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Effect of Bio-Stimulant Application on Seed Yield and Seed Quality in Rice (*Oryza sativa* L.)

Elavarasan E., A. Kamaraj*, B. Sunil Kumar, P. Satheeshkumar and S. Suganthi
Department of Genetics and Plant Breeding, Faculty of Agriculture,
Annamalai University, Annamalai Nagar (Tamil Nadu), India.

(Corresponding author: A. Kamaraj)*
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ABSTRACT: Bio-stimulant has demonstrated advantages in crop growth and seed quality across a range of crops. Due to low field population and nutrient disorders after transplanting—possibly as a result of inadequate root establishment —rice production was decreased. By keeping these criteria, a field trial was carried out to study the effect of root dipping with seaweed extracts on seed yield and quality in rice cv. ADT 36. The seedling's roots were dipped in seaweed extract of two species *viz.*, *Gracilaria carticata* and *Sargassum wightii* in different concentrations *viz.*, 5%, 10%, 15%, and 20% for 1 hour each, along with the control. The results showed that the roots of rice seedlings before transplanting dipped in 20% *Sargassum wightii* seaweed extract for 1 hour registered higher values for growth parameters and yield parameters. The harvested seeds from the plants of the above treatment registered the better seed quality which could be a boon to the farmers for getting the better crop and yield. Hence, the roots of rice seedlings before transplanting could be dipped in 20% *Sargassum wightii* seaweed extract for 1 hour to acquire better seed yield and seed quality.

Keywords: Rice, root dipping, Seaweed extract, seed quality, seed yield.

INTRODUCTION

Rice (*Oryza sativa* L.) is an essential grain crop for human consumption in the world, feeding more than half of mankind (Fukagawa and Ziska 2019), even though it is the main source of income for the greater part of Asians as well as Africans (FAO, 2019). Rice production in the world was 759.6 million tonnes in 2017, and it climbed by 1.4 per cent in 2018, to 769.9 million tonnes (FAO, 2019).

In India, it is cultivated in 44 million hectares, with a seed production of 117.47 million tonnes. It is cultivated in an area of 17.21 lakh hectares in nearly all districts of Tamil Nadu, including Ooty and the hill regions, with a production of 61.38 lakh tonnes. Over the last few decades, the human population has grown dramatically and as a result of urbanisation and land clearance for human habitation, the need for food has increased, while the amount of land available for crop cultivation has decreased (Bellemare, 2015).

By 2050, global food demand is predicted to be double, owing to a raise in global population from 7 billion in 2013 to 9 billion or more, as well as an increase in per capita consumption. To meet the ever-increasing and diverse food demand, output must be increased using existing resources, which are already stressed (Singh, 2017). As a result, rice demand is raising in tandem with raising consumption due to population growth, so finding new ways to enhance crop productivity is critical. As a consequence, agricultural scientists must anticipate production and productivity, and novel agricultural technologies are needed to encourage sustainable use of natural resources, such as salty water, to allow for the rehabilitation of polluted soils. It is necessary to increase the application of bio-stimulant compounds, which have demonstrated immediate benefits for rice yield that is sustainable. Biostimulants have demonstrated advantages in field establishment and seed quality across a range of crops. Due to low field establishment after transplanting—possibly as a consequence of insufficient root establishment and nutrients absorption—rice yield was lowered.

Seeds are the basic input for crop production. A crop can only be improved to the extent that the seed allows. Any achievement in crop improvement can be propagated and established in a field only through good-quality seeds. Hence, the production of high-quality seeds is necessary and important to the agricultural industry. Seaweed and seaweed products have been used worldwide to increase plant growth and yield. Seaweed extract had a beneficial effect on seed germination and plant growth. Because of their potential use in environmentally friendly farming, seaweed extracts are gaining in popularity nowadays (Layek *et al*., 2018). Seaweed extract has been used by farmers, even since the early 1900s. In India, a large quantity of macroscopic marine algae is utilized directly as manure or in the form of compost by coastal communities (Nedumaran and Arulbalachandran 2015).

The seaweed extracts were used as foliar sprays, soil drenches, and root dips on the crops. The use of seaweed extracts as a root dip before planting reduces transplant stress and produces healthier, seedlings in a variety of plant species. Root dipping of rice seedlings in seaweed extract increases the vigour of root and shoot growth, enhances nematode resistance, increases yield, and extends the shelf life of the produce (Norrie and Keathley 2006). Many crops, including vegetables, trees, floral plants, and cereal crops, benefits from the use of seaweed concentrate as a bio-stimulant. With this background knowledge, a field experiment was done to determine how root dipping in seaweed extract effects the rice crop, seed yield, and quality.

MATERIAL AND METHODS

A genetically and physically pure seed of rice cv. ADT 36 was obtained from Tamil Nadu Rice Research Institute (TRRI), Aduthurai, which formed the basic material for the study. A field experiment was carried out by dipping the roots of rice seedlings in varied concentrations of *Sargassam wightii* and *Gracilaria carticata* seaweed saps *viz.*, 5%, 10%, 15%, and 20% for 1 hour before transplanting under the field condition and each treatment was replicated thrice. Then the seedlings were transplanted in the main field.

The treatment details are given below.

T_0 – Control
T_1 – 5% *Gracilaria corticata* root dipping for 1 hour
T_2 – 10% *Gracilaria corticata* root dipping for 1 hour
T_3 – 15% *Gracilaria corticata* root dipping for 1 hour
T_4 – 20% *Gracilaria corticata* root dipping for 1 hour
T_5 – 5% *Sargassam wightii* root dipping for 1 hour
T_6 – 10% *Sargassam wightii* root dipping for 1 hour
T_7 – 15% *Sargassam wightii* root dipping for 1 hour
T_8 – 20% *Sargassam wightii* root dipping for 1 hour

Five plants were randomly selected in each of the treatments replication-wise. Observations on growth parameters *viz.*, Plant height (cm), Leaf length (cm), Leaf breadth (cm), Panicle length (cm), Number of tillers per plant and yield parameters *viz.*, Number of productive tillers per plant, Number of seeds per panicle, Seed yield per plant (g), Dry matter production (g), 100 seed weight (g) and protein content (µg/ml) (Lowry *et al.,* 1951) were recorded.

After harvest, the resultant seeds were pooled, cleaned, dried to a moisture content of 12% and graded for uniformity. The randomly selected sample of seeds from each treatment was evaluated for their seed quality characteristics such as Germination per cent (ISTA Rules,2013), Root Length (cm), Shoot Length (cm), Dry matter production (mg/10 seedlings), Vigour index I (Abdul-Baki and Anderson 1973) and Vigour index II (Abdul-Baki and Anderson 1973). The data was analyzed statistically adopting the procedure described by Panse and Sukhatme (1985).

RESULT AND DISCUSSION

A field experiment was conducted with various concentrations of *Sargassam wightii* and *Gracilaria carticata* seaweed saps for root dipping of rice seedlings before transplanting. The root-dipped treated plants showed a significant result. Plant height (75.39 cm), number of tillers per plant (24.90), number of productive tillers per plant (15.00), panicle length (25.50 cm), leaf length (31.58 cm), leaf breadth (1.18 cm), number of seeds per panicle (146.13), seed yield per plant (25.99 g) and dry matter yield per plant (25.99 g) were the maximum among the root dipping treatments (Table 1).

Rice seedlings dipped in the seaweed extract of Sargassam *wightii* at 20% concentration (T_8) had higher plant height values in the current investigation. Treatment (T_8) plants grew 7.64 per cent taller than control. The presence of cytokinins and auxins in seaweed extract may have contributed to T_8's outstanding performance by promoting root growth and stimulating cell division and elongation expansion of plant tissues, which may have aided in higher rice crop growth parameters (Yogendra, 2015). Kumar *et al*. (2012) published similar findings with green gram.

The root of rice seedlings dipped in 20% *Sargassam wightii* seaweed extract had 16.19% increase in panicle length above control, which could be related to the favourable effects of seaweed extracts on ion uptake under ideal conditions (Crouch *et al*., 1990). The presence of macronutrients (N, P, K) and micronutrients (Fe, Cu, Zn, Co, Mo, Mn, and Ni) in seaweed extract, as well as plant growth hormones (Auxins, cytokinins, Gibberellins), vitamins, carbohydrates, and amino acids, stimulated numerous enzymes involved in growth and development (Shamirkhan *et al*., 2017). In treated rice plants (T_8), leaf length and leaf breadth enhanced by 22.64 per cent and 12.71 per cent, respectively, as compared to untreated plants (Table 1). This could be because the chemicals in seaweed extract were able to drive development by increasing protein synthesis and cell division, increasing leaf features (Sasireka *et al*., 2016).

The number of tillers plant^{-1}, productive tillers plant^{-1}, seeds panicle^{-1}, seed L/B ratio, seed yield plant^{-1}, dry matter production, 100 seed weight, and protein content were all higher than the untreated plants, at 19.79%, 32.20%, 9.34%, 11.87%, 14.39%, 17.95%, 17.82%, and 35.71%, respectively (Table 1). Many of the biochemical components (IAA, IBA, Cytokinins, GA3) found in seaweed extracts have additive or synergistic activities that promote crop growth and development, which could explain the positive influence on yield indices. Increased seed output might be attributed to better yield-attributing features such as the number of productive tillers per plant and the number of seeds per panicle when compared to the control.

Higher seed yield indicates a plant's improved reproductive efficiency, as seen by a lower percentage of sterile pollens, reduced flower drop, and more full seeds, all of which were attributed to higher values of growth characteristics such as plant height, leaf area, and blooming time. The increased rice seed output in rice seedlings dipped in *Sargassam wightii* seaweed extract could be attributed to the seaweed extract's stimulatory influence on growth and root development, which was more obvious when the extracts were applied at early growth stages (seedling stage) root dipping.

Seaweed extract improves the overall nutritional environment of the root by increasing root growth (Jadhao *et al*., 2015), and liquid seaweed extract can suppress the damaging infection process in roots because it contains natural plant growth regulators such as auxins, cytokinins, ethylene, gibberellins, abscisic acid, and more (Arioli *et al.*, 2015). The presence of alginates, polysaccharides, and sulphates in seaweed extracts stimulates the root growth of plants, both directly and indirectly in association with microbes, which in turn accelerates plant metabolism, photosynthetic activity through increased leaf area and photosynthetic pigment, resulting in better crop growth and yield attributes of the plant.

Rice seedlings dipped in 20 per cent *Sargassam wightii* seaweed extract had a protein content increase of 35.71 per cent when compared to control (Table 1). This was in line with Singh and Chandel's findings in wheat, which could be explained by stimulatory effects on root proliferation that lead to higher nutrient uptake, especially of nutrients required as building blocks in protein synthesis (nitrogen, phosphorus, and sulphur), which in turn leads to higher protein synthesis because both N and S are synergistically linked to protein metabolism and protein synthesis. The use of seaweed extract increased protein content significantly by either enhancing protein production or lowering protein oxidation (Abd El-Moniem and Abd-Allah 2008). Reduced cell size, thickening of cells, reduced rate of enzyme activity, and poor availability of nutrients to growing seedlings result in delayed emergence and reduced vigour, which leads to poor seed productivity, and the absence of exogenous availability of bio-available substances, which is present in seaweed extract.

Rice seedlings dipped in 20% *Sargassam wightii* seaweed extract possessed elevated germination percentage (91%), speed of germination (36.04), root length (26.95 cm), shoot length (13.42 cm), seedling fresh weight (2.64 g), dry matter production (0.27 g), vigour index I (3673.67), and vigour index II (24.57), while harvested seed from untreated plants had lower values (Table 2). The seeds from T_8 may be better because they have more mobilization of metabolites and stored reserves (better transportation from source to sink), better DNA repair mechanisms and higher activity of enzymes that help during germination and seedling emergence, which in turn leads to better seedling growth (Hugar and Kurdikeri 2000).

Thus, the root dipping with 20% *Sargassam wightii* seaweed extract improved vegetative growth, yield parameters, and seed quality compared to the control.

Table 1: Effect of root dipping with seaweed extract on vegetative growth and seed yield in rice cv. ADT36.

Treatment	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Panicle length (cm)	Number of tillers per plant	Number of productive tillers per plant	Number of seeds per panicle	Seed yield per plant (g)	Dry matter production(g)	100 seed weight(g)	Protein content(µg/ml)
T_o	69.63	24.43	1.03	21.37	19.97	10.17	132.47	**22.25**	**52.90**	**2.12**	**0.09**
T_1	70.17	26.11	1.05	21.77	20.41	11.37	134.47	**23.21**	**54.23**	**2.23**	**0.11**
T_2	70.88	28.93	1.09	22.37	21.38	12.47	138.43	**23.52**	**58.52**	**2.32**	**0.11**
T_3	71.29	30.17	1.08	25.08	21.61	13.47	141.47	**25.51**	**62.23**	**2.39**	**0.12**
T_4	73.70	31.25	1.17	25.31	24.55	14.43	144.30	**25.56**	**63.08**	**2.49**	**0.13**
T_5	70.64	28.12	1.16	22.37	20.77	11.57	136.17	**23.50**	**57.23**	**2.25**	**0.11**
T_6	71.00	29.33	1.12	23.37	21.57	13.07	140.47	**24.23**	**59.02**	**2.33**	**0.12**
T_7	73.49	31.07	1.10	25.22	23.17	14.07	142.60	**25.54**	**62.50**	**2.41**	**0.12**
T_8	75.39	31.58	1.18	25.50	24.90	15.00	146.13	**25.99**	**64.48**	**2.58**	**0.14**
Mean	79.79	29.22	1.10	23.72	22.07	12.84	139.61	**24.36**	**59.37**	**2.34**	**0.11**
S.Ed	1.6927	1.5772	0.0257	0.8424	1.0955	0.2133	3.1228	**0.3501**	**1.3669**	**0.0543**	**0.0030**
CD(P=0.05)	3.5885	3.3437	0.0545	1.7860	2.3225	0.3017	6.6204	**0.4951**	**2.8979**	**0.1150**	**0.0064**

Table 2: Effect of root dipping with seaweed extract on seed qualities of resultant seed of rice cv. ADT 36.

Treatment	Germination percentage (%)	Speed of germination	Seedling root length (cm)	Seedling shoot length (cm)	Seedling dry weight (g per 10seedlings)	Seed vigour index I	Seed vigour index II
T_o	80(63.59)	25.88	20.35	10.99	0.18	2507	14
T_1	81(64.55)	27.31	20.78	11.09	0.21	2581	17
T_2	82(64.96)	31.35	22.38	11.55	0.22	2782	18
T_3	89(71.69)	33.47	23.86	12.59	0.24	3244	21
T_4	90(71.82)	35.34	24.78	13.09	0.26	3408	23
T_5	82(64.85)	28.55	21.69	11.16	0.21	2693	17
T_6	87(68.84)	31.58	23.47	12.17	0.23	3100	20
T_7	89(71.78)	34.55	24.75	12.61	0.25	3325	22
T_8	91(72.75)	36.04	26.95	13.42	0.27	3673	24
MEAN	86(68.32)	31.59	23.22	12.07	0.23	3035	19
S.Ed	0.02561 (0.1884)	0.8709	0.9956	0.3045	0.0123	78.7177	0.4213
CD(P=0.05)	0.5923 (0.4206)	1.8289	2.0909	0.6395	0.0258	165.3072	0.8846

(Figures in parenthesis indicate arcsine transformed values)

CONCLUSIONS

Overall, the results of the field experiment suggest that the use of seaweed extract, particularly *Sargassam wightii*, as a root dipping treatment for rice seedlings before transplanting can significantly improve various growth parameters and seed yield. The presence of nutrients, growth hormones, and other bioactive compounds in seaweed extract may have contributed to the observed effects on plant growth and development. The highest concentration of seaweed extract (20%) showed the most significant improvements in plant height, number of tillers, panicle length, leaf length, leaf breadth, number of seeds per panicle, seed yield per plant, and dry matter yield per plant. The current study concluded that the roots of rice seedlings before transplanting could be dipped in 20% *Sargassum wightii* seaweed extract concentration for 1 hour to realize better seed yield and seed quality. These findings support the potential use of seaweed extract as a natural and sustainable plant growth regulator in rice seed production.

FUTURE SCOPE

The present theme of the study shows significant potential for further research on the use of bio-stimulants, including seaweed extracts to improve the sustainability and productivity of agriculture; enhance the resilience of crops to abiotic stresses such as drought, heat and salinity; improve water and nutrient uptake by plants; enhancement of microbial communities in the rhizosphere soil surrounding plant roots to reduce oxidative stress. By exploring the mechanisms underlying the effects of these bio-stimulants and optimizing their application methods and dosages, the researchers can help unlock their full potential for sustainable seed and crop production.

Author Contribution. All authors contributed to this work as follows: A. Kamaraj and E. Elavarasan were involved with the plan out of the experimental works and data logistics. B. Sunil Kumar contributed through data analysis and shaping of the paper. S. Suganthi and P. Satheeshkumar were involved in the computation of tables and document Framework.

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Conflict of Interest. None.

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