+10% K sap	86.37	77.66	32.36	33.51
T_7	RDF+15% K sap	91.64	81.19	33.83	38.40
T_8	RDF+2.5% G sap	67.15	65.87	26.35	24.24
T_9	RDF+5% G sap	78.22	71.37	29.74	27.16
T_{10}	RDF+10% G sap	83.46	75.82	30.33	33.05
T_{11}	RDF+15% G sap	90.99	77.79	33.25	38.17
T_{12}	50% RDF +7.5% G sap	35.56	58.00	25.65	15.97
SE(d)		1.22	0.19	0.07	0.87
Cd		2.54	0.40	0.15	1.81

3.4 Effect of Seaweed Saps on Chlorophyll Content

Concerning the foliar application of seaweed extract on chlorophyll content, data showed that chlorophyll 'a', chlorophyll 'b' and total chlorophyll 'a+b' in leaves increased by increasing foliar application of seaweed extract concentration. A gradual and steady decline of chlorophyll content in third leave of rice plant from initial up to harvest was noted irrespective of the treatments. Chlorophyll 'a' content was higher at 15% K sap with 100%RDF treated plant in all growth stages with 4.73, 5.24 and 3.28 mg g^{-1} respectively which was followed by 15% G sap with 100% RDF by 4.63, 5.01 and 3.20 mg g^{-1} correspondingly at 30, 60 and 90 DAT. In case of chlorophyll 'b' content, it followed similar trend to chlorophyll 'a' content (Table 5), foliar application of 15% K sap (T_7:100% RDF+15% K sap) was observed maximum 1.76, 3.57 and 1.55 mg g^{-1} respectively. This was on par with 15% G sap (T_{11}:100% RDF+15% G sap) by 1.75, 2.94 and 1.36 mg g^{-1} corresponding at all different growth stages. Total chlorophyll 'a+b" content in rice plant was also high in 15% foliar spray of K sap with 100% RDF at all growth stages by 4.33, 5.87 and 2.42 mg g^{-1} respectively which was comparable with 15% foliar spray of G sap with 100% RDF by 4.24, 5.27 and 2.28 mg g^{-1} at 30, 60 and 90 DAT correspondingly. Chlorophyll content was lower at 50% RDF+7.5% K and G sap at all growth stages. Foliar application of seaweed extract increased the chlorophyll content may be due to presence of betalins[16] inducing of essential nutrients and increase in associated enzymes activity[17] as well as high amount of Mg and Fe present in the seaweed liquid concentration which influence the synthesis of chlorophyll. Maximum chlorophyll contents increased in the seaweed extract added plants[18]. Amount of leaf chlorophyll "a", chlorophyll "b" and total chlorophyll (a+b) were reduced as the harvest was nearer. Phenol and peroxidase has been reported to function as chlorophyll degradation during senescence and the activity increases with ageing process[19].

Table 5. Effect of Seaweed Sap on Chlorophyll Content of Rice (Mg G^{-1})

Treatment	chlorophyll 'a'			chlorophyll 'b'			Total chlorophyll (a+b)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_1:RDF	3.45	3.93	2.92	1.60	2.23	1.10	3.37	4.09	2.02
T_2:RDF+ Water spray	3.40	4.01	3.08	1.62	2.20	1.15	3.36	4.02	2.12
T_3:50% RDF +7.5% K sap	3.28	3.71	2.59	1.49	2.25	1.06	3.17	3.99	1.83
T_4:RDF+2.5% K sap	3.40	4.12	3.08	1.66	2.29	1.25	3.38	4.27	2.17
T_5:RDF+5% K sap	4.12	4.32	3.12	1.71	2.43	1.32	3.86	4.51	2.22
T_6:RDF+10% K sap	4.33	4.78	3.17	1.74	2.56	1.38	4.05	4.91	2.28
T_7:RDF+15% K sap	4.73	5.24	3.28	1.76	3.57	1.55	4.33	5.87	2.42
T_8:RDF+2.5% G sap	3.33	3.62	3.06	1.64	2.23	1.23	3.30	3.89	2.15
T_9:RDF+5% G sap	3.58	4.14	3.10	1.66	2.38	1.24	3.51	4.36	2.18
T_{10}:RDF+10% Gsap	4.14	4.67	3.15	1.68	2.45	1.30	3.87	4.76	2.23
T_{11}:RDF+15% G sap	4.63	5.01	3.20	1.75	2.94	1.36	4.24	5.27	2.28
T_{12}:50% RDF+7.5% G sap	3.25	3.65	2.71	1.37	2.19	1.05	3.09	3.89	1.89
SE(d)	0.047	0.151	0.039	0.044	0.038	0.024	0.140	0.265	0.024
Cd	0.097	0.316	0.081	0.092	0.079	0.050	0.291	0.554	0.049

4. Conclusion

In the present study an attempt has been made to explore the extend of applicability of seaweed extract *Kappaphycus alvarezii* and *Gracilaria* as organic fertilizer in rice crop variety ADT 43. To observe the impact of seaweed sap on the growth, yield and quality improvement of rice seaweed sap of 2.5%, %.0%, 7.5%, 10% and 15% concentration were applied foliar spray at 35, 45 and 60 DAT. Analysis of recorded data shows that foliar application 15% of both K sap and G sap with 100% RDF to rice plant yield effective increased in growth, yield attributes, quality and chlorophyll content of rice variety ADT 43 when compared to that of other treatments. Among this two saps, *Kappaphycus alvarezii* at 15% concentration responded well when compared to that of *Gracilaria* sap. Study results shows effective impact on application of seaweed sap of 15% K sap and G sap with 100%RDF to rice plant. Application of seaweed sap K sap and G sap at 15% with100% RDF to rice plant increases growth, yield attributes, quality and chlorophyll content when compared to that of control one. Thus from the present study it can be observe that application of seaweed sap as organic farming technique can greatly enhance the growth, yield parameters, quality and chlorophyll content of rice variety ADT 43.

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