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Effect of foliar application of bio-stimulants on growth, yield and yield attributing characters of rice (*Oryza sativa* L.)

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Abstract
The field experiment entitled, "Effect of foliar application of bio-stimulants on growth, yield and uptake of nutrients in rice (*Oryza sativa* L.)" was conducted during *kharif*, 2021 at Instructional Farm, Department of Agronomy, College of Agriculture, Dapoli, Ratnagiri, Maharashtra. The treatments comprise of Sea grow powder, Triacontanol, Chitosan and Chitosan irradiated. Parameters such as plant height (cm), number of functional leaves hill^{-1}, number of tillers hill^{-1}, dry matter hill^{-1} (g), number of panicles hill^{-1}, number of grains panicle^{-1} and panicle length (cm), grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) were observed with application of various bio-stimulants at 30, 60 and 90 DAT and at harvest stage. The results of the experiment showed that application of different bio-stimulants has positive effect on growth, yield attributes and yield of rice. Significantly higher values of above-mentioned parameters were recorded with application of bio-stimulant Sea grow powder @ 1.5 g lit^{-1} (T_3) and lower values were observed with treatment T_7 Control (Water spray). Thus, higher growth and yield can be obtained with foliar application of bio-stimulant (Sea grow powder) @ 1.5 g lit^{-1} (T_3) along with RDF in rice crop.

Keywords: Rice, bio-stimulant, growth, yield, economics

1. Introduction
Rice (*Oryza sativa* L.) is one of the most favoured world cereal and major staple food for more than half of global population and considered as the "global grain". India is the world's second largest producer and consumer of rice after China and the largest exporter of rice in the world. It plays a vital role in India's national food security. Rice contributes 43 per cent of total food grain production and 46 per cent of total cereal production in India. Of all countries in the world India has the largest area of land for rice cultivation. In India the area occupied under rice cultivation is 45.07 million hectares with production of 122.27 million tones and an average productivity of 2713 kg ha^{-1} (Anonymous, 2021a) [1].
In Maharashtra area under rice is 15.61 lakh hectares with production of 32.91 lakh tonnes and productivity 2109 kg ha^{-1} (Anonymous, 2021b) [2]. The average productivity of the Maharashtra state is low as compared to other rice growing states *viz*., West Bengal, Uttar Pradesh, Punjab, Odisha, Tamil Nadu, Haryana, Andhra Pradesh etc. (Anonymous, 2021a) [1]. Rice is major cereal crop grown in Konkan region. In Konkan rice is cultivated over an area of 3.57 lakh hectares with an annual production of about 8.52 lakh tonnes with average productivity around 2386.01 kg ha^{-1}. The area, production and average productivity of the Konkan region is more as compared to Western Maharashtra, Marathwada and Vidarbha (Anonymous, 2021b) [2].
As mentioned above rice is mainly grown crop in India and 50 per cent of the fertilizer is used in the rice and wheat production. The use of high yielding and hybrid varieties increased the rate of fertilizer application, which became important to boosting agricultural output and feeding the rapidly expanding Indian population. (Jena *et al*., 2020). There are various reasons of fertilizer losses and low fertilizer use efficiency like immobilization, de-nitrification, leaching, soil fixation and volatilization etc. By using the proper fertilizer application technique, nutrient use efficiency can be increased. This can further enable soil fertility restoration, nutrient prevention and production sustainability of rice crop (Swamy *et al*., 2020) [15]. Heavy rainfall in the Konkan region during the monsoon season causes considerable leaching losses of chemical fertilizers applied to the crop. Foliar delivery of nutrients via bio-stimulants may be the best option in this situation.

A bio-stimulant is any substance applied to plants with the aim to increase nutrition efficiency, stimulate natural processes to enhance nutrient uptake, abiotic stress tolerance and/or crop quality traits and yield in spite of its nutrient content (Jardin, 2015) [6]. Bio-stimulants are materials, other than fertilizers, that promote plant growth and yield when applied in low quantities (Kauffman *et al*., 2007) [8]. Hence plant bio-stimulants are products that reduces the need for fertilizers by helping to improve nutrient uptake with nutrient use efficiency also increases plant growth, health, production and productivity. In small concentration, these substances are effective by serving the good performance of the plant's vital processes like photosynthesis, plant nutrition, respiration and allowing high yields and improve quality attributes of products (Vasconcelos *et al*., 2019) [16].

The functional changes resulting from exposure of a bio-stimulants are varying and may include activation of nitrogen metabolism or release of phosphorus from soil, generic stimulation of soil microbial activity or stimulation of root growth and increased plant establishment (Yakhin *et al*., 2017) [17]. Various bio-stimulants like Chitosan, Triacontanol, Sea grow powder, etc are used for foliar spray in crops at different growth stages which contain micronutrients, complex mixture of polysaccharides, plant growth regulators and plant growth hormones that have a stimulatory effects on plant growth and can enhance grain yield.

2. Material and Methods

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) during *kharif*, 2021. Geographically, experimental plot is situated in the subtropical region at 17°45'55" N latitude and 73°10'26" E longitude having elevation of about 157.8 m above mean sea level. The climate is sub-tropical which is characterized by warm and humid atmosphere which is very much favourable for a crop like rice during *kharif* season. The soil of the experimental plot was sandy clay loam in texture, medium in available nitrogen (263.86 kg ha^{-1}), phosphorus (11.22 kg ha^{-1}) and potassium (231.54 kg ha^{-1}), very high in organic carbon (11.05g kg^{-1}) and acidic in reaction (pH 6.34).

The experiment was laid out in randomized block design consists of 7 treatments *viz.*, T_1: Bio-stimulant (Sea Grow Powder) @ 0.75 g lit^{-1}, T_2: Bio-stimulant (Sea Grow Powder) @ 1 g lit^{-1}, T_3: Bio-stimulant (Sea Grow Powder) @ 1.5 g lit^{-1}, T_4: Bio-stimulant (Triacontanol) @ 1 ml lit^{-1}, T_5: Bio-stimulant (Chitosan) @ 2.5 ml lit^{-1}, T_6: Bio-stimulant (Chitosan Irradiated) @ 2.5 ml lit^{-1}, T_7: Control (Water spray) which were replicated thrice. The foliar application of bio-stimulants was done at 10-12 days after transplanting, at panicle initiation stage and at milk/ dough stage. The gross and net plot size were 4.00 m × 4.50 m and 3.60 m × 3.90 m, respectively. Spacing adapted for rice variety Ratnagiri 1 was 20 cm × 15 cm. The recommended dose of fertilizer (100:50:50 N P K kg ha^{-1}) and other package of practices for rice were imposed uniformly for all the treatments including control treatments. During the study, growth observation, yield attributing characters and yields were recorded at harvest to evaluate treatment effects.

3. Result and Discussion

3.1 Effect of bio-stimulants on rice growth

The bio-stimulants indicates remarkable variation in growth parameters of the rice such as plant height (cm), number of functional leaves hill^{-1}, number of tillers hill^{-1} and dry matter hill^{-1} (g) during the field experimentation (Table 1). Bio-stimulant (sea grow powder) @ 1.5 g lit^{-1} (T_3) produced significantly higher mean plant height at harvest, which was statistically at par with treatment bio-stimulant (chitosan) @ 2.5 ml lit^{-1}(T_5) as compared to other treatments. Further the data indicate that the significantly lowest mean plant height was observed in control (T_7) treatment. The increase in plant height might be due to the existence of plant hormones, plant growth regulators like auxin, gibberellins, cytokinin, macro and micro elements in seaweed extract which bring out the strong physiological response (Deepana *et al*. 2021) [4].

The higher number of functional leaves hill^{-1} was influenced significantly with the application of sea grow powder at 1.5 g lit^{-1} (T_3) which was statistically at par with treatment bio-stimulant (chitosan) @ 2.5 ml lit^{-1}(T_5). The treatment control (T_7) showed significantly lowest mean number of functional leaves hill^{-1}. This phenomenon may be due to the presence of active compounds, macro and micro nutrients in the seaweed extract, which is essential for vegetative growth, thus resulting in an increase in number of functional leaves hill^{-1} (Sunarpi *et al*. 2010) [14].

The number of tillers hill^{-1} were found to be maximum in treatment (T_3) bio-stimulant (sea grow powder) at 1.5 g lit^{-1} which was statistically at par with treatment bio-stimulant (chitosan) @ 2.5 ml lit^{-1}(T_5). In contrast lowest number of tillers hill^{-1} was recorded in control T_7 (water spray) during the entire crop growth period. The extract of seaweed aids in enzyme activation, photosynthates translocation, meristematic growth, elongation of cell and stability of cell (Pramanick *et al*., 2014) [10].

Application of bio-stimulant (sea grow powder) @1.5 g lit^{-1} (T_3) significantly recorded higher dry matter accumulation hill^{-1} which was statistically at par with treatment bio-stimulant (chitosan) @ 2.5 ml lit^{-1}(T_5) and significantly superior over rest of the treatments. The minimum dry matter accumulation was recorded in treatment control (T_7). The physiological responds were might be due to foliar application of sea grow powder that improved nutrient absorption, metabolism and partitioning (including protein synthesis) in increase leaf area, dry matter production and crop growth rate (Devi and Mani, 2015) [5]. Deepana *et al*. (2021) [4] reported that the application of seaweed extract might lead to the upliftment of dry matter production.

Amongst rest of the treatments T_2 and T_6 were at par with each other and T_4, T_1 and T_7 showed level of significance in descending order with respect to plant height (cm), number of functional leaves hill^{-1}, number of tillers hill^{-1} and dry matter hill^{-1} (g).

Table 1: Effect of bio-stimulants on growth parameters of rice at harvest

Treatment	Plant height (cm)	Number of functional leaves hill^{-1}	Number of tillers hill^{-1}	Dry matter (g) hill^{-1}
T_1	71.07	29.18	8.77	46.31
T_2	75.09	31.90	9.95	49.48
T_3	77.02	33.84	10.58	51.68
T_4	72.79	30.01	9.21	47.30
T_5	76.94	33.75	10.47	51.57
T_6	74.80	31.85	9.86	49.41
T_7	67.73	24.51	8.13	41.06
S.Em. (±)	0.55	0.59	0.16	0.67
C.D. at 5%	1.69	1.82	0.50	2.07

3.2 Effect of bio-stimulants on yield attributes, yield and economics

The results of present study (Table 2) indicates that there was a significant influence of various bio-stimulant treatments on the yield attributes *viz*., number of panicles hill^{-1}, panicle length (cm), number of grains panicle^{-1} and yield (grain yield, straw yield and biological yield) of rice. Whereas, application of bio-stimulants was found to be non-significant with respect to the 1000 grain weight (g) during the study. The number of panicles hill^{-1}, panicle length (cm) and number of grains panicle^{-1} were significantly higher in treatment sea grow powder at 1.5 g lit^{-1} than rest of the treatments which was statistically at par with treatment bio-stimulant (chitosan) @ 2.5 ml lit^{-1}(T_5). Amongst rest of the treatments T_2 and T_6 were at par with each other and T_4, T_1 and T_7 showed level of significance in descending order with respect to yield attributes. The chlorophyll production, photosynthetic process, protein synthesis, etc, might be energized due to presence of bio-stimulants which resulted in higher yield attributes Deepana *et al*. (2021) [4]. The increase in yield attributes in rice crop is due to effectual use of innate as well as applied nutrients through roots and foliar application of seaweed extract (Arun *et al*. 2019) [3].

The study in respect to yield of rice indicated (Table 4.12) that the application of bio-stimulant (sea grow powder) @ 1.5 g lit^{-1} (T_3) resulted significantly higher grain, straw and biological yield of rice crop over rest of treatments which was statistically at par with treatment bio-stimulant (chitosan) @ 2.5 ml lit^{-1}(T_5). Treatment control (T_7) showed minimum grain, straw and biological yield of rice. The per cent increase in grain yield and straw yield was to the tune of 33.06% and 24.92% in treatment T_3, respectively over control (T_7). Amongst rest of the treatments T_2 and T_6 were at par with each other and T_4, T_1 and T_7 showed level of significance in descending order with respect to grain, straw and biological yield. This remarkable response to yield might be obtained due to the better availability of plant nutrients throughout the growing period of crop and especially in critical growth period of rice crop which lead into better plant vigour and higher yield (Arun *et al*. 2019) [3]. The positive effects of phyto-hormones like betaines, cytokinins, etc, minerals, vitamins, amino acids, enzymes, etc. exist in extract of seaweed which results in maximization of grain, straw and biological yields of rice crop Khan *et al*. (2009) [9].

The impact of different bio-stimulants on the economics are presented in Table 2. The data revealed that, foliar application of bio-stimulant T_3 (sea grow powder) at 1.5 g lit^{-1} recorded higher gross return (₹ 113909.9 ha^{-1}), net return ((₹ 18748.15 ha^{-1}) and B:C ratio (1.20) closely followed by treatment bio-stimulant T_5 (chitosan) at 2.5 ml lit^{-1} recording gross return (₹113141.5 ha^{-1}), net return (₹18159.77 ha^{-1}) and B:C ratio (1.19). The lowest gross return (₹ 86368.03 ha^{-1}), net return (₹ -8051.25 ha^{-1}) and B:C ratio (0.91) was recorded in treatment control (T_7). Application of seaweed extract enhanced the early growth and yield attributes in rice and yield return of 24.85 than that of control (Sethi and Adhikary, 2008) [12]. These results are in conformity with Sebastian *et al*. (2021) [11], Sharma *et al*. (2016) [13].

Table 2: Effect of bio-stimulants on yield attributing characters, yield and economics of rice

Tr.	No. of panicles hill^{-1}	Length of panicle (cm)	No. of grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Cost of cultivation (₹. ha^{-1})	Gross returns (₹. ha^{-1})	Net returns (₹. ha^{-1})	B: C ratio
T_1	8.37	19.47	116.98	29.49	4205.77	5355.33	9561.10	94791	94980	190	1.00
T_2	9.27	20.73	124.00	29.68	4715.88	5848.70	10564.58	94914	106110	11196	1.12
T_3	9.92	21.45	127.52	29.80	5070.89	6213.89	11284.78	95162	113910	18748	1.20
T_4	8.66	19.91	119.45	29.52	4321.11	5491.01	9812.12	94824	105202	10377	1.11
T_5	9.87	21.39	127.37	29.73	5035.21	6183.39	11218.60	94982	113141	18160	1.19
T_6	9.25	20.68	123.66	29.57	4686.25	5830.06	10516.30	95049	105488	10439	1.11
T_7	7.37	18.18	110.21	29.34	3810.97	4974.08	8785.05	94419	86368	-8051	0.91
S.Em. (±)	0.19	0.18	1.04	0.31	100.49	108.57	145.12	-	-	3846.27	-
C.D. at 5%	0.60	0.55	3.19	N.S.	309.63	334.55	447.16	-	-	11851.53	-

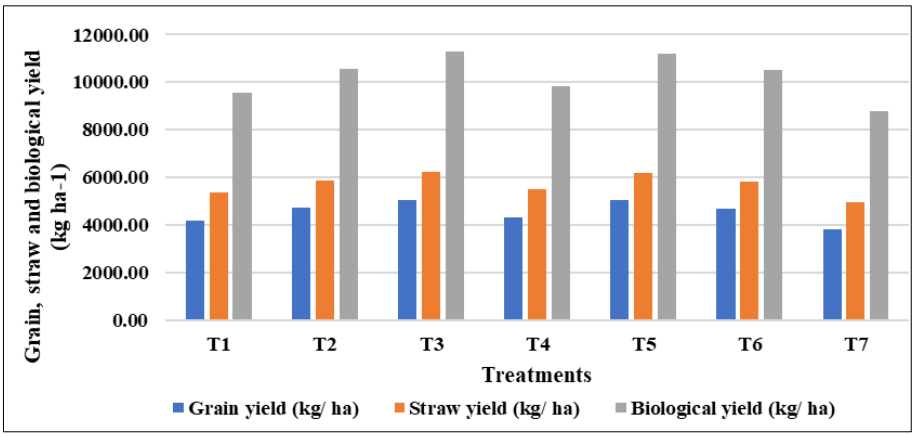

Fig 1: Grain yield, straw yield and biological yield of rice (kg ha^{-1}) as influenced by the different treatments

4. Conclusion

The study on effect of foliar application of biostimulants on growth, yield and yield attributing characters in rice (*Oryza sativa* L.) concluded that foliar application of biostimulant sea grow powder @ 1.5 g lit^{-1} at 10 to 12 days after transplanting, panicle initiation stage and milking or dough stage along with recommended dose of fertilizer on rice variety Ratnagiri 1 results in significantly higher growth parameters *i.e.*, plant height (cm), number of functional leaves hill^{-1}, number of tillers hill^{-1}, dry matter g hill^{-1}, yield attributes *viz.*, number of panicles hill^{-1}, panicle length (cm), number of grains panicle^{-1} and yield (grain, straw and biological yield kg ha^{-1}) of rice. The per cent increase in grain yield was to the tune of 33.06% in T_3 than control (T_7). Also, foliar application of 1.5 g lit^{-1} sea grow powder (T_3) recorded higher net return and B:C ratio which was closely followed by foliar application of 2.5 ml lit^{-1} chitosan (T_5).

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