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Effect of doses of seaweed-based biostimulant (Equilibrium) on growth indices and economics of rice cultivar PAC 807

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Abstract

A field experiment was conducted during *kharif* 2022 at the Experimental Farm of Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur to evaluate the effect of various doses of seaweed based biostimulant Equilibrium® in rice crop. The experiment was conducted in Randomized Completely Block Design with eleven treatments comprising of single spray (500, 750, 1000 and 1250 ml ha^{-1}) at tillering, two sprays (500, 750, 1000, 1250, 1500 and 2000 ml ha^{-1}) at tillering and boot-leaf stages plus one control (water spray), replicated thrice. Two sprays using 1250 ml ha^{-1} each at tillering and boot-leaf stage showed at par performance with low dose of 1000 ml ha^{-1}, and was found effective to boost rice growth in terms of plant height (100.4 cm), dry matter accumulation (1039.6 g m^{-2}), CGR (16.72 g m^{-2} day^{-1}) and RGR (11.06 mg g^{-1} day^{-1}) during 60-90 days after transplanting, and thereby leading to maximum returns of Rs 72.7 thousand ha^{-1}.

Keywords: Economics, equilibrium, growth analysis, rice

Rice (*Oryza sativa* L.) is one of the most important cereal crops globally, especially in developing countries. Rice is a primary source of nutrition for over half of the world's population. It is a staple food for majority of the population of Himachal Pradesh where it provides a substantial portion of daily caloric intake (Manuja *et al.* 2015). Rice is a rich source of carbohydrates, which are essential for energy. It is relatively low in fat and contains some protein, vitamins, and minerals, depending on the variety and processing. For many nations, ensuring a stable rice supply is vital for food security as it contains about 80% carbohydrates, 7-8% proteins, 3% fat and 3% fibre (Saikia and Deka 2011).

Globally, rice covers an area of about 161.77 million ha with a production of 749.19 million tonnes and average productivity of 4631 kg ha^{-1} (Anonymous 2022a). India has largest area under rice and in case of production is next to China. Presently, rice occupies an area of 45.77 million ha with an average production of 124.37 million tons and productivity of 2717 kg ha^{-1} in India (Anonymous 2022b). In Himachal Pradesh, this crop was cultivated in an area of 72 thousand hectares during 2021–22, with a total production of 138.46 thousand metric tonnes and productivity of 1923.05 kg ha^{-1}(Anonymous 2022a). It is estimated that India needs to produce 140 million tons of rice by 2025 to meet the demand of its growing population (Duttarganvi *et al.* 2016). While farmers have recognized the importance of rice in ensuring food security, the relatively low production levels indicate that additional efforts are required (Sharma *et al.* 2015).

Over the past few years, Agriculture is facing the challenges of boosting food grain production to feed the increasing population and improving resource use efficiency, all the while reducing its impact on environmental ecosystems and human health. Hence, there is an urgent need of finding suitable solutions that can be adopted on sustainable basis without adversely affecting the natural resources. A promising and environment friendly innovation would be the use of natural plant biostimulants that enhance nutrient use efficiency and crop productivity along with tolerance to a wide range of biotic and abotic stresses.

Of late, there has been serious concern about long term adverse effect of continuous and indiscriminate use of inorganic fertilizers to enhance soil fertility and crop productivity as it often leads to negative effect on the complex system of biogeochemical cycles and reduction in quality (Sharma *et al*. 2014; Sharma *et al*. 2016). The use of plant biostimulants in agriculture is a sustainable and effective growth alternative approach in enhancing plant growth and development. Biostimulants can be derived from various sources, including natural substances, such as seaweed extracts, humic acids, and beneficial microorganisms like bacteria and fungi. One such biostimulant is Equilibrium which has a synergistic action of amino acids and seaweed extracts besides containing alginic acid or mannitol and betaines obtained from the extract of seaweed *Ascophyllum nodosum* which enhance the crop yields as well as its quality. Little work has been done to study the effect of application of this biostimulant on the performance of rice crop and the present study was carried out to evaluate the efficacy of this biostimulant in enhancing rice productivity.

Materials and Methods

The experiment was conducted at the Experimental Farm of Department of Agronomy CSKHPKV Palampur, Himachal Pradesh. This experimental location is situated in the mid-hills sub-humid zone of Himachal Pradesh, which is characterized by mild summers and cool winters. The experiment comprised of eleven treatments *viz*., single spray of Equilibrium @ 500 ml ha^{-1}, 750 ml ha^{-1}, 1000 ml ha^{-1} and 1250 ml ha^{-1} at tillering stage and double spray of Equilibrium @500 ml ha^{-1}, 750 ml ha^{-1}, 1000 ml ha^{-1}, 1250 ml ha^{-1}, 1500 ml ha^{-1} and 2000 ml ha^{-1} at the tillering and boot leaf stages along with one control (water spray) . The trial was laid out in Randomised Complete Block Design with three replications.

The soil of the experimental site was silty clay loam in texture, acidic in reaction, medium in available nitrogen, phosphorus and potassium. The nursery was sown on 04thJune 2022 and was transplanted on 30th June, 2022 with harvesting done on 14th October 2022. The recommended dose of fertilizers @ 90:40:40 kg N, P_2O_5 and K_2O ha^{-1} + 10 tonnes farmyard manure ha^{-1} was applied across the treatments in addition to other cultural practices as per package of practices. Based on the current market pricing for inputs and products, the economics of the treatments were calculated. The data on the different parameters were statistically analyzed as per the procedures proposed by Gomez and Gomez (1984).

Results and Discussion

The spray of Equilibrium did not significantly increase the plant height at 30 days after transplanting (DAT) but thereafter the increase was significant at 60 DAT, 90 DAT and at harvest (Table 1). At 60 DAT,

Table 1. Effect of doses of seaweed based biostimulant Equilibrium on plant height (cm) and dry matter accumulation (g m^{-2}) of rice

Dose (ml ha^{-1})	Plant height (cm)				Dry matter accumulation(g m^{-2})			
	30 DAT	60 DAT	90 DAT	Harvest	30 DAT	60 DAT	90 DAT	Harvest
Single spray at tillering								
T_1: 500 ml ha^{-1}	58.1	77.6	88.8	92.2	96.9	414.1	806.7	890.6
T_2: 750 ml ha^{-1}	58.5	79.4	90.8	93.5	98.2	420.8	815.0	899.8
T_3: 1000 ml ha^{-1}	59.2	80.7	91.4	94.2	98.7	423.1	819.1	904.3
T_4: 1250 ml ha^{-1}	59.6	82.9	92.2	94.7	99.3	429.3	830.6	917.0
Two sprays at tillering and boot-leaf stage								
T_5: 500 ml ha^{-1}	*59.8*	*82.4*	*93.0*	*95.3*	*97.5*	*416.6*	*838.0*	*925.1*
T_6: 750 ml ha^{-1}	60.0	83.4	93.8	95.8	98.8	431.8	861.8	954.7
T_7: 1000 ml ha^{-1}	60.2	84.9	94.5	97.2	99.3	434.4	903.7	1,004.3
T_8: 1250 ml ha^{-1}	60.3	86.4	98.4	100.4	100.1	437.2	938.7	1,039.6
T_9: 1500 ml ha^{-1}	60.3	85.2	97.0	99.0	99.7	434.0	925.9	1,038.7
T_{10}: 2000 ml ha^{-1}	60.2	84.6	96.7	98.3	99.5	434.7	921.8	1,028.7
T_{11}: Control (Water spray)	57.9	75.0	87.0	90.4	95.3	399.2	737.3	814.0
SEm±	1.0	1.2	1.4	1.5	2.3	6.3	16.3	17.0
LSD	NS	3.6	4.1	4.4	NS	18.6	48.2	50.2

double spray of Equilibrium @ 1250 ml ha^{-1} applied each at tillering and boot leaf stages recorded significantly higher plant height though this treatment remained statistically at par with the double spray of Equilibrium @ 750 ml ha^{-1} (T_6), 1000 ml ha^{-1} (T_7), 1500 ml ha^{-1} (T_9) and 2000 ml ha^{-1} (T_{10}) and single spray of Equilibrium @1250 ml ha^{-1} (T_4) during the tillering stage. At 90 DAT and at harvest significantly higher plant height was observed with the double spray of Equilibrium @1250 ml ha^{-1}, though this treatment remained statistically at par with the double spray of Equilibrium @1000 ml ha^{-1} (T_7), 1500 ml ha^{-1} (T_9) and 2000 ml ha^{-1} (T_{10}). Significantly lower plant height at 60 DAT, 90 DAT and at harvest was observed in control treatment where no biostimulant was sprayed.

The increase in plant height might be due to the presence of plant hormones, plant growth regulators like auxin, gibberellin, cytokinin, macro and micro elements in seaweed extract which bring out the strong physiological response (Deepana *et al*. 2021). Similar results of increase in plant height of rice crop due to the application of seaweed extract have been reported by Khan *et al*. (2013), Satapathy *et al*. (2014) and Sunarpi *et al*. (2011).

The application of biostimulant Equilibrium had no significant influence on dry matter in rice during early stages (30 DAT), thereafter effect of biostimulant application recorded significant differences in rice during later stages of growth (60 DAT, 90 DAT, and at harvest). Significantly, higher dry matter was recorded with the double application of this biostimulant @ 1250 ml ha^{-1} at tillering and boot leaf stages (T_8) though treatment was at par with the application of this biostimulant twice at the application doses of 750 ml ha^{-1} (T_6), 1000 ml ha^{-1} (T_7), 1500 ml ha^{-1} (T_9), 2000 ml ha^{-1} (T_{10}), and single application of 1250 ml ha^{-1} (T_4). At 90 DAT double application of this biostimulant @ 1250 ml ha^{-1} at tillering and boot leaf stages accumulated significantly higher dry matter though this treatment was at par with the double application at application rates of 1000 ml ha^{-1} (T_7), 1500 ml ha^{-1}(T_9), and 2000 ml ha^{-1} (T_{10}) while the rice crop which received only the water sprays (T_{11}) recorded significantly lower dry matter accumulation at 90 DAT. At harvest similar trend was observed as that of 90 DAT.

A close perusal of data revealed that CGR values were higher between 60 and 90 DAT than between 30 and 60 DAT (Table 2), indicating that greater dry matter build-up occurred between 60 and 90 DAT. Significantly higher CGR between 30 DAT and 60 DAT (11.24 g m^{-2} day^{-1}) was recorded with double spray of Equilibrium @ 1250 ml ha^{-1} at tillering and boot-leaf stages (T_8) which was at par with all other treatments except single application this biostimulants @ 500 ml ha^{-1} (T_1), 750 ml ha^{-1} (T_2), and double application of this biostimulants at the lowest dose of 500 ml ha^{-1} (T_5) and

Table 2. Effect of doses of seaweed based biostimulant on the crop growth rate (g m^{-2} day^{-1}) and relative growth rate (mg g^{-1} day^{-1}) of rice

Dose (ml ha^{-1})	CGR		RGR	
	30-60 DAT	60-90 DAT	30-60 DAT	60-90 DAT
Single spray at tillering				
T_1: 500mlha^{-1}	10.57	13.09	21.03	9.65
T_2: 750mlha^{-1}	10.75	13.14	21.07	9.57
T_3: 1000ml ha^{-1}	10.81	13.20	21.07	9.56
T_4: 1250ml ha^{-1}	11.00	13.38	21.19	9.55
Two sprays at tillering and boot-leaf stage				
T_5: 500mlha^{-1}	10.64	14.05	21.02	10.12
T_6: 750ml ha^{-1}	11.10	14.33	21.35	10.00
T_7: 1000ml ha^{-1}	11.17	15.64	21.36	10.60
T_8: 1250ml ha^{-1}	11.24	16.72	21.34	11.06
T_9: 1500ml ha^{-1}	11.14	16.40	21.29	10.97
T_{10}: 2000ml ha^{-1}	11.17	16.24	21.35	10.88
T_{11}: Control (Water spray)	10.13	11.27	20.74	8.88
SEm±	0.15	0.38	0.28	0.30
LSD	0.44	1.12	NS	0.89

control. Significantly higher CGR between 60 DAT and 90 DAT (16.72 g m^{-2} day^{-1}) was recorded with two sprays of Equilibrium @ 1250 ml ha^{-1} at tillering and boot-leaf stages (T_8) though this treatment was at par with double application of this biostimulant @ 1000 ml ha^{-1} (T_7), 1500 ml ha^{-1} (T_9) and 2000 ml ha^{-1} (T_{10}). Similar results were obtained in the study conducted by Sood *et al*. (2024) with the foliar application of Terra Sorb Complex® at the same dose.

A close perusal of data revealed that the application of Equilibrium has no significant effect on the relative growth rate between 30 to 60 DAT (RGR_1) though the differences were significant between 60 DAT and 90 DAT. Significantly higher RGR between 60 DAT and 90 DAT was obtained with double spray of Equilibrium @ 1250 ml ha^{-1} (11.06 mg g^{-1} day^{-1}) which was at par with the double application of this biostimulant at application doses of 1000 ml ha^{-1}, 1500 ml ha^{-1} and 2000 ml ha^{-1}. Significantly lower relative growth rate was recorded in control. This increase in RGR with the application of Equilibrium could attributed to the supply of macro and micro nutrients along with growth promoting phytohormones like gibberellins and cytokinins by this bostimulant (Colla *et al*. 2014).

Economics of Rice

The maximum gross return was obtained with the double spray of Equilibrium @ 1250 ml ha^{-1}(T_8) which was followed by double application of biostimulant Equilibrium @ 1000 ml ha^{-1}(T_7) (Table 3. The lowest gross return was obtained in control treatment. Double spray of Equilibrium @ 1250 ml ha^{-1} (T_8) also resulted in higher net return which was followed by double spray of Equilibrium @ 1000 ml ha^{-1} (T_7) while lowest net returns were obtained in control. These results are in agreement with the findings of Satapathy *et al*. (2014), Pramanick *et al*. (2014) and Nayak *et al*. (2020).

Conclusion

Two sprays of seaweed based biostimulants 'Equilibrium' using 1250 ml ha^{-1} each at tillering and boot-leaf was found effective to boost the rice growth in terms of plant height , dry matter accumulation and CGR and RGR and economical also. Hence, use of 2.5ℓ 'Equilibrium' may be used in rice, half at tillering and half at boot-leaf stage,though results may be confirmed for one year more.

Conflict of interest: Authors declare no competing interest.

Table 3. Effect of doses of seaweed based biostimulantEquilibrium on economics of rice

Dose (ml ha^{-1})	Cost of cultivation (Rs. × 10^3 ha^{-1})	Gross Return (Rs. × 10^3 ha^{-1})	Net Return (Rs. × 10^3 ha^{-1})
Single spray at tillering			
T_1: 500 ml ha^{-1}	51.10	106.65	55.55
T_2: 750 ml ha^{-1}	51.41	108.15	56.74
T_3: 1000 ml ha^{-1}	51.73	108.54	56.81
T_4: 1250 ml ha^{-1}	52.04	110.75	58.71
Two sprays at tillering and boot-leaf stage			
T_5: 500 ml ha^{-1}	52.63	111.78	59.15
T_6: 750 ml ha^{-1}	53.25	116.26	63.01
T_7: 1000 ml ha^{-1}	53.88	123.06	69.18
T_8: 1250 ml ha^{-1}	54.50	127.23	72.73
T_9: 1500 ml ha^{-1}	55.13	127.08	71.95
T_{10}: 2000 ml ha^{-1}	56.38	126.22	69.84
T_{11}: Control (Water spray)	49.58	96.95	47.37

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