Effect of Seaweeds on Growth and Yield of Boro Rice (Oryza sativa L.)

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Authors’ contributions

This work was carried out in collaboration among all authors. Author DD conceptualized and designed the study. Author MP investigated the study in field and performed the statistical analysis. Authors MP and IS wrote the protocol and first draft of manuscript. Review and editing was done by author DD. All authors read and approved the final manuscript.

ABSTRACT

Introduction: Seaweed extract, an organic bio-stimulant has emerged as a promising tool for increasing crop growth and yield without affecting soil health and environment.

Aim: i) To study the efficacy of seaweed extract on growth and yield of boro rice ii) To evaluate the nutrients uptake and residual soil fertility under different treatments iii) To assess the economic viability of using the bio-stimulants in rice production.

Study Design: Seven treatments were laid out in randomized block design with three replications.

Methods: Field experiment was carried out in boro (summer) rice (cv. Satabdi) with seven treatments viz., T₁-100% RDF (120:60:60 kg/ha N, P₂O₅ and K₂O), T₂-100% RDF+ biozyme liquid @ 2.5ml/l of water (seed soaking), T₃-100% RDF + biozyme liquid @ 10ml/l of water (root dipping), T₄-100% RDF+ biozyme granule @15 kg/ha (soil application at 15 and 45 DAT)+ liquid @ 625 ml/ha (foliar spray at 15 and 45 DAT), T₅-75% RDF + biozyme liquid, T₆-75% RDF + biozyme granule+ liquid and T₇-75% RDF+ amaze-X granule @ 10kg/ha at 45 DAT + biozymegranule + liquid.

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**Results:** Results revealed that the maximum grain yield (4.88 t/ha) was obtained under T$_7$ followed by T$_4$ and T$_6$, however, the net return (Rs.25576/ha) and benefit-cost ratio (1.51) of T$_6$ treatment gave maximum.

**Conclusion:** It may be concluded that T$_7$ treatment performed best in terms of growth and yield of *Boro rice* but T$_4$ treatment gave the highest B:C ratio and net income which is supposed to be more economical to the small and marginal farmers. Therefore, integrated use of 75% RDF and biozyme soil & foliar application can be recommended for *boro rice* under new alluvial zone of West Bengal.

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**Keywords:** *Boro rice; biozyme; seaweed; bio-stimulant.*

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**1. INTRODUCTION**

The sea weed extracts, commonly known as plant bio-stimulants is new technology being used in crop production [1]. These organic based products are rich in plant nutrients containing different phytohormones like Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Betaine and Polyamines and other growth promoters along with trace elements, vitamins, amino acids, antibiotics and micronutrients [2],[3],[4] which produce an array of positive responses in plant physiological processes, such as improving nutrient uptake, root development and photosynthetic activity, as well as producing bioactive molecules acting to prevent plant diseases [5]. Therefore, it has a great potentiality to be an alternative of chemical fertilizers to sustain the production system and reduce chemical hazards on environment [6].

Biozyme and Amaze-X (silica based) are the commercial products of bio-stimulants, derived from the Norwegian seaweed *Ascophyllum nodosum* which influences plants physiological system at low concentration [7]. Soil application and foliar sprays of biozyme were studied on many crops [8]. Although biozyme is produced and marketed in different trade names by different agro-input agencies, it contains nearly 78.7% biological active extracts of plant origin and growth regulators (32.2 ppm GA$_3$, 32.2 ppm IAA and 82.2 ppm Zeatin), 1.88% plant micronutrients (0.49% Fe, 0.37% Zn, 0.12% Mn, 0.14% Mg, 0.30% B and 0.44% S) and 19.27% solvents and conditioners [9].

Considering the importance of bio-stimulants application in sustainable crop production, a field experiment was carried out at New Alluvial zone of West Bengal to study the efficacy of bio-stimulants like Biozyme and Amaze-X on growth and yield of *boro rice*; and their residual effect on soil.

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**2. MATERIALS AND METHODS**

The field experiment was conducted on *boro rice* (cv. Satabdi) during January to April of 2016-17 and 2017-18 at Instructional Farm (22°93’ N latitude and 88°53’E longitude with an elevation of 9.75 m above mean sea level) of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal under low land situation of Gangetic alluvial soil. The soil of the experimental field was sandy loam texture, with pH 7.04, organic carbon 0.62%, available nitrogen 188 kg/ha, available P$_2$O$_5$ 39.4 kg/ha and available K$_2$O 184 kg/ha. The experiment comprised of seven treatments viz., T$_1$ - 100% RDF (i.e. 120: 60: 60 kg/ha N:P$_2$O$_5$:K$_2$O, T$_2$ - 100% RDF + biozyme liquid (seed treatment in biozyme liquid at 2.5ml/l of water for 24 hrs before sowing), T$_3$ - 100% RDF + biozyme liquid (Root dipping of seedlings in biozyme liquid at 10 ml/l of water for 30 minutes before transplanting), T$_4$ - 100% RDF + biozyme granule @15 kg/ha + biozyme liquid @625 ml/ha, T$_5$ - 75% RDF + biozyme liquid @ 625 ml/ha, T$_6$ - 75% RDF + biozyme granule @15 kg/ha + biozyme liquid @625 ml/ha, T$_7$-75% RDF + amaze-X granule @10 kg/ha + biozyme granule@15 kg/ha + biozyme liquid @ 625 ml/ha in RBD design with three replications. Soil application of biozyme granule as well as foliar spraying of biozyme liquid was carried out at 15 and 45 DAT as per the treatments scheduled. Amaze-X was applied in soil in T$_7$ treatment plots only at 45 DAT. The entire doses of P$_2$O$_5$ and K$_2$O and $\frac{1}{2}$ of N were applied as basal and the top dressing of $\frac{1}{4}$th N at tillering (30 DAT) and $\frac{1}{4}$th N at PI stage (60 DAT). Thirty five days seedlings were transplanted in the main field on 10$^{th}$ and 8$^{th}$ February in the respective years at a spacing of 20 cm × 15 cm and plot size of 4 m × 3 m. A shallow depth (2-3 cm) of water was maintained from transplanting to maximum tillering stage and thereafter, the depth of water was increased to 5 cm up to flowering stage. The irrigation was withdrawn at 15 days before harvesting. Two hand-weeding at 3 and 6 weeks
after transplanting was followed. The crop was harvested in the last week of May in both the years.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The bio-stimulants significantly influenced the growth attributes of rice in both the years (Table 1). Among the different treatments, plots receiving 75% RDF + amaze-X granule (soil appli.) + biozyme granule (soil appli.) + biozyme liquid (foliar) and 75% RDF+ biozyme granule (soil appli.)+ biozyme liquid (foliar) recorded significantly taller plant (93.71 cm). The leaf area recorded highest (4.26) at 60 DAT under the treatment of 75% RDF+ amaze-X granule (soil appli.) + biozyme granule (soil appli.) + biozyme liquid (foliar), which was at par with T4 and T6 treatments. At 100 DAT, the maximum dry matter (1024.2 g/m²) accumulated in case of treatment 75% RDF+ amaze-X granule (soil appli.) + biozyme liquid (foliar) which was statistically at par with T4. The positive effect of sea weed extracts in increasing plant height, leaf area, dry weight per plant and biomass accumulation in conjugation with inorganic fertilizers was reported by many workers [10] [11] [12]. It might be due to the fact that the formulation of sea weed extract not only provided the plant growth promoting substances like hormones, organic acids, polysaccharides, amino acids, and proteins [13] and micronutrients [14], but accelerated the soil biological activities which enhanced the inherent plant capacity to express itself with more dry matter production and full growth potential [15].

3.2 Yield Attributing Parameters

Yield attributes like number of panicles/m², filled grains/panicle and 1000 grain weights were recorded at harvest (Table 2) and the pooled data exhibited that number of panicles/m² was found maximum (174.9) in T4 treatment, followed by T7 (173.9) and T6 (170.9) treatments. However, the number of filled grains/panicle was highest in T7 treatment (123.4). The better effects of bio-stimulants applied with 75% of recommended dose of NPK might be due to biozyme and amaze-X regulated plant bio-physiological activities which in turn increased higher chlorophyll content in leaves and ultimately helped in maintaining higher photosynthetic activity even during later stages of growth (i.e. grain filling stage), and thereby, increased the proportion of filled grains. The result was in conformity with other findings [16]. The test weight (1000 grain weights) of rice as governed by the genetic factor did not vary significantly among the different treatments, however, the highest and lowest values were obtained with T7 (22.77 g) and T4 (22.35 g) treatments respectively.

Table 1. Effect of bio-stimulants on plant height, leaf area index and dry matter accumulation of rice (pooled data of 2 years)

| Treatment                                                                 | Plant height (cm) | LAI | Dry matter accumulation (g/m²) |
|---------------------------------------------------------------------------|-------------------|-----|--------------------------------|
| 100 DAT*                                                                  | 60 DAT*           | 100 DAT*                                 |
| T1 - 100% RDF (Control)                                                   | 83.36 f           | 3.72 c                      | 887.1 f                      |
| T2 - 100% RDF + biozyme liquid (seed treatment)                           | 87.13 d           | 4.07 b                      | 953.8 c                      |
| T3 - 100% RDF + biozyme liquid (root dipping)                             | 85.00 e           | 3.81 c                      | 908.7 e                      |
| T4 - 100% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar)   | 91.65 b           | 4.23 a                      | 1012.3 a                     |
| T5 - 75% RDF + biozyme liquid (foliar)                                    | 89.91 c           | 4.06 b                      | 931.1 d                      |
| T6 - 75% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar)    | 93.71 a           | 4.16 ab                     | 988.3 b                      |
| T7 - 75% RDF + amaze-X granule (soil appli.) + biozyme liquid (foliar)    | 93.71 a           | 4.26 a                      | 1024.2 a                     |

*DAT, Days after transplanting; Values are the mean of three replicates of the sample on each treatment. Means in a column with the same letter are not significantly different (P≤0.05)
Table 2. Effect of bio-stimulants on yield attributes, grain and straw yields and nutrients uptake of rice (pooled data of 2 years)

| Treatment                                                                 | No. of panicles/m² | No. of filled grains/ panicle | 1000 grain weight (g) | Grain yield (t/ha) | Straw yield (t/ha) | Uptake (kg/ha) |
|---------------------------------------------------------------------------|--------------------|-------------------------------|-----------------------|--------------------|--------------------|-----------------|
| T₁- 100% RDF (Control)                                                   | 156.9 g            | 115.8 f                       | 22.56 abc             | 4.101 e            | 5.316 e            | 65.86 g         |
| T₂- 100% RDF + biozyme liquid (seed treatment)                           | 161.7 e            | 119.4 c                       | 22.54 abc             | 4.354 c            | 5.703 c            | 70.82 e         |
| T₃- 100% RDF + biozyme liquid (root dipping)                             | 158.7 f            | 117.4 e                       | 22.47 bc              | 4.188 d            | 5.542 d            | 69.04 f         |
| T₄- 100% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar)   | 174.9 a            | 118.8 d                       | 22.35 c               | 4.641 b            | 5.969 b            | 84.74 b         |
| T₅- 75% RDF + biozyme liquid (foliar)                                    | 168.1 d            | 113.9 g                       | 22.67 ab              | 4.339 c            | 5.622 cd           | 74.58 d         |
| T₆- 75% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar)    | 170.9 c            | 120.3 b                       | 22.53 bc              | 4.633 b            | 5.921 b            | 80.15 c         |
| T₇- 75% RDF + amaze-X granule (soil appli.) + biozyme granule (soil appli.) + biozyme liquid (foliar) | 173.9 b            | 123.4 a                       | 22.77 a               | 4.885 a            | 6.068 a            | 89.00 a          |

Values are the mean of three replicates of the sample on each treatment; Means in a column with the same letter are not significantly different (P≤0.05)
3.3 Grain and Straw Yield

The grain and straw yields of boro rice increased significantly under the treatments of 75% RDF + amaze-X granule (soil appli.) + biozyme granule (soil appli.) + biozyme liquid (foliar) (Table 2), which produced 12.4% and 13.9% higher grain yield than 100% RDF. The enhanced grain yield of rice was due to the improvement in yield attributes. The synergistic effects of bio-stimulant application on rice yield due to the stimulation of plant physiological processes were reported earlier [17],[18].

3.4 Nutrients Uptake

Total N, P and K uptake were having linear association with grain yield. Significant increase in grain yield of rice with N uptake by plants was formerly reported by scientist [19]. The uptake of N was highest (89 kg/ha) in T7 treatment while the lowest was in control plot (Table 2) and it was strongly correlated with grain yield ($R^2 = 0.854$). It was reported that bio-stimulants increased the efficiency of mineral fertilizers by reducing leaching and other losses [20]. Similarly, the highest uptake of P (12.06 kg/ha) and K (185.4 kg/ha) was registered in T6 and T7 treatments respectively. The uptake of P and K was responsible for 58% and 50% variation in the grain yields respectively.

3.5 Residual Soil Nutrients

The residual soil fertility after harvesting of rice (Table 3) exhibited that there was no significant difference in soil organic carbon among the treatments. However, all the treatments showed a marginal increase in organic C from the initial level. The incremental trend was higher in plots received biozyme/amaze-X in granular forms. The enhancement of N, P and K status than the initial levels was higher where full dose of NPK fertilizers were applied. This might be due to the less uptake of NPK which led to a substantial amount of left-over nutrients in the soil. However, addition of bio-stimulants coupled with 25% reduced dose of fertilizers showed a lower residual fertility compared to that of 100% RDF and this might be due to greater uptake of nutrients as well as less addition of inorganic nutrients to soil.

3.6 Economic Analysis of the Experiment

Economic analysis indicated that combined application of bio-stimulants and RDF increased the gross and net returns compared to 100% RDF (Table 4). The maximum gross return was recorded in T7 (Rs.75042/ha) due to the higher productivity. But the highest net return recorded in T6 treatment (Rs. 25576/ha) was due to lower cost of cultivation compared to T7. The lowest net return recorded as Rs. 18030/ha was in control treatment T1 due to lower grain yield. The maximum benefit-cost ratio was obtained in treatment T6 (1.51) followed by treatment T7 (1.49) which was attributed to higher returns and lower cost of cultivation. The higher economic profitability by using bio-stimulants along with reduced application of recommended fertilizers was in conformity with other findings [21],[22].

### Table 3. Effect of bio-stimulants on residual soil fertility (mean of two years)

| Treatment | Organic carbon (%) | Available N (kg/ha) | Available P2O5 (kg/ha) | Available K2O (kg/ha) |
|-----------|--------------------|---------------------|-----------------------|----------------------|
| T1 - 100% RDF (Control) | 0.65                | 200                 | 45.1                  | 213                  |
| T2 - 100% RDF + biozyme liquid (seed treatment) | 0.63                | 196                 | 44.2                  | 220                  |
| T3 - 100% RDF + biozyme liquid (root dipping) | 0.63                | 199                 | 42.1                  | 209                  |
| T4 - 100% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar) | 0.65                | 203                 | 43.2                  | 217                  |
| T5 - 75% RDF + biozyme liquid (foliar) | 0.64                | 178                 | 40.8                  | 191                  |
| T6 - 75% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar) | 0.66                | 186                 | 41.1                  | 199                  |
| T7 - 75% RDF + amaze-X granule (soil appli.) + biozyme granule (soil appli.) + biozyme liquid (foliar) | 0.67                | 191                 | 42.7                  | 204                  |
| SEm (±) | 0.02                | 4.98                | 1.73                  | 5.15                 |
| LSD (ps0.05) | NS                 | 14.7                | NS                   | 15.2                 |
Table 4. Production economics of rice under different treatments (mean of two years)

| Treatment                                                                 | Cost of cultivation (Rs./ha) | Gross return (Rs./ha) | Net return (Rs./ha) | BCR  |
|---------------------------------------------------------------------------|-----------------------------|-----------------------|---------------------|------|
| T<sub>1</sub> - 100% RDF (Control)                                        | 48714                       | 66744                 | 18030               | 1.37 |
| T<sub>2</sub> - 100% RDF + biozyme liquid (seed treatment)                | 48827                       | 69144                 | 20317               | 1.42 |
| T<sub>3</sub> - 100% RDF + biozyme liquid (root dipping)                  | 49164                       | 67806                 | 18642               | 1.38 |
| T<sub>4</sub> - 100% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar) | 50327                       | 73547                 | 24220               | 1.46 |
| T<sub>5</sub> - 75% RDF + biozyme liquid (foliar)                        | 47417                       | 70268                 | 23851               | 1.48 |
| T<sub>6</sub> - 75% RDF + biozyme granule (soil appli.) + biozyme liquid (foliar) | 49102                       | 74043                 | 25576               | 1.51 |
| T<sub>7</sub> - 75% RDF + amaze-X granule (soil appli.) + biozyme liquid (foliar) | 50067                       | 75042                 | 24975               | 1.49 |

4. CONCLUSION

The highest gross return was recorded in T<sub>7</sub> (Rs.75042/ha) due to the highest productivity. But maximum net return was recorded with T<sub>6</sub> (Rs. 25576/ha) due to comparatively lower cost of cultivation than T<sub>7</sub>. The maximum benefit-cost ratio was obtained in treatment T<sub>6</sub> (1.51). Considering the findings as summarized above, it can be concluded that the bio-stimulants biozyme and amaze-x, an extracts of brown seaweed *Ascophyllum nodosum*, when applied in soil and foliar spray is effective in increasing the growth parameters, yield attributes as well as grain yield of rice and gave its best result in T<sub>7</sub>. But from the context of enhancing economic profitability and environmental sustainability, the integrated use of 75% RDF along with soil application of biozyme granule @ 15 kg/ha plus foliar spraying of biozyme liquid @ 625 ml/ha at 15 and 45 DAT (T<sub>6</sub>) is found beneficial to small and marginal farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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