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Growth and yield response to the application of different bio-stimulants on summer paddy

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Abstract
A field experiment was conducted during rabi season of 2017-18 and 2018-19 at "C" block farm B.C.K.V Mohanpur, to study the growth and yield response of rice to the application of different bio-stimulants. The experimental design was "RBD" having ten treatments and three replications.Three types of bio-stimulants (Soligro,Opteine and Biozyme) along with vermiwash are applied in different formulation i.e granular and foliar application and combination of different time of application (Basal, Tillering and Panicle initiation Stage) along with Recommended dose of Fertilizer (RDF). The highest plant height and CGR were observed significantly in 100% RDF+ Soligro Granule at Basal and 30 DAT over control. Highest yield attributes and grain yield found in 100% RDF+ Opteine liquid at 30 DAT and 60 DAT treatment resulting in an increase by 35.03% grain yield, respectively compared to the control. The maximum straw yield was also achieved with the application of 100% RDF+ Soligro Granule at 30 and 60 DAT.

Keywords: Seaweed extract, bio-stimulant, growth and yield parameters, rice

Introduction
Rice is central to the lives of billions of people around the world. Possibly the oldest domesticated grain (~10,000 years provides 21% of global human per capita energy and 15% of per capital protein. It is predicted that a 50 - 60% increase in rice production will be required to meet demand from population growth by 2025.India needs to produce 281 MT of food grains by 2020 to meet the food demand of 1.3 billion populations with an annual growth target of 2 per cent (Shetty *et al*., 2013) [10]. A rapidly growing world population has highlighted the need to significantly increase food production in the context of a world with accelerating soil and water shortages as well as climatic stress.
This all the problem has generated new interest in the application of bio-stimulants in form of solid and liquid seaweed extracts because of their potent plant growth and yield enhancing properties through metabolic benefits, increased nutrient uptake, changes in plant tissue composition, increased resistance to frost, triggering disease response pathways and increasing stress tolerance (Zhang *et al*., 2003) [13] longer self-life of fruit and better seed germination (Tay *et al*. 1987, Stirk and Van Staden, 1997) [17, 11]. In recent years, the use of marine algae extracts as biofertilizers has allowed the partial substitution of conventional mineral fertilizers. These can be used as liquid extracts for foliar and soil applications, or in granular form as soil improvers and fertilizer. More than 15 million tons of seaweeds are produced annually (FAO, 2006) [4]. A bio-stimulant is an organic substance, when applied in small amounts enhances the plant growth and development and such response cannot be achieved by application of traditional plant nutrients (EBIC, 2012) [3].
Very little work on Seaweed fertilizer in rice has been reported so far. However, there is a lot of information have come out on the nutrient management of high yielding variety of rice. Considering the aforesaid facts this study aims to find an effective and efficient combination of bio-stimulant to increase the growth and yield of summer rice.

Materials and Method
Experimental site and soil information
The field experiment was conducted in the Boro season of 2017-18 and 2018-19 on inceptisol at 'C' Block Farm of Bidhan Chandra Krishi Viswavidyalaya of Nadia district, of West Bengal

in India situated in New Alluvial Zone. The soil of the site was sandy clay loam with pH 7.04, organic carbon 0.45%, total nitrogen 188.9 kg ha $^{-1}$, availableP_2O_5 26.29 kg ha^{-1} and available K_2O 148.72 kg0 ha^{-1}. The climate ofthe region is humid subtropical. The experimental site is located at 22°57′ Nattitude and 88°20′E longitude with an altitude of 9.75 m above mean sea level and the ecosystem is in medium land.

Experimental designs and treatments

The experiment was laid out in a Randomized Block Design (RBD) having three replications with 10 treatments.

Table 1: Treatment Details

Treatment	Dose ha^{-1}	Time of application
T_1- Control	No fertilizer	
T_2 -100% RDF	NPK @120:60:60 kg [RDF]	Entire P and K and 1/2nd of N as BasaL; top dressing of 1/4th N at 30 DAT and 1/4th N at 60 DAT stage
T_3-100% RDF+ Soligro granule	10 kg	Fertilizer application as in T1 + Soil applications of soligro granule at Basal
T_4 - 100% RDF+ Soligro granule	10 kg	Fertilizer application as in T1 + Soil applications of soligro granule at Basal and 30 DAT
T_5 - 100% RDF+ Soligro granule	10 kg	Fertilizer application as in T1 + Soil applications of soligro granule at 30 DAT and 60 DAT
T_6 - 100% RDF+ Opteine liquid	625 ml	Fertilizer application as in T1 + Foliar applications of Opteine liquid at 30 DAT
T_7 - 100% RDF+ Opteine liquid	625ml	Fertilizer application as in T1 + Foliar Applications of Opteine liquid at 30 DAT and 60 DAT
T_8 - 100% RDF+ Biozyme liquid	625 ml	Fertilizer application as in T1 + Foliar Applications of Biozyme liquid at 60 DAT
T_9 - 100% RDF+Biozyme liquid + Vermiwash	Biozyme 650 ml Vermiwash 10 lit	Fertilizer application as in T1 + Foliar Applications of Biozyme liquid and Vermiwash at 60 DAT
T_{10} - 100% RDF+ Vermiwash	10 lit	Fertilizer application as in T1 + Foliarapplications of Vermiwash at 60 DAT

Plant sampling

Data were taken through random sampling at 30 DAS, 60 DAS and 90 DAS to measure plant height, dry matter accumulation, crop growth rate (CGR) and leaf area index (LAI). CGR was computed with the help of the formula: $[(W_2– W_1)/ (t_2– t_1)]$ where, W_1= dry weight per unit area at t_1, W_2 = dry weight per unit area at t_2, t_1 = first sampling and t_2 = second sampling. LAI was computed by the ratio of leaf area to the area of ground cover. Data on yield attributes were taken randomly before harvesting. At maturity, rice grain and straw samples were collected from each plot. Data were analysed using ANOVA following Randomized Block Design (RBD) (Gomez and Gomez 1984) [5]. Differences were considered significant at 5% level of probability.

Result and Discussion

Effect of treatments on growth of rice

Data on plant height of rice recorded at different days i.e., 30, 45, 60 and 90 days after transplanting (DAT) presented in Table 2. A positive response on plant height of sea weed extract was obtained in all treatments over control (no fertilizer) and 100% RDF due to the fact that the formulations of sea-weed extract (*Ascophyllum nodosum*) which not only provided the plant growth promoting substances like hormones, organic acids, polysaccharides, amino acids, and proteins (Cassan *et al*.1992) [1] and thereby accelerated soil biological activities but also enhanced the inherent plant capacity to express itself with full potential.

The maximum plant height was observed in T_4 treatment i.e.100% RDF+ Soil applications of Soligro granule at Basal and 30 DAT followed by T_6 i.e.100% RDF+ Foliar applications of Optein liquid at 30 DAT and T_3 treatment i.e.100% RDF+ Soil applications of Soligro granule at Basal. The above findings were related to the observations reported by Lekharam *et al*. 2011 [7], on cotton and P.S Deshmukh and D.B Phonde, 2009-10 on sugarcane.

In case of LAI, it almost increased up to 60 DAT and decreased thereafter. Highest LAI found in T_5 treatment i.e. 100% RDF+ Soil application of Soligro granule at 30 DAT and 60 DAT followed by T_4 treatment which was statistically at par, this might be due to the favourable effects of bio-stimulants to supply of growth promoting hormones and other materials in readily available form.

Crop growth in terms of the dry matter production of transplanted summer rice at 30, 60 and 90 DAT were significantly influenced by different treatments (Table 1).Maximum dry matter production was recorded inT_4 treatment followed by T_5 treatment. This might be due to the biotechnological product of *Ascophyllum nodosum*, a plant growth regulator that enables the plants to develop bio-morphological and physiological behaviour in such a way that they can have best use of existing as well as applied input (Humphries, 1968) [6].

The CGR of rice varied from 14.29 to 18.21 g m^{-2} day^{-1} and 11.08 to 12.85 g m-2 day-1 at 30-60 DAT and 60-90 DAT respectively and the treatment variation was to the tune of 27.43% and 15.97% respectively. The increased CGR along with higher uptake of nutrients due to application of bio-stimulants coupled with chemical fertilizers also reported by Mitra and Mandal (2012) [8]. The above findings confirm the observations reported by Pramanik *et al*. (2014) [9].

Effect of treatments on yield parameter of rice

Data on yield and yield parameters of rice were presented in Table 3. The most important yield component of rice in terms of panicle per square meter area was found statistically significant as influenced by application of different bio-stimulants during rabi seasons. The highest number of panicles m^{-2} was recorded by the rice plot fertilized with 100% RDR+ Foliar application of Opteine liquid at 30 DAT and 60 DAT (T_7) (281 m^{-2}) followed by treatment of 100% RDF+ Optein liquid at 30 DAT (T_6) (278 m^{-2}) which was statistically at par with T_7 treatment might be due to better utilization of growth resources in the plots receiving growth hormones, micronutrients, enzymes, proteins, vitamins etc. through the addition of *Ascophyllum nodosum* extracts. The maximum panicle length (24.68 cm) was achieved in T_7 treatment i.e.100% RDF + Foliar application of Opteine liquid at 30 DAT and 60 DAT followed by T_8 treatment (100% RDF+ Foliar applications of Biozyme liquid at 60 DAT) (24.52 cm). T_8 treatment was statistically at par with T_7 treatment. The best effects of bio-stimulants applied with

100% RDF + Foliar application of Opteine liquid at 30 DAT and 60 DAT might be due to Optein liquid regulated plant bio-physiological activities which in turn resulted in higher chlorophyll content in leaves that's help in maintaining higher photosynthetic activity even during later stages of growth (i.e. grain filling stage), which collectively increased the proportion of filled grains. The result was in conformity with the findings of Mitra and Mandal (2012) [8]. The test weight (1000 grain weight) of rice did not vary significantly among the different treatments employed here due to genetic factor which governed the test weight, not being influenced largely by the external inputs.

Effect of treatments on grain and straw yield parameter of rice

Bio-stimulants prepared from the extracts of seaweed *Ascophyllum nodosum* improved significantly the grain yield of rice due to the improvement in yield attributing characters. The highest grain yield (4.51 t ha^{-1}) was recorded in T_7 treatment [100% RDF+ Foliar applications of Optein liquid at 30 DAT and 60 DAT] which was significantly higher than other treatments. Besides inorganic fertilizers, the application of bio-stimulants at 30 and 60 DAT coincided with the critical physiological growth stages which favoured the crop to put forth better growth characteristics as well as increased yield components which in turn yielded the highest grain yield. The increased in yield in combined bio- stimulants and fertilizers treated plots was 35.03% in T_7, 28.74% in T_9 and 27.25% in T_5 over the control T_1 (no fertilizer), which produced the lowest grain yield (3.34 t ha^{-1}). Application of 100% RDF+ Soil application of Soligrogranule at 30 DAT and 60 DAT (T_5) recorded the highest straw yield of 6.83 t ha^{-1}, followed by T_4 (6.77 t ha^{-1}) and T_7 (6.73 t ha^{-1}). The lowest straw yield was recorded in control plot (5.50 t ha^{-1}). The higher straw yields obtained in bio-stimulants applied plots was due to the greater production of dry matter. Treatment T_6 (100% RDF+ Foliar applications of Optein liquid at 30 DAT) gave highest value of harvest index (40.14%) compared to rest of the treatment combinations. The lowest value of 37.77% was recorded in T_1. The higher values of harvest index indicated the greater translocation of photosynthates from source to sink and also better portioning towards reproductive growth.

Effect of treatments on economics

The cost of cultivation varied according to treatment. Economic analysis indicated that combined application of bio-stimulants and RDF increased the gross and net returns compared to standard check treatment (Table 4).The highest gross return, net return and benefit cost ratio recorded in the plot was fertilized with 100% RDF+ Foliar applications of Optein liquid at 30 DAT and 60 DAT (T_7) due to highest productivity. In terms of expenditure incurred for cultivation, the highest cost of cultivation was recorded in the T_4 (100% RDF+Soil application of Soligro granule at Basal and 30 DAT) and T_5 (100% RDF+ Soil application of Soligrogranule at 30 DAT and 60 DAT) treatment (Rs 57162/- per ha).

Table 2: Effect of bio-stimulants on growth parameter of rice

Treatment	Plant Height (cm)				Drymatter accumulation ($g\ m^{-2}$)			CGR ($g\ m^{-2}day^{-1}$)		LAI		
	30 DAS	45 DAS	60 DAS	90DAS	30 DAS	60 DAS	90 DAS	30-60 DAS	60-90 DAS	30 DAS	60 DAS	90 DAS
T_1	34.85	69.98	74.78	83.39	47.83	476.58	809.12	14.29	11.08	1.83	3.73	1.96
T_2	39.98	71.18	79.35	87.27	50.95	487.66	815.92	14.57	10.94	1.96	3.85	2.02
T_3	40.68	74.35	83.55	94.24	57.58	574.65	890.03	17.23	10.51	1.92	4.02	2.04
T_4	43.08	77.96	86.43	98.63	60.23	600.70	987.10	18.21	12.85	2.07	4.12	2.55
T_5	39.00	68.57	79.13	93.69	54.32	582.84	957.00	17.40	12.47	2.12	4.21	2.59
T_6	41.81	73.03	83.50	94.30	53.58	515.30	845.25	15.39	10.99	1.92	4.01	2.08
T_7	39.45	73.70	82.69	92.68	55.05	548.00	838.94	16.43	9.69	1.87	4.17	2.19
T_8	39.65	73.95	82.10	92.02	53.37	542.42	842.50	16.30	10.00	2.02	4.08	2.15
T_9	39.37	74.41	79.60	88.85	53.17	531.29	859.32	15.94	10.93	1.93	4.05	2.02
T_{10}	38.91	71.87	79.14	89.91	52.70	551.97	832.85	16.63	9.36	1.92	3.97	2.19
Sem (±)	1.03	NS	1.23	1.59	1.35	12.31	23.63	0.41	1.06	0.023	0.011	0.030
CD at 5%	3.06	NS	3.67	4.74	4.02	36.59	70.19	1.22	NS	0.067	0.033	0.090

Table 3: Effect of bio-stimulants on Yield, yield attributes and associative character of rice

Treatment	Yield attributes				Grain and straw yields				
	No of paniclem^{-1}	No of filled grainpanicle^{-1}	Panicle length (cm)	Test weight(gm)	Grain yield (t ha^{-1})	Grain Yield increase over control (%)	Straw yield (t ha^{-1})	Straw Yield increase over control (%)	Harvest Index (%)
T_1	199	104	22.51	22.53	3.34	-	5.50	-	37.77
T_2	219	109	22.94	22.91	3.88	16.17	5.98	8.73	39.36
T_3	259	114	23.09	22.67	4.03	20.66	6.15	11.82	39.60
T_4	263	112	23.20	22.92	4.19	25.45	6.77	23.09	38.24
T_5	264	117	23.87	23.15	4.25	27.25	6.83	24.18	38.32
T_6	278	114	23.47	22.66	4.16	24.55	6.20	12.73	40.14
T_7	281	129	24.68	22.67	4.51	35.03	6.73	22.36	40.13
T_8	265	119	24.52	22.87	4.2	25.75	6.46	17.45	39.61
T_9	270	121	23.79	22.77	4.30	28.74	6.42	16.73	40.10
T_{10}	261	117	23.86	22.93	4.17	24.85	6.33	15.09	39.73
SEm (±)	2.98	2.39	0.21	0.21	0.049	-	0.085	-	0.362
CD at 5%	8.86	7.10	0.65	NS	0.146	-	0.251	-	1.076

Table 4: Production economics of rice under different treatments

Treatment	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs.ha^{-1})	B:C
T_1	47062	58450	11388	1.24
T_2	53961	67900	13939	1.26
T_3	55561	70525	14964	1.27
T_4	57162	73325	16163	1.28
T_5	57162	74375	17213	1.30
T_6	54461	72800	18339	1.34
T_7	54961	78925	23964	1.44
T_8	54501	74200	19699	1.36
T_9	55301	75250	19949	1.36
T_{10}	54761	72975	18214	1.33

Conclusion
Thus, it may be concluded from the present study that 100% RDF with foliar application of opteine liquid at tillering and panicle initiation stage could be recommended for cultivation due to maximum yield (4.51 t ha $^{-1}$), higher net return (Rs. 23946 ha^{-1}) and B:C ratio (1.44) during Boro season in New Alluvial Zone of West Bengal.

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