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Effect of seaweed extract as biostimulant on crop growth and yield in rice (*oryza sativa* l.) under transplanted condition

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Abstract

Enhancing productivity through integrated nutrient management is pertinent to sustainable intensification of agricultural ecosystems. Field experiments were conducted during *kharif* and *rabi* 2016 at the research farm of Indian Institute of Rice Research, Hyderabad, Telangana in a clay loam soil to study the effect of sea weed extract (Liquid Bio-stimulant6, LBS6_S, LBS8, LBS9 and LBS10) with various concentrations on growth, yield of rice under transplanted condition. Positive effects and significant variation was observed on the plant height (98.9 cm) at harvest stage of rice when LBS6_S bio-stimulant (T_3) was sprayed when compared to other bio-stimulant application while least plant height was recorded with recommended dose of fertilizer (120:60:40 NPK Kg/ha). Grain yield due to seaweed bio-stimulants application varied from 5.31 to 5.58 t/ha and significantly increased over recommended dose of fertilizer alone (T_7). Per centage increase of grain yield was 4.15 to 9.14 per cent over recommended dose of fertilizer. Hence, bio-stimulant LBS6_S can be applied for improving growth and grain yield of transplanted rice.

Keywords: Liquid Biostimulant, Seaweed Extracts, transplanted rice

Introduction

Rice is the most important staple food crop for more than half of the global population and is grown extensively in the world. India occupies first position in area (44.2 M ha) and second position in production after China (140.8 million tonnes) in the world. In India, rice production has increased by fivefold from 20.51 mt during 1950 – 1951 to more than 108.86 mt in 2016 -17 and this increase in rice production can be attributed to the development of fertilizer responsive high yielding rice varieties which made nearly 50 per cent contribution in tapping the high yield potential of varietal technology (Anonymous, 2017). Indiscriminate use of fertilizers had resulted in imbalanced use which gradually decreased the productivity of the soil over the years and balanced fertilizer use is a pre-requisite for sustaining rice production. Seaweeds are one of the most important marine resources of the world and derived products have been widely used as amendments in crop production system due to the presence of number of plant growth- stimulating compounds such as cytokinin, auxins, gibberellins, betaines, as well as presence of macronutrients such as Ca, K, P, and micronutrients like Fe, Cu, Zn, B, Mn, Co and Mo, which are necessary for plant growth and development (Mahima Begum, 2018). Seaweeds, particularly brown algae, have been used in agriculture since the twelveth century with much success (Temple and Bomke, 1988). They were added either directly to the soil as seaweed compost or dried and ground and added to the soil as seaweed meal. Both the seaweed compost and meal serve as a slow release fertilizer and act as soil conditioner, improving aeration and aggregate stability. However, the bio-stimulatory potential of many of these products has not been fully exploited due to the lack of scientific data on growth factors present in sea weeds and their mode of action in affecting plant growth. The seaweed bio-product is a bio-stimulant formulation that is a mixture of micro and macro nutrients, amino acids, carbohydrates, plant growth regulators and other plant growth elicitors emerging as commercial formulations for use as plant growth-promoting factors and a method to improve tolerance to salinity, heat, and drought due to presence of plant hormones (Kavipriya *et al*, 2011). Modern agriculture is searching for new technologies that would allow for a reduction in the use of chemical inputs without negatively affecting crop yield or the farmers' income. In recent years, the use of natural seaweed as fertilizer has allowed for partial substitution of conventional inorganic fertilizer (Zodape *et al*., 2010). One of the most consistent effects of sea weed concentrate (SWC) application is the development of a vigorous root system if applied during the early vegetative growth phase (Metting *et al*., 1990).

In this connection it is essential to utilize the different bio-stimulants which indirectly enhances the plant to assimilate more nutrients from the soil and also translates into increase yield. Hence, the present investigation was conducted to study the response of different concentration seaweed bio-stimulant LBS6, LBS6_S, LBS8, LBS9 and LBS10 as foliar application in addition to recommended fertilizer dose on growth, yield and productivity of the system.

Materials and Methods

A field experiment was conducted during *kharif and rabi* 2016 with rice variety RP Bio-226 (Improved Samba Mahsuri) of 135 days duration (latitude - 17^{o}23´ N, longitude - 78^{o}25´ E and altitude – 508 M) at the research farm of Indian Institute of Rice Research Rajendranagar Hyderabad. The soil of the experimental field was clay loam in texture with a pH 7.9, organic carbon (0.37%), low in available nitrogen (206 kg / ha), medium in available phosphorous (22.3 kg / ha) and high in available potassium (304 kg / ha). Entire dose of phosphorus and potassium (60 and 40 K Kg / ha) and one third dose of nitrogen (40 Kg /ha) was applied as basal. The remaining nitrogen (80 Kg / ha) was top dressed equally at tillering and panicle initiation stage. The experiment consisted of seven treatments *viz*.,T_1 – LBS6 @ 1ml / Litre of water – one spray during nursery transplanting + two sprays (30 and 60 days after transplanting) T_2 – LBS6 @ 1.0 ml / Litre of water – one spray during nursery transplanting + two sprays during vegetative stage (30 and 60 days after transplanting) (20% Less NPK fertilizer dose) T_3- LBS6_S @ 1.0 ml / Litre of water – one spray during nursery transplanting + two sprays during vegetative stage (30 and 60 days after transplanting) T_4- LBS8 @ 1.0 ml / Litre of water – one spray during nursery transplanting + two sprays during vegetative stage (30 and 60 days after transplanting), T_5- LBS9 @ 1.0 ml / Litre of water – one spray during nursery transplanting + two sprays during vegetative stage (30 and 60 days after transplanting) T_6- LBS10 @ 1.0 ml / Litre of water - one spray during nursery transplanting + two sprays during vegetative stage (30 and 60 days after transplanting) T_7- Recommended NPK (120: 60: 40 NPK kg /ha) (Nitrogen -1/3 basal 1/3 tillering and 1/3 panicle initiation stage). The experiment was laid out in randomized block design with three replications. Twenty five days seedlings of rice were transplanted manually with a spacing of 20 x 15 cm. Recommended agronomic practices such as gap filling, weeding and pest and disease control were carried out uniformly as and when needed. Two hand weeding at 25 and 45 DAT were done for weed control. The growth attributes like plant height and dry matter production were recorded from randomly selected five plants in each plot (30, 60, 90 DAT and at harvest). The yield parameters (panicles hill^{-1}, effective grains panicle^{-1} and test weight) were measured at maturity from randomly selected five hills in each plot. The post harvest data on grain and straw yields and harvest index (HI) were recorded from the net plot yield 6 x 2.0 m. and data were statistically analyzed using variance for randomized block design (Gomez and Gomez, 1984).

Results and Discussion

Growth and physiological attributes in rice

Crop growth attributes showed significant improvement with application of various sea weed liquid bio-stimulant formulations over recommended dose of fertilizer. All the growth and yield parameters such as plant height, number of leaves per hill, number of tillers / m^2 and SPAD reading recorded at 30 DAT and 60 DAT increased with the application of various seaweed bio-stimulants as compared to recommended dose of fertilizer (Table 1 & 2). The growth parameters were higher in Seaweed bio-stimulants (LBS6, LBS6_S, LBS-8, LBS-9 and LBS-10) over recommended dose of fertilizer (T_7) at 90 days after transplanting (Table 3). SPAD meter reading was highest in all the seaweed liquid bio-stimulant treatment compared to recommended dose of fertilizer (T_7) at 30, 60 and 90 days after transplanting. The organic constituents of seaweed extract include plant hormones which elicit strong physiological responses in low doses. The seaweed extracts helps in meristematic growth, translocation of photosynthates, enzyme activation, cell elongation and cell stability (Pramanick *et al*., 2013).

Positive effects and significant variation was observed on the plant height of rice when LBS6_S bio-stimulant (T_3) (81.3 cm and 80.3 cm, respectively) was sprayed when compared to other bio-stimulant application and the least plant height was recorded in recommended dose of fertilizer (72.1 cm and 71.0 cm) (Table 3). More number of tillers was obtained from LBS6_S (T_3) (562 tillers / m^2) followed by LBS6 (T_1) (554 tillers/ m^2) (Pooled data). Days to 50 per cent flowering was minimum in LBS6_S (91.7 days) and maximum in recommended dose of fertilizer (99.1 days) (T_7) (Figure 1). Layek *et al* (2018) reported that foliar spray sea weed sap of *Kappaphycus* and *Gracilara* species at 5 per cent and above concentration increased plant height, dry matter accumulation, chlorophyll index and crop growth rate as compared to recommended dose of fertilizer.

Yield attributes

All the yield parameters such as number of panicles/ m^2, panicle weight, grains per panicle, test weight, grain yield (t/ha) and harvest index increased with the application of various seaweed bio-stimulants as compared to recommended dose of fertilizer (Figure 1 & 2). Highest number of panicles was recorded in LBS6_S (T_3) (508 and 478 number of panicles / m^2) followed by LBS10 (T_6) (489 and 449 panicles / m^2) and LBS6 (T_1) (484 and 454 panicles / m^2) during *kharif* and *rabi* season. Number of grains per panicle was highest in LBS6_S (197 and 193 grains/ panicle *kharif* and *rabi* season, respectively) when compared to all treatments The increase in yield attributes in rice crop is due to efficient utilization of native as well as applied nutrients through roots and foliar application of seaweed bio-stimulants. The spraying of seaweed extract at 30 and 60 days interval after planting recorded higher tuber yield, improved nitrogen, total soluble solids and protein contents of the potato tubers (Haider *et al.* 2012).

Table 1: Effect of Sea6 – Bio-stimulant on the plant growth of rice under puddled condition at 30 days after transplanting

Treatment	Plant Height (cm)			Number of leaves / hill			Tillers/ m^2			SPAD Meter Reading		
	Kharif	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled	*Kharif*	*Rabi*	*Pooled*	*Kharif*	*Rabi*	Pooled
T_1	33.6	31.3	32.5	16.0	15.5	15.8	187	179	183	32.30	30.40	31.35
T_2	31.0	30.7	30.8	13.9	13.2	13.55	189	173	181	32.60	30.26	31.43
T_3	34.9	33.8	34.4	19.3	17.9	18.6	201	190	196	33.93	32.49	33.21
T_4	31.6	31.9	31.8	17.4	16.6	17.0	197	177	187	33.17	31.20	32.19
T_5	33.9	32.6	33.3	15.1	14.4	14.75	181	169	175	32.63	30.60	31.62
T_6	34.5	33.1	33.8	15.8	15.2	15.5	183	171	177	33.59	31.92	32.76
T_7	27.7	28.5	28.1	13.7	12.1	12.9	167	159	163	31.23	30.12	30.68
CD (0.05)	1.86	1.82	1.84	2.81	2.70	2.78	28.13	26.34	27.25	2.09	2.01	2.06
CV	3.41	3.36	3.38	10.53	10.41	10.46	8.93	8.43	8.69	4.67	4.45	4.59

Table 2: Effect of Sea6 - Bio-stimulant on the plant growth of rice under puddle condition at 60 days after transplanting

Treatment	Plant Height (cm)			Number of leaves / hill			Tillers/ m^2			SPAD Meter Reading		
	Kharif	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
T_1	63.1	61.9	62.5	34.1	33.3	33.7	289	284	286.5	37.8	36.07	36.93
T_2	60.8	61.7	61.3	36.3	33.7	35.0	321	310	315.5	38.5	35.63	37.07
T_3	63.9	63.5	63.7	38.1	37.1	37.6	324	304	314	38.9	36.65	37.78
T_4	61.6	60.8	61.2	36.0	35.6	35.8	302	288	295	37.1	37.18	37.14
T_5	62.9	61.4	62.1	34.3	33.5	33.9	309	300	304.5	37.4	35.49	36.45
T_6	63.5	61.1	62.3	32.4	31.9	32.1	293	281	287	36.3	35.90	36.1
T_7	57.7	52.9	55.3	30.3	29.1	29.7	230	252	241	35.2	33.47	34.34
CD (0.05)	4.39	3.85	4.12	2.91	2.83	2.87	41.01	38.03	39.52	3.38	3.04	3.21
CV	3.41	4.31	3.86	7.92	8.7	8.31	8.89	8.22	8.56	5.3	5.12	5.21

T_1- LBS6@ 1ml/lts (1spray at seedling transplantation +2 spray (30 and 60 DAS) + Recommended Dose of Fertilizer); T_2 - LBS6@ 1ml/lts (1 spray transplantation + 2 spray (30 and 60DAS 20% lower Recommended Dose of Fertilizer); T_3 - LBS6_S ml/lts (1 spray at seedling transplantation+ 2 spray (30 and 60DAT); T_4 - LBS8 @ 1ml/ lts 1 spray at seedling transplantation+ 2 spray (30 and 60 DAT); T_5 - LBS9 1Ml/lts (1 Spay at seedling transplantation + 2 spray (30 and 60 DAT); T_6 - LBS10 1ml/lts (1 spray at seedling transplantation + 2 spray (30 and 60 DAT); T_7 - Recommended Dose of Fertilizer (100 per cent).

Table 3: Effect of Sea6 – Bio-stimulant on the plant growth of rice under puddle condition at 90 days after transplanting

Treatments	Plant height (cm)			No of leaves / hill			Tillers / m^2			SPAD Meter Reading		
	Kharif	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled	*Kharif*	*Rabi*	Pooled
T_1	75.8	74.1	74.9	42.3	43.0	42.7	557	551	554	39.77	39.9	39.83
T_2	76.3	75.2	75.8	43.1	41.3	42.2	509	503	506	35.97	35.8	35.9
T_3	81.3	80.3	80.8	46.3	45.8	46.1	565	560	562	37.50	37.6	37.6
T_4	76.5	75.5	76.0	42.3	42.1	42.2	513	506	509	38.03	38.5	38.27
T_5	77.4	76.3	76.9	40.3	42.6	41.5	545	540	542	40.13	40.7	40.42
T_6	77.5	75.0	76.3	39.0	39.3	39.1	547	541	544	39.23	39.3	39.27
T_7	72.1	71.0	71.6	35.7	37.0	36.4	503	499	501	37.67	37.1	37.39
CD (0.05)	4.49	4.52	4.50	4.89	4.92	4.90	65.51	65.65	65.57	5.03	5.06	5.04
CV	3.43	3.47	3.45	6.78	6.83	6.80	7.32	7.38	7.35	7.74	7.79	7.76

T_1- LBS6@ 1ml/lts (1spray at seedling transplantation +2 spray (30 and 60 DAS) + Recommended Dose of Fertilizer); T_2 - LBS6@ 1ml/lts (1 spray transplantation + 2 spray (30 and 60DAS 20% lower Recommended Dose of Fertilizer); T_3 - LBS6_S ml/lts (1 spray at seedling transplantation+ 2 spray (30 and 60DAT); T_4 - LBS8 @ 1ml/ lts 1 spray at seedling transplantation+ 2 spray (30 and 60 DAT); T_5 - LBS9 1Ml/lts (1 Spay at seedling transplantation + 2 spray (30 and 60 DAT); T_6 - LBS10 1ml/lts (1 spray at seedling transplantation + 2 spray (30 and 60 DAT); T_7 - Recommended Dose of Fertilizer (100 per cent).

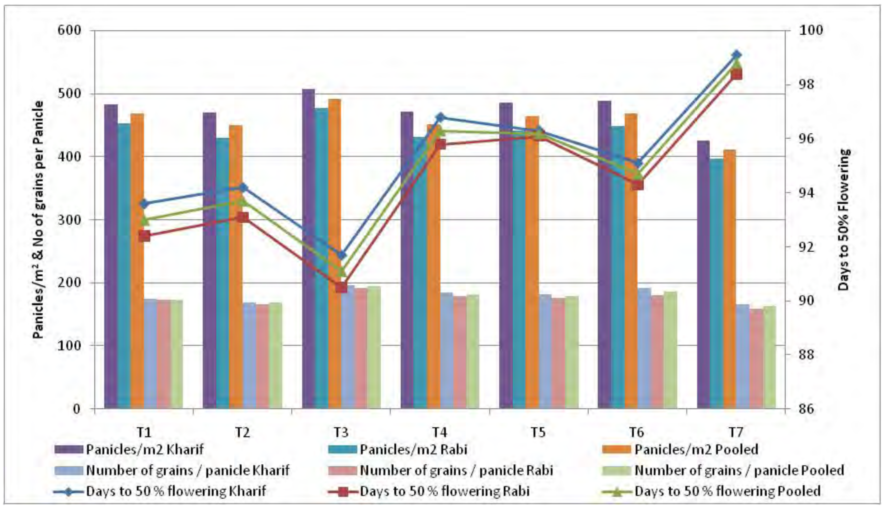

Figure 1: Effect of Sea6 – Bio-stimulant on number of panicles /m², number of grains / panicle and days to 50 per cent flowering in rice

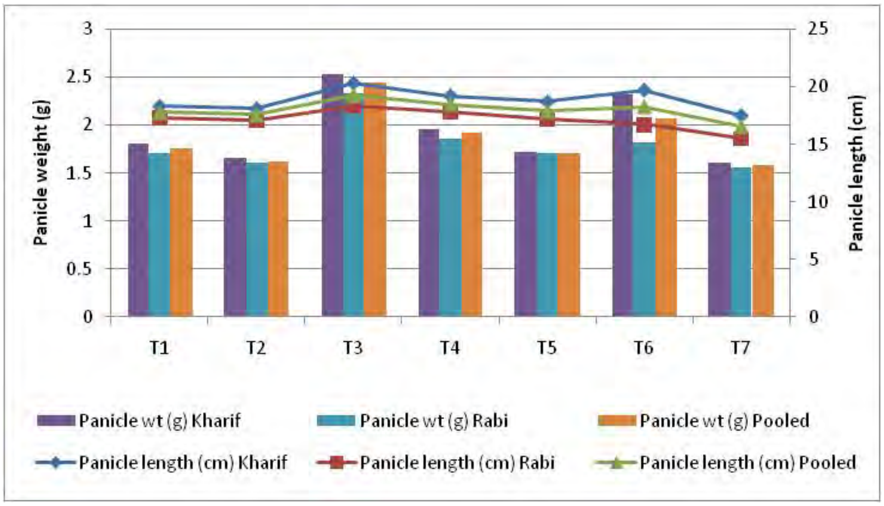

Figure 2: Effect of Sea6 – Bio-stimulant on panicle weight and panicle length in rice crop

Test Weight and Grain Yield (Kg /ha)

The highest test weight was recorded in LBS6_S (T_3) (21.68 g) followed by LBS6 (21.4 g) (pooled data). Grain yield due to seaweed bio-stimulants application varied from 5.31 t/ha to 5.58 t/ha (pooled) and significantly increased over recommended dose of fertilizer alone (T_7). Per centage increase of grain yield was 3.51 to 11.62 per cent in *kharif* and 2.05 per cent to 6.65 per cent during *rabi* season over recommended dose of fertilizer (Fig. 3). Favourable response to yield might be attributed to the better availability of plant nutrients throughout the growth period and especially in critical growth period of rice crop which resulted into better plant vigour and superior yield attributes. This is due to rapid growth caused by adequate nutrient supply to the rice crop which resulted in increase in various metabolic processes and better mobilization of synthesized carbohydrates in amino acids and protein which in turn stimulated the rapid cell division and cell elongation thus allowed the plant to grow faster (Anil *et al.*, 2014). The positive effect of seaweed extracts application on soybean yield was also investigated. Foliar application of extracts in different concentrations resulted in higher yield, more intensive growth and better nutrients absorption of soybean (Rathore *et al.*, 2009). Seaweed extracts can act by increasing plant vigor and vitality due to the presence of several bioactive substances that are important for plants and also they can improve nutrient uptake from soil. There are many advantages of using seaweed extracts as stimulants of plant growth, including higher germination rates, root-system development, increased leaf area, fruit quality and plant vigor. Besides this, plants treated with seaweed extracts have a higher content of biochemical constituents such as chlorophyll, carotenoids, protein, and amylases (Rosalba Mireya Hernández-Herrera *et al.*, 2018). Layek *et al* (2018) reported that foliar spray of sea weed sap of *Kappaphycus* and *Gracilara* species at 5 per cent and above concentration increased yield attributes and yield of rice 5.4 to 18.4 per cent higher as compared to control.

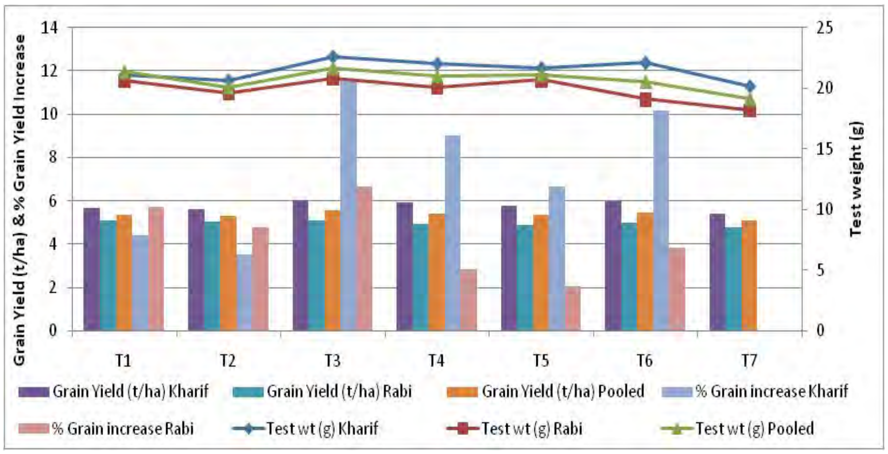

Fig. 3: Effect of Sea6 – Bio-stimulant on Test weight, Grain yield and per centage grain yield in rice

Conclusion

Seaweeds provide an abundant source of natural growth substances that can be used to enhance plant growth. Seaweed liquid bio-stimulants are complex and diverse in nature and yet have great potential for enhancing crop productivity and offer novel biological mechanisms to exploit to ensure farmers for improving yield. It improves plant growth and yield with increased crop resistance to certain pests allowing for lower amounts of synthetic fertilizers and pesticides to be used. Escalating costs and increased awareness of the negative effects of using synthetic agrochemicals makes the use of sea weed extracts an attractive alternative. The results of the present study showed that the application of liquid bio-stimulant LBS6_S was found superior to all other bio-stimulants along with recommended dose of fertilizer which helped in the balance availability of nutrients to the plant and maintenance of organic and inorganic nutrient in soil and hence increased rice productivity by 3.51 to 11.62 per cent in *kharif* and 2.05 to 6.65 per cent during *rabi* season. In places where inorganic fertilizer effects are limited, liquid bio-stimulant may provide a powerful and environmentally friendly approach to nutrient management and enhance the sustainability of rice productivity.

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