

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.710.060>

## Unravelling the Effect of Seaweed Bio Formulations in Relieving Biotic and Abiotic Stress in Rice

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### ABSTRACT

#### Keywords

Tropical seaweeds,  
bioformulations, LBS6,  
LBD1, Tricyclazole and  
Carbendazim

#### Article Info

Accepted:  
06 September 2018  
Available Online:  
10 October 2018

A field experiment was conducted during *Kharif* 2017-2018 to study the effect of tropical red seaweed (*Kappaphycus alvarezii*) bioformulations (LBS 6 and LBD 1 in relieving the fungicidal stress and imparting the resistance to blast disease) in rice. Foliar application of LBS6 @ 1 ml/l was found to be statistically superior in improving yield parameters viz., straw (6.94 kg/plot) and grain weight (5.59 kg/plot). There was 41.90 and 27.04 per cent increase over control with respect to straw and grain yield in T<sub>3</sub> (LBS6 @ 1.0 ml/l). Lower disease severity of 11.52 per cent was recorded in T<sub>1</sub> (tricyclazole 75 %WP). The bioformulation LBD1 (T<sub>4</sub>) treated plots recorded 12.11 per cent disease severity. However there was no significant difference between T<sub>1</sub> and T<sub>4</sub>. It was observed that LBD1 was on par with the fungicide in controlling the disease.

### Introduction

Rice (*Oryza sativa* L.) is an important cereal crop and staple food for large population of the world especially in South and Southeast Asia. The global annual demand for rice will be around 800 million tons by 2025 in view of expected increase in population.

More than 90 per cent of the world's rice is grown and consumed in Asia. In this region it represents a high-value commodity crop. The global production of rice has been estimated 697.22 million tons at an average yield of 4.4 tons ha<sup>-1</sup> is being harvested from 158.43 million ha annually producing 21 per cent of world's food calorie supply (FAO, 2012).

India is one of the world's largest producers of white rice and brown rice, accounting for 20 per cent of all world rice production.

In India rice is grown in 433.88 lakh ha<sup>-1</sup> with the production of 104.32 mt and the productivity of 2404 kg ha<sup>-1</sup> (Anon., 2016). It is known for high nutritional quality. Rice grain contains on an average of 7 per cent protein, 62-65 per cent starch, 0.7 per cent fat and 1.3 per cent fibre and rice is a main source of vitamin B1 (thiamin), B2 (riboflavin), B3 (niacin) and B5 (pantothenic acid).

The biological value of rice is 63 per cent whereas biological value of wheat and maize is 49 per cent and 36 per cent respectively.

Biotic and abiotic stresses are the primary constraints in rice production worldwide. These stresses are responsible for large-scale crop loss each year and with the predicted climate change, such losses are expected to increase. Therefore, research for sustainable approaches to alleviate these stresses is a high priority (Bird *et al.*, 2016). Among biotic stresses, rice blast caused by *Magnaporthe oryzae* is of significant economic importance and serious threat with yield losses up to 60-100 per cent (Yashaswini *et al.*, 2017).

Since fungal diseases are most devastating in rice worldwide, fungicides are important tools to manage these diseases. Consequences of heavy usage of pesticides specifically fungicides leads to fungicidal stress. Apart from fungicidal stress, application of fungicides contributes more towards the residual level. Recently, there was ban on India's basmati rice exports as Iran imposed caps on imports because of high MRL of 0.01 ppm (Maximum Residual Level). Reducing the pesticides in agriculture is essential to minimize the environmental impact and improve the sustainability of agricultural systems (Van Oosten *et al.*, 2017).

Hence agricultural growing practices have been evolving towards organic, sustainable or environmental friendly systems. Red seaweed extracts contain a wide range of bioactive compounds that are mostly still unknown.

Seaweed extracts are the biostimulants which can be applied as foliar spray for enhancing the plant growth, tolerance to abiotic stress, photosynthetic activity and also provide resistance to many diseases as they serves as a source of large number of compounds such as laminarin, fucans, ulvans and carrageenans, which act as elicitor molecules against pathogens (Shukla *et al.*, 2016). Many of these extracts are also able to counteract the effect of biotic and abiotic stresses, enhancing

quality and crop yield by stimulating plant physiological processes (Ziosi *et al.*, 2013). The research of red seaweed extracts and their formulated products on rice is very limited in India and mainly done in the plain land rice ecosystems (Devi and Mani, 2015). However, the effects of *K. alvarezii* on rice with respect to fungicidal stress and induced disease resistance have not been studied. Therefore, the current investigations were carried out to know the biological effects of bioformulations (LBD1 as defence activator and LBS6 growth stimulant) obtained from tropical red seaweed (*Kappaphycus alvarezii*) in relieving the fungicidal stress and imparting the blast disease resistance in rice

## Materials and Methods

### Seaweed extracts

Bioformulations of red tropical seaweed (*Kappaphycus alvarezii*) were procured from Sea6 energy lab, NCBS, Bengaluru

### Experimental design

In order to determine the possible effect of seaweed bioformulations in relieving the fungicidal stress, field experiment was conducted during the *Kharif* 2017-18 at ZARS, V.C Farm, Mandya. Rice variety IR-64 was used in the experiment which is susceptible to blast disease. The net plot size of 5 m<sup>2</sup> was maintained for each replication with 20 cm distance between rows and 15 cm between plants. Total of 13 treatments were selected and laid out as per Random Complete Block Design (RCBD).

### Stress induction

Fungicidal stress was induced by spraying of selected fungicides at the interval of 15 days to rice in field condition. First spray was taken at 15 days after transplanting. Total four

sprays were taken up in study. Treatment details and dosages are furnished below. Observations *viz.*, disease severity and yield parameters *viz.*, number of panicles, panicle weight and panicle length were taken in to consideration.

### **Disease severity**

After the second spray, plots were inspected periodically until harvest to determine the severity of blast disease. Five random plants per plot were selected to assess the severity of the disease. Assessment of blast was carried out by 0-9 scale (*Standard Evaluation System*, 1996).

### **Growth and yield parameters**

In each trial plot, with an area of 1 m<sup>2</sup> was randomly selected. Meter square and whole plots were harvested individually and the grain as well as straw yields were determined using electronic balance. Sub-samples of randomly selected five plants were taken from every plot to determine the number of panicles, panicle length and weight, straw and grain weight. Analysis and interpretation of the experimental data was performed as per RCBD.

### **Experimental details**

T<sub>1</sub>: Tricyclazole 75 %WP @ 0.6g/l

T<sub>2</sub>: Carbendazim 50 %WP @ 1.0 g/l

T<sub>3</sub>: LBS6 @ 1.0 ml/l

T<sub>4</sub>: LBD1 @ 2.0 ml/l

T<sub>5</sub>: Tricyclazole 75 %WP + LBS6 @ 0.6g + 1.0ml/l

T<sub>6</sub>: Tricyclazole 75 %WP + LBS6 @ 0.4g + 1.0 ml/l

T<sub>7</sub>: Tricyclazole 75 %WP + LBD1 @ 0.4g + 1 ml/l

T<sub>8</sub>: Tricyclazole 75 %WP + LBD1 @ 0.4 g + 2 ml/l

T<sub>9</sub>: Carbendazim 50 %WP + LBS6 @ 1.0g + 1ml/l

T<sub>10</sub>: Carbendazim 50 %WP + LBS6 @ 0.6g + 1.0 ml/l

T<sub>11</sub>: Carbendazim 50 %WP + LBD1 @ 0.6 g + 1 ml/l

T<sub>12</sub>: Carbendazim 50 %WP + LBD1 @ 0.6 g + 2 ml/l

T<sub>13</sub>: Untreated check (water spray)

### **Results and Discussion**

#### **Efficacy of seaweed bioformulations in management of rice blast in field condition**

The effect of seaweed extracts with fungicides and their combinations as explained in the material and methods was investigated during *Kharif* 2017-18 in field condition. Lower disease severity of 11.52 per cent was recorded in T<sub>1</sub> (tricyclazole 75 %WP). The bioformulation LBD1 (T<sub>4</sub>) treated plots recorded 12.11 per cent disease severity (Table 1). However there was no significant difference between T<sub>1</sub> and T<sub>4</sub>. It was observed that LBD1 was on par with the fungicide in controlling the disease. Severity of the disease was 19.56 per cent in carbendazim 50 %WP @ 1 g/l treated plots.

Whereas the combination of carbendazim 50 %WP @ 0.6g/l and LBD1 @ 2ml/ 1 (T<sub>12</sub>) showed lower disease severity (13.80 %) compared to carbendazim alone. The seaweed bioformulation LBS6 recorded disease severity of 20.50 per cent. However, there was

no significant difference in disease severity between combinations of LBS6 with both fungicides. LBD1 recorded 33.15 per cent disease decrease over control, whereas tricyclazole 75 % WP was efficient in decreasing the disease up to 44.38 per cent. Disease severity was found to be statistically superior in seaweed bioformulation LBD1@ 2ml/l treated plot which was on par with the fungicide tricyclazole. When carbendazim was combined with LBD-1, disease severity was reduced, which directly implies that LBD-1 had increased the efficacy of the fungicide and there by reduced the disease.

Oligosaccharides and carrageenans present in the seaweed bioformulations are known induce plant defence responses by modulating the activity of different defence pathways, including salicylate, jasmonate and ethylene signalling pathways. Foliar application with 0.5 per cent seaweed extract reduced diseases caused by *Alternaria solani* and *Xanthomonas campestris* pv. *vesicatoria* by up to 63.00 per cent and 44.00 per cent respectively in tomato (Ali *et al.*, 2016). Presence of iota ( $\iota$ ), lambda ( $\lambda$ ) and kappa ( $\kappa$ ) carrageenan in seaweeds decreased the replication and symptom expression of Tomato Chlorotic Dwarf Viroid (TCDVd) in tomato. There was up regulation of defense related genes *viz.*, allene oxide synthase (AOS), lipoxygenase (LOX) and PR1, suggesting that  $\lambda$ -carrageenan induced defense against TCDVd in tomato (Sangha *et al.*, 2015). Similar compounds might be present in LBD-1 which has suppressed the disease by inducing defence response

### **Yield parameters**

Foliar application of seaweed bioformulations was efficacious in improving the yield. The yield parameter results of randomly selected five plants revealed that LBS6 and the combination of carbendazim 50 %WP + LBS6 were effective. Number of panicles recorded

higher in T<sub>10</sub> (average of 23.90/ plant). LBS 6 treated plants recorded 23.50 panicles/plant (Table 2).

Length of panicles was more in plants treated with LBS6 @ 1 ml/l (16.19 cm) followed by T<sub>6</sub> (tricyclazole 75 %WP @ 0.4 g L<sup>-1</sup> + LBS6 @ 1 ml/l). Panicle weight was higher in LBS 6 @ 1ml/l treated plants with 31.60 g which was followed by T<sub>7</sub> (carbendazim 50 %WP + LBS6). Untreated check recorded reduced panicle length as well as weight (15.15 cm and 22.80 g respectively). Significant differences with respect to the grain and straw yield was observed in treated plants when compared to untreated control in randomly selected five plants. Highest straw weight of 22.90 g/plant was recorded in T<sub>10</sub> (carbendazim 50 %WP @ 0.6 g/l + LBS6 @ 1 ml/l). Results of randomly selected five plants revealed that there were statistically remarkable differences with respect to the grain and straw yield in treated plants when compared to untreated control. Highest straw weight and grain weight of 32.12 g and 27.27 g/plant respectively was recorded in T<sub>3</sub> (LBS6 @ 1.0 ml/l). Tricyclazole 75 %WP @ 0.6g/l and carbendazim 50 %WP @ 1.0 g/l alone recorded 27.42 g (straw weight), 24.24 g (grain weight) and 25.76 g (straw weight), 26.21 g (grain weight) respectively (Table 3).

Whereas combination of fungicides and seaweed bioformulations *i.e.*, T<sub>5</sub> (tricyclazole 75 %WP @ 0.6 g/l + LBS6 @ 1 ml/l), T<sub>6</sub> (tricyclazole 75 %WP @ 0.4 g/l + LBS6 @ 1 ml/l), T<sub>7</sub> (tricyclazole 75 %WP @ 0.4 g/l + LBD1 @ 1 ml/l), T<sub>8</sub> (tricyclazole 75 %WP @ 0.4 g/l + LBD1 @ 2 ml/l), T<sub>9</sub> (carbendazim 50 %WP + LBS6 @ 1.0g/l + 1ml/l), T<sub>10</sub> (carbendazim 50 %WP + LBS6 @ 0.6g/l + 1.0 ml/l), T<sub>11</sub> (carbendazim 50 %WP + LBD1 @ 0.6 g/l + 1 ml/l) and T<sub>12</sub> (carbendazim 50 %WP + LBD1 @ 0.6 g/l + 2 ml/l) recorded higher straw and grain weight compared to fungicide alone (Table 3).

**Table.1** Effect of seaweed bioformulations on the severity of rice neck blast disease during *Kharif* 2017-18

Treatment ents	Treatment details	<i>Kharif</i> - 2017-18	
		Per cent disease	Per cent decrease over control
T <sub>1</sub>	Tricyclazole @ 0.6 g/l	11.52 (19.83)*	47.08
T <sub>2</sub>	Carbendazim @ 1 g/l	19.56 (26.24)	10.15
T <sub>3</sub>	LBS6@ 1ml/l	20.50 (26.91)	5.80
T <sub>4</sub>	LBD1@ 2 ml/l	12.11 (20.35)	44.38
T <sub>5</sub>	Tricyclazole+LBS6 (0.6g+1ml/l)	13.29 (21.37)	38.92
T <sub>6</sub>	Tricyclazole+LBS6 (0.4g+1ml/l)	12.11 (20.35)	44.36
T <sub>7</sub>	Tricyclazole+LBD1 (0.4g+1ml/l)	13.44 (21.49)	38.27
T <sub>8</sub>	Tricyclazole+LBD1 (0.4g+2ml/l)	12.97 (21.10)	40.43
T <sub>9</sub>	Carbendazim+LBS6 (1g+1ml/l)	18.74 (25.63)	13.92
T <sub>10</sub>	Carbendazim+LBS6 (0.6g+1ml/l)	18.15 (25.20)	16.62
T <sub>11</sub>	Carbendazim+LBD1 (0.6g+1ml/l)	18.38 (25.38)	15.54
T <sub>12</sub>	Carbendazim+LBD1 (0.6g+2ml/l)	13.80 (21.80)	36.60
T <sub>13</sub>	Untreated check	21.77 (27.80)	
	<b>SEm±</b>	<b>0.332</b>	
	<b>C.D at 5%</b>	<b>1.016</b>	
	<b>CV %</b>	<b>2.021</b>	

\*Figures in parenthesis are arcsine transformed values

**Table.2** Effect of seaweed bioformulations on panicles parameters during *Kharif*- 2017-18

Treatments	Treatment details	<i>Kharif</i> - 2017-18		
		No. of panicles	Panicle length (cm)	Panicle weight (g)
T <sub>1</sub>	Tricyclazole @ 0.6 g/l	19.20	15.70	24.60
T <sub>2</sub>	Carbendazim @ 1 g/l	22.05	15.90	27.30
T <sub>3</sub>	LBS6@ 1ml/l	25.25	16.19	31.60
T <sub>4</sub>	LBD1@ 2 ml/l	20.80	15.75	28.90
T <sub>5</sub>	Tricyclazole+LBS6 (0.6g+1ml/l)	23.15	15.89	29.10
T <sub>6</sub>	Tricyclazole+LBS6 (0.4g+1ml/l)	23.60	15.91	29.70
T <sub>7</sub>	Tricyclazole+LBD1 (0.4g+1ml/l)	21.45	15.32	28.70
T <sub>8</sub>	Tricyclazole+LBD1 (0.4g+2ml/l)	21.00	15.19	27.90
T <sub>9</sub>	Carbendazim+LBS6 (1g+1ml/l)	21.05	15.75	30.60
T <sub>10</sub>	Carbendazim+LBS6 (0.6g+1ml/l)	23.90	15.70	29.60
T <sub>11</sub>	Carbendazim+LBD1 (0.6g+1ml/l)	21.05	15.21	25.60
T <sub>12</sub>	Carbendazim+LBD1 (0.6g+2ml/l)	22.45	15.45	24.90
T <sub>13</sub>	Untreated check	16.00	15.15	22.80
	<b>SEm±</b>	<b>1.69</b>	<b>0.22</b>	<b>0.21</b>
	<b>C.D at 5%</b>	<b>5.18</b>	<b>0.69</b>	<b>0.66</b>
	<b>CV %</b>	<b>11.00</b>	<b>1.89</b>	<b>1.08</b>

**Table.3** Effect of seaweed bioformulations on yield parameters of rice during *Kharif*- 2017-18

Treatments	Treatment details	Average of 5 plants (g)		Meter square area (kg)		whole plot (kg)		% increase over control	
		Straw weight	Grain weight	Straw weight	Grain weight	Straw weight	Grain weight	Straw weight	Grain weight
T <sub>1</sub>	Tricyclazole @ 0.6 g/l	27.42	24.24	1.57	1.46	5.66	4.80	28.80	14.93
T <sub>2</sub>	Carbendazim @ 1 g/l	25.76	26.21	1.51	1.53	5.21	5.31	22.62	23.09
T <sub>3</sub>	LBS6@ 1ml/l	32.12	27.27	1.72	1.56	6.94	5.59	41.90	27.04
T <sub>4</sub>	LBD1@ 2 ml/l	24.70	25.30	1.48	1.50	4.92	5.06	18.08	19.35
T <sub>5</sub>	Tricyclazole+LBS6 (0.6g+1ml/l)	28.03	25.76	1.59	1.51	5.83	4.68	30.82	12.78
T <sub>6</sub>	Tricyclazole+LBS6 (0.4g+1ml/l)	29.85	26.67	1.65	1.54	6.32	5.43	36.22	24.83
T <sub>7</sub>	Tricyclazole+LBD1 (0.4g+1ml/l)	28.03	26.67	1.59	1.54	5.83	5.43	30.82	24.83
T <sub>8</sub>	Tricyclazole+LBD1 (0.4g+2ml/l)	28.33	26.06	1.60	1.52	5.91	5.26	31.78	22.49
T <sub>9</sub>	Carbendazim+LBS6 (1g+1ml/l)	31.09	26.21	1.69	1.53	6.66	5.31	39.46	23.09
T <sub>10</sub>	Carbendazim+LBS6 (0.6g+1ml/l)	30.91	26.82	1.68	1.55	6.61	5.47	39.00	25.40
T <sub>11</sub>	Carbendazim+LBD1 (0.6g+1ml/l)	26.52	25.45	1.54	1.50	5.41	5.10	25.56	20.00
T <sub>12</sub>	Carbendazim+LBD1 (0.6g+2ml/l)	24.85	26.21	1.48	1.53	4.96	5.31	18.76	23.09
T <sub>13</sub>	Untreated check	21.52	21.36	1.37	1.37	4.06	3.99		
	<b>SEm±</b>	<b>1.617</b>	<b>1.534</b>	<b>0.053</b>	<b>0.050</b>	<b>0.780</b>	<b>0.450</b>		
	<b>C.D at 5%</b>	<b>4.940</b>	<b>4.689</b>	<b>0.163</b>	<b>0.154</b>	<b>2.384</b>	<b>1.375</b>		
	<b>CV %</b>	<b>4.801</b>	<b>4.739</b>	<b>13.197</b>	<b>14.005</b>	<b>5.007</b>	<b>15.206</b>		

T<sub>9</sub> (carbendazim 50 %WP + LBS6 @ 1.0g/l + 1ml/l) and T<sub>10</sub> (carbendazim 50 %WP + LBS6 @ 0.6g/l + 1.0 ml/l) were found to be superior to T<sub>2</sub> (carbendazim 50 %WP @ 1.0 g/l).

Data of each plot (m<sup>2</sup> area) revealed that the straw weight was recorded higher in LBS 6 @ 1ml/l treated plots (1.72 kg) which was followed by T<sub>9</sub> (carbendazim 50 %WP + LBS6 @ 1.0g/l + 1ml/l) and T<sub>10</sub> (carbendazim 50 %WP + LBS6 @ 0.6g/l + 1.0 ml/l) with straw weight of 1.69 and 1.68 kg respectively. However, T<sub>3</sub> was found to be statistically superior over T<sub>9</sub> and T<sub>10</sub>, however there was no significant difference between T<sub>9</sub> (carbendazim 50 %WP + LBS6 @ 1.0g/l + 1ml/l) and T<sub>10</sub> (carbendazim 50 %WP + LBS6 @ 0.6g/l + 1.0 ml/l) was observed. Highest grain weight of 1.56 kg was recorded in T<sub>3</sub> (LBS 6 @ 1ml/l) treated m<sup>2</sup> plots followed by T<sub>6</sub> (tricyclazole 75 %WP + LBS6 @ 0.4g/l + 1.0 ml/l) with grain weight of 1.54 kg. Combination of tricyclazole 75 %WP and LBS 6 yielded more than tricyclazole 75 %WP alone with respect to both straw and grain weight. However yield was found to be lower in untreated check (Table 3).

There was significant difference between the treatments and the control with respect to whole plot yield (straw and grain). Carbendazim 50 %WP (@ 1.0 g/l) alone recorded 5.21 kg, 5.31 kg of straw and grain yield respectively (Table 3).

Straw and grain yield in tricyclazole 75 %WP (@ 0.6g/l treated plot was 5.66 and 4.80 kg respectively. However, increasing trend was observed in yield when these two fungicides combined with seaweed bioformulation (LBS-6). Straw and grain yield were recorded higher in T<sub>3</sub> (LBS6 @ 1.0 ml/l) with 6.94 kg and 5.59 kg respectively. While in control, yield was significantly lower (4.06 and 3.99 kg straw and grain weight respectively). There was 41.90 and 27.04 per cent increase

over control with respect to straw and grain yield was recorded in T<sub>3</sub> (LBS6 @ 1.0 ml/l).

The present study indicates that the seaweed bioformulations especially LBS 6 had improved the efficacy of the fungicides which was evident from the increased level of yields. Upturn of all the parameters has directly reflected on yield. Increased yields are also attributed to stimulation of mineral nutrient uptake with increased accumulation of macro and micro nutrients. Zodape *et al.*, (2011) reported that there was elevated accumulation of both macronutrients (N, P, K, Ca and S) and micronutrients (Mg, Zn, Mn and Fe) and a subsequent increase in yield of tomato fruits (60.89 %) compared to control plants when tomato plants were sprayed with seaweed extracts (*Kappaphycus alvarezii*).

Similar results were obtained by Kavitha *et al.*, (2008) who reported that spraying of seaweed extract @ 0.3 per cent on rice twice at 50 per cent flowering and at milk stages recorded significantly higher growth and yield attributes and was followed by spraying of seaweed extract @ 0.3 per cent at milk stage. Spraying of seaweed extract @ 0.3 per cent at fifty per cent flowering and milk stages recorded 26 per cent higher grain yield (6055 kg ha<sup>-1</sup>) when compared to control (4432 kg ha<sup>-1</sup>).

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#### How to cite this article:

Sahana, N. Banakar, K.T. Rangaswami and Prasanna Kumar, M.K. 2018. Unravelling the Effect of Seaweed Bio Formulations in Relieving Biotic and Abiotic Stress in Rice. *Int.J.Curr.Microbiol.App.Sci*. 7(10): 543-550. doi: <https://doi.org/10.20546/ijcmas.2018.710.060>