



## Effect of seaweed (*Kappaphycus alvarezii*) extract on rainfed aerobic rice (*Oryza sativa* L.)

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### ARTICLE INFO

Received : 06 December 2021

Revised : 15 April 2022

Accepted : 30 April 2022

Available online: 26 July 2022

#### Key Words:

7.5% k-sap

Foliar spray

Liquid fertilizer

Pusa basmati-1

Randomised block design

Yield

### ABSTRACT

Rice is grown throughout the year in India, in a variety of agro-climatic conditions, and it is grown on 43.39 million hectares with a production of 159.20 MT with an average productivity of 3623 kg/ha. Aerobically produced rice may be an option for farmers on rainfed areas where rainfall is not sufficient or availability of water is rare and expensive too for flooded rice production but enough for cultivation of upland rice. The field experiment took place at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India, during the kharif season of 2020. The experiment was done by using Randomized Block Design with three replications. The findings of the experiments revealed a considerable rise in the growth parameter viz., plant height (46.0 cm), total tillers/m<sup>2</sup> (564.3), plant dry matter accumulation (1938.0 g/m<sup>2</sup>), leaf area index (19.07) and crop growth rate (49.47 g/m<sup>2</sup>/day) and yield attributing parameters viz., effective tillers/m<sup>2</sup> (362.3), weight of panicle/m<sup>2</sup> (856.9), number of filled grain/panicle (115.7), grain yield (4.7 t/ha), test weight (28.9 g), straw yield (11.3 t/ha) with foliar application of 7.5 percent *Kappaphycus alvarezii* seaweed sap four times, plus RDF and two foliar applications of 10% K-sap yielded the greatest harvest index (32.7%).

### Introduction

Rice (*Oryza sativa* L.) is a crucial staple food crop, feeding two-thirds of the world's population (Kahani *et al.*, 2015). Rice is a less expensive source of dietary calories, fibre, and proteins for the poor, especially those who are economically disadvantaged. Because there is high demand for rice, we must increase rice output and productivity. We need to implement new techniques to increase production and productivity that are economically affordable to poor farmers, as the majority of our country's farmers are marginal farmers. To achieve high demand of rice we have to increase production of rice in this limited cultivable area by using high yielding varieties to achieve the requirement of these rice varieties application of chemicals fertilizers is the only easy way out available to the farmers till now. Chemical fertilizer use not only raises production costs, but it also diminishes soil fertility and pollutes the environment. In order to

relieve farmers' financial burdens, the government has increased fertilizer subsidies. However, providing subsidised cash did not fix the agricultural productivity problem. As a result, spraying extracts of natural items containing stimulants to improve nutrient absorption is a strategic approach to reduce the usage of excessive amounts of inorganic fertilizer. To prevent any of these situations, a farmer's only option is to employ organic fertilizers. Seaweed sap has been shown to promote nutrient absorption, which can help rice grow, develop, and produce more. Seaweed sap can be a good alternative as it contains growth regulators like cytokinins, auxins, gibberelins and abscisic acid, as well as micro and macro nutrients, amino acids, vitamins etc. Which stimulate growth and yield of crops. On the other hand, it is also economically cheaper than chemical fertilizers and environment friendly. Because of global warming

monsoon delaying become a common phenomenon these days. Delayed monsoon causing a great effect on sowing of paddy and farmers have to rely on irrigation. To achieve huge demand of rice we have started cultivation of rice in low rainfall areas also where supply of water is only through irrigation of fresh water. Fresh water makes up only 3 percent of water on the surface and, the rest 97 percent in the ocean. Many parts of India facing serious problem due to over exploitation of ground water. Tuong and Bouman (2003) estimate that physical water scarcity may affect 15 million hectares of irrigated rice land in Asia, whereas economic water scarcity may affect 22 million hectares. To deal with the dilemma, researchers must find a means to lower rice's water consumption while increasing its output. Aerobic rice is going to be a great solution to this problem. Aerobic rice produces 4-6 t/ha rice with 50% saving irrigation water. This cultivation also does not need puddled field, there is no need heavy amount of water to do puddling. All these things make aerobic rice cultivation an excellent solution for water management. On the other side it also reduces irrigation cost, field preparation cost and also produces 4-6t/ha which is also beneficial in terms of return for farmers. So the combination of both aerobic rice cultivation and seaweed sap application not only saves our mother nature but also reduces production cost and increases their production.

### Material and Methods

To find out the ability of seaweed sap as a productivity booster in Aerobic rice a field experiment was conducted in Crop research farm, Department of Agronomy, Naini Agriculture Institute, SHUATS, Prayagraj, Uttar Pradesh which is located at 25° 24' 42" N latitude, 81° 50' 56" E longitude and at an altitude of 98 m above mean sea level during *kharif* season of 2020 on sandy loam soil, having neutral soil reaction (pH 7.68), low in available nitrogen (226.49 kg/ha), low in available phosphorus (6.90 kg/ ha) and medium in available potassium (161.20 kg/ ha). The climate of region is sub-tropical and semi-arid.

The study used a Randomized Block Design with ten treatments replicated three times with one source of seaweed sap namely *Kappaphycus alvarezii* consisted of 3 concentrations (5%, 7.5%

and 10%). Every concentration was sprayed in 3 different days combination (2 spray, 3 spray and 4 spray). Two spray was done at (20 & 40 DAS), three spray was done at (20, 40 & 60 DAS) and four spray was done at (20, 40, 60 & 80 DAS). Treatments comprise of T<sub>1</sub> - water spray, T<sub>2</sub> - 5% K-sap with 2 spray, T<sub>3</sub> - 5% K-sap with 3 spray, T<sub>4</sub> - 5% K-sap with 4 spray, T<sub>5</sub> - 7.5% K-sap with 2 spray, T<sub>6</sub> - 7.5% K-sap 3 spray, T<sub>7</sub> - 7.5% K-sap 4 spray, T<sub>8</sub> - 10% K-sap 2 spray, T<sub>9</sub> - 10% K-sap 3 spray, T<sub>10</sub> - 10% K-sap 4 spray along with RDF, respectively in every treatment.

Sowing was done by line sowing method where seeds were planted with a row to row distance of 20 cm and plant to plant distance of 15 cm. Recommended dose of fertilizers in the form of urea, DAP and MOP were applied at the time of sowing. At the time of sowing half dose of urea was applied as a basal dose along with full dose of DAP and MOP and the other half of the urea was applied in two equal parts at 30 DAS and 60 DAS. Seaweed sap applied as per treatment as per solution as recommended. Sap application is done with the help of a sprayer. At various growth stages, observations on growth parameters such as plant height, total tillers/m<sup>2</sup>, plant dry matter accumulation, leaf area index, and crop growth rate were recorded from five randomly tagged plants from each plot, and yield attributing parameters such as effective tillers/m<sup>2</sup>, weight of panicle/m<sup>2</sup>, number of filled grain/panicle, grain yield, test weight, and straw yield were recorded at the harvesting stage. The recorded data were statistically analysed using the ANOVA approach. When the 'F' test was determined to be significant at the 5% level, the critical difference (CD) value was calculated (Mead *et al.*, 2017).

### Results and Discussion

#### Plant height (cm)

Data of plant height was collected at 15, 30, 45, 60, 75, and 90 days after sowing, and the results were summarised in Table 1. The plant height gradually increased as the crop stages progressed in all treatment, and achieve maximum height during harvest. At 15 DAS, it showed non-significant result while at 30 DAS, RDF + 7.5 percent K-sap with 3 spray was produced significantly maximum plant height (12.7 cm). Significantly maximum

**Table 1: Effect of seaweed (*Kappaphycus alvarezii*) extract on plant height, total tillers, and plant dry matter accumulation of aerobic rice**

Treatment	Plant height(cm)						Total tillers/m <sup>2</sup>				Plant dry matter accumulation (g/m <sup>2</sup> )					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS	75 DAS	90 DAS	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Water spray	6	11.8	15.6	23.1	24.5	35.7	72.3	380.7	423.0	467.3	8.1	30.2	106.5	201.4	907.5	1122.0
5% K-sap with 2 Spray	6.6	11.7	16.3	22.0	26.3	35.8	79	408.0	469.0	511.3	8.6	30.7	119	214.6	1060.3	1457.0
5% K-sap with 3 Spray	6.6	12.1	17.8	23.8	28.3	38.1	78.7	427.3	487.0	485.7	9.5	35.7	121.3	219.9	1076.4	1369.0
5% K-sap with 4 spray	6.4	12.1	16.9	25.4	29.9	39.5	79.7	423.7	473.7	485.0	9.2	35.7	153	247.5	1086.4	1552.7
7.5% K-sap with 2 spray	6.7	12.2	17.1	25.3	30.2	41.0	92.7	461.7	500.7	505.3	11.1	41.5	142.8	240.3	1122.8	1586.7
7.5% K-sap with 3 spray	7	12.7	18.6	25.8	33.3	43.2	95	487.7	535.0	521.3	10.8	41.8	155.3	257.7	1150.4	1802.0
7.5% K-sap with 4 spray	7.3	12.4	19.0	26.9	37.1	46	92.7	495.0	562.0	564.3	12.4	43.9	175.7	297.4	1196.0	1938.0
10% K-sap with 2 spray	5.9	11.2	14.9	20.0	23.1	32.1	74.3	378.3	391.7	419.3	5.7	27	73.7	186.3	892.6	1086.0
10% K-sap with 3 spray	6.1	11.0	16.1	22.7	26.1	35.2	74.7	381.0	446.0	451.3	6.9	27.1	113.3	214.5	995.7	1201.3
10% K-sap with 4 spray	5.7	11.2	16.7	23.2	26.9	36.9	72.3	401.0	446.7	471.3	8.1	34.2	120.1	222.8	1059.1	1212.7
SEm (±)	0.386	0.349	0.752	1.265	1.507	1.719	3.266	18.56	31.123	19.612	1.08	2.948	9.092	29.27	43.03	110.84
CD (5%)	-	1.04	2.23	3.76	4.48	5.11	9.7	55.15	92.47	58.27	3.24	8.76	27.02	-	127.86	329.34

plant height was observed at 4 foliar spray of 7.5 percent K-sap + RDF respectively at 45, 60, 75 and 90 DAS. Which was significantly superior over control treatment *i.e* RDF + water spray. While at 75 DAS treatment T<sub>6</sub> and at 90 DAS treatment T<sub>5</sub> and T<sub>6</sub> found to be at par with foliar application of 7.5 percent K-sap with 4 spray. Plant height increases with increase of sap concentration up to 7.5 percent. The reason behind it may be presence of plant growth regulator in seaweed sap which is resulting in enhancement of growth and development. While working with rain-fed maize, (Singh *et al.*, 2015) observed increase of plant height is proportional with the increase in K-sap concentration up to 7.5 percent. Pramanik *et al.* 2017 also reported the increase in plant height when 7.5% K-sap sprayed on the foliage of the crop along with 100% RDF on potato plants. According to Mooney and Van Staden in 1986, reported that presence of major and minor minerals, amino acids, vitamins, cytokinins, auxin, and abscisic acid like other growth boosting chemicals in seaweed extract resulting in dramatically increased plant height. The reason behind a decreased performance in high concentration may be very high salt index in higher concentration of seaweed sap (Aitken and senn 1965; Abetz 1980).

#### **Number of tillers/ m<sup>2</sup>**

Collection of data on number of tillers/m<sup>2</sup> was done at 45, 60, 75 and 90 DAS. A great difference between all the treatment was observed which is depicted in Table 1. At 45 DAS 7.5 percent K-sap with 3 foliar spray along with RDF was found significantly highest total tillers (95.0/m<sup>2</sup>). Maximum number of tillers was observed with the 4 spray of 7.5 percent K-sap along with RDF on the leaves at 60, 75 and 90 DAS. Singh *et al.*, (2016) and Shah *et al.*, (2013) observed that on wheat highest tillers/m<sup>2</sup> was counted with the application of 7.5 percent K-sap. Various active compound, micro and macro nutrients present in the extract of seaweeds which increases the number of tillers of rice plants (Singh *et al.*, 2018).

#### **Dry matter accumulation (g/m<sup>2</sup>)**

Total dry matter accumulation of aerobic rice significantly influence by foliar application of seaweed sap (Table 1). As the crop progressed toward harvest dry matter accumulation also increased progressively but although the pattern of

dry matter accumulation in different plant parts is different during various phases of crop growth period. In the early stages of growth leaf accumulated more dry matter than later stages of growth. During vegetative growth stage (up to 75 DAS) dry matter accumulation was at its peak in leaf and stem and in case of panicle it improved from flowering till maturity. All the treatment combinations were significantly different from each other recorded on 15, 30, 45, and 90 DAS. Significantly maximum plant dry matter accumulation was recorded with treatment of 4 foliar application of 7.5 percent K-sap + RDF (T<sub>7</sub>) and at 60 DAS it displayed non-significant result while at 15 DAS, 30 DAS and 75 DAS treatment T<sub>6</sub>, T<sub>5</sub>, T<sub>4</sub>, T<sub>3</sub>, at 45 DAS treatment T<sub>4</sub>, and at 90 DAS treatment T<sub>6</sub> was found to be similar trends with 4 foliar spray of 7.5 percent K-sap (T<sub>7</sub>). According to Pramanik *et al.*, 2017, the seaweed sap has a considerable impact on growth and the use of 7.5% K-sap in combination with RDF produces the best results in terms of potato dry matter accumulation. Another study conducted by Singh *et al.*, 2015 showed that the dry matter production was maximised when a maize crop was sprayed with 7.5% K-sap and 100% RDF. Seaweed constitutes of various growth substances which increases number of leaf, tillers and plant height in different growth stages of paddy plant which combinedly increases dry matter.

#### **Leaf Area Index (LAI)**

In the present investigation all treatments were influenced significantly at 15, 30, 45, 60, 75 & 90 DAS were presented in Table 2. Significantly maximum leaf area index was recorded at 30, 45, 60, 75 and 90 DAS with 4 foliar application of 7.5 percent K- sap + RDF (T<sub>7</sub>). While at 30 DAS 3 foliar spray of 7.5% K-sap, 2 foliar spray of 7.5% K-sap, 4 foliar spray of 5% K-sap, at 45 DAS 3 foliar spray of 7.5% K-sap, 2 foliar spray of 7.5% K-sap and at 75 DAS treatment 3 foliar spray of 7.5% K-sap (T<sub>6</sub>) was found to be statistically at par with 4 foliar spray of 7.5% K-sap along with RDF. Pramanik *et al.*, 2017, revealed that foliar application of 7.5% K-sap with 100% RDF exhibit the significant results regarding the growth of leaf area index. Another study by Singh *et al.*, 2015 also showed that spraying maize crops with 7.5% K-sap with 100% RDF maximizes the leaf area index.

**Table 2: Effect of seaweed (*Kappaphycus alvarezii*) extract on leaf area index and crop growth rate of aerobic rice.**

Treatment	Leaf area index (LAI)					Crop growth rate (g/m <sup>2</sup> /day)				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	15-30 DAS	30-45 DAS	45-60 DAS	60-75 DAS	75-90 DAS
Water spray	0.09	0.33	3.23	5.73	11.20	1.54	5.09	6.32	47.07	15.53
5% K-sap with 2 spray	0.09	0.36	3.70	6.77	12.0	1.48	5.88	7.04	56.38	26.44
5% K-sap with 3 spray	0.09	0.43	4.70	7.70	13.17	1.75	5.70	7.06	59.33	23.75
5% K-sap with 4 spray	0.10	0.43	4.93	7.63	14.17	1.77	7.82	6.90	55.93	31.08
7.5% K-sap with 2 spray	0.10	0.49	5.63	8.10	14.60	2.03	6.75	7.26	58.84	30.93
7.5% K-sap with 3 spray	0.10	0.54	6.37	10.17	16.23	2.07	7.56	7.49	59.52	43.44
7.5% K-sap with 4 spray	0.11	0.55	6.57	11.33	19.07	2.10	8.78	8.11	59.91	49.47
10% K-sap with 2 spray	0.08	0.31	2.73	4.73	9.90	1.42	3.11	6.51	47.09	15.56
10% K-sap with 3 spray	0.08	0.32	3.17	6.73	11.23	1.34	5.75	6.75	52.53	16.61
10% K-sap with 4 spray	0.09	0.32	3.93	6.40	12.33	1.74	5.73	6.85	55.75	15.99
SEm (±)	0.002	0.034	0.39	0.51	0.72	0.21	0.61	1.59	2.77	5.00
CD (5%)	0.01	0.10	1.19	1.61	2.14	-	1.82	-	8.26	14.86

**Table 3: Effect of seaweed (*Kappaphycus alvarezii*) extract on yield attributes and yield of Aerobic rice.**

Treatment	Effective Tillers/m <sup>2</sup>	Weight of panicle/m <sup>2</sup> (g)	Number of filled panicle grain/	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Water spray	249.0	365.3	81.6	21.7	3.4	7.9	30.2
5% K-sap with 2 spray	259.3	403.8	95.2	22.2	3.6	8.1	30.6
5% K-sap with 3 spray	281.0	456.9	97.1	22.3	3.8	8.4	30.9
5% K-sap with 4 spray	301.0	581.4	98.7	24.1	3.9	8.2	32.4
7.5% K-sap with 2 spray	297.7	512.3	99.6	24.4	3.9	9.0	30.3
7.5% K-sap with 3 spray	332.7	698.3	109.3	27.7	4.3	10.2	29.5
7.5% K-sap with 4 spray	362.3	856.9	115.7	28.9	4.7	11.3	29.3
10% K-sap with 2 spray	250.3	382.1	85.5	21.5	3.4	7.1	32.7
10% K-sap with 3 spray	259.3	399.4	87.8	21.1	3.5	7.8	31.1
10% K-sap with 4 spray	273.0	452.3	99.3	22.4	3.7d	8.1	31.3
SEm(±)	13.39	53.01	2.51	0.95	0.06	0.21	0.70
CD (5%)	39.81	157.49	7.48	2.81	0.18	0.62	2.09

Application of seaweed sap in plants showed that it is capable of enhancing concentration of nutrients in the leaves as growth hormone is involved in the nutrient absorption process and movements in a plant (Sunarpi *et al.*, 2010). The leaves of the rice plant increase, because there are some effective chemicals and vital nutrient present in seaweed extract, it has ability to accelerate plant growth (Abetz 1980; Finnie and Van Stadan 1985).

#### Crop growth rate (g/m<sup>2</sup>/day)

Data pertaining to Crop growth rate was recorded during 15-30, 30-45, 45-60, 60-75, 75-90 days after sowing periodically and tabulated in Table 2. There was no significant difference between all treatments during 15-30 DAS and 45-60 DAS. Whereas significantly highest CGR was found with RDF + 4 foliar spray of 7.5 percent K-sap during 30-45, 60-75 and 75-90 DAS. Further these findings are permitted by Pramanick *et al.*, (2017) and Singh *et al.*, (2015) on rain-fed maize and Singh *et al.*, (2016) recorded that increase of CGR on wheat crop proportional with increasing K-sap concentration upto 7.5 percent. Because it was previously proposed that certain kinds of marine algae species found in nature contains biologically active cytokinin, gibberelin and auxin. Presence of cytokinin enhances cell division. These compounds were able to stimulate growth by increasing protein synthesis and cell division, as well as mobilising resources needed for development (Patier, 1993).

#### Yield attributes and yield

Observation regarding yield attributes and yield like effective tillers per m<sup>2</sup>, weight of panicle, number of filled grain per panicle, test weight (g), grain yield (t/ha), straw yield (t/ha), harvest index (%) of aerobic rice depicted in table 3. Four foliar spray of 7.5% seaweed sap (*Kappaphycus alvarezii*) + RDF was found considerably higher effective tillers/m<sup>2</sup> (362.3), weight of panicle (856.9), number of filled grain/panicle (115.7), test weight (28.9 g), grain yield (4.7 t/ha), straw yield (11.3 t/ha) which was 31.2%, 57.3%, 29.47%, 24.9%, 27.6%, 30.0% more over control (Water Spray; T<sub>1</sub>), respectively. In harvest index

application of RDF along with two foliar spray of 10 percent K-sap resulted in a much higher value i.e. (32.7%) which was 10.3% more over control. On wheat, Shah *et al.*, (2012), on maize, Singh *et al.*, (2015), on maize, Singh *et al.*, (2015), on rain-fed maize, Singh *et al.*, (2015), found that lower sap concentrations enhanced production while higher sap concentrations (over 7.5 percent K sap) lowered yield. May be the reason behind increased grain yield is presence of plant growth regulator in the sap and minerals elements in seaweed extract, which enhances rates of photosynthesis and delayed leaf senescence, resulting in a greater performance of photosynthetic rate, which is help for better grain filling, so grain become bigger and hence greater grain production (Beckett and Staden, 1990).

#### Conclusion

Seaweed liquid fertiliser, made from locally available seaweeds, is an excellent technique to boost plant growth and biochemical activity and many plant production characteristics are improved, as is soil fertility and long term output, but also hugely reduces fertilizer carbon footprint and eutrophication potential per unit of output, through which it reduces environment pollution. It is concluded that application of seaweed (*Kappaphycus alvarezii*) extract to aerobic rice (Pusa basmati-1) crop significantly influence the crop productivity and profitability. Four foliar sprays of 7.5 percent K-sap extract + RDF found to be more productive (4.7 t/ha).

#### Acknowledgement

The authors are thankful to advisor Dr. (Mrs) Shikha Singh and other faculty, Department of Agronomy Naini Agricultural Institute, SHUATS, Prayagraj, (U.P.), India for providing support and necessary facility to undertake the studies.

#### Conflict of interest

The authors declare that they have no conflict of interest.

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