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Effect of wider spacing, nutrient levels and bio stimulant on growth and yield of rice (*Oryza sativa* L.) under transplanted field conditions

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Abstract
A field experiment was conducted during *kharif* 2024 at the Agronomy Farm, Regional Agricultural Research Station, Karjat, Raigad (M.S.) to assess the effects of spacing, nutrient levels, and bio-stimulant application on growth, yield, and quality of transplanted rice (*Oryza sativa* L.). The study was arranged in a split-plot design with 18 treatment combinations replicated thrice, comprising three spacings (20 cm × 15 cm, 25 cm × 15 cm, and 30 cm × 15 cm), two nutrient levels (100% and 75% RDF), and three bio-stimulant treatments (control, irradiated chitosan @ 50 ppm, and @ 100 ppm). Results indicated that wider spacing (30 cm × 15 cm) significantly enhanced growth parameters, yield attributes, grain yield, and nutrient uptake. Application of 100% RDF improved growth and yield over 75% RDF, while foliar application of irradiated chitosan @ 50 ppm proved superior to control and 100 ppm for growth, yield, and physiological traits. Economic analysis revealed that 30 cm × 15 cm spacing with 75% RDF and irradiated chitosan @ 50 ppm yielded the highest net returns and benefit-cost ratio. The study suggests that applying 75% RDF with four foliar sprays of irradiated chitosan @ 50 ppm is a cost-effective strategy for maximizing yield and profitability in *kharif* rice under Konkan conditions.

Keywords: Rice (*Oryza sativa* L.), spacing, nutrient levels, irradiated chitosan, bio-stimulant, RDF, yield, economic analysis, Konkan region, foliar spray

Introduction
Rice (*Oryza sativa* L.) is the staple food crop of India, contributing significantly to food security and rural livelihoods. In the Konkan region, rice cultivation faces challenges of low productivity due to suboptimal plant spacing, inadequate nutrient management, and limited use of bio-stimulants. Optimizing plant spacing improves light interception, nutrient uptake, and tiller production, while balanced nutrient application through recommended doses of fertilizers (RDF) ensures sustained crop growth and yield. Bio-stimulants, particularly irradiated chitosan, have gained attention for enhancing physiological efficiency, stress tolerance, and grain productivity through foliar application. Integrating these factors in a site-specific manner can improve yield, nutrient use efficiency, and economic returns.

Present Address
This study was undertaken to evaluate the effects of different spacings, nutrient levels, and irradiated chitosan applications on growth, yield, and profitability of transplanted rice under Konkan conditions.

Materials and Methods
The field experiment was conducted during *kharif* 2024 at the Agronomy Farm, Regional Agricultural Research Station, Karjat, Maharashtra. A split plot design with replications. The main plot treatments included three spacings (20 cm × 15 cm, 25 cm × 15 cm, and 30 cm × 15 cm), while sub-plot treatments involved two nutrient levels (100% and 75% RDF) and three bio stimulant sprays (control, 50 ppm, and 100 ppm gamma-irradiated chitosan).

The rice variety used was Karjat 3. Standard agronomic practices were followed, and biometric observations were recorded periodically on five randomly selected plants per plot. Bio stimulants were applied at nursery and 20, 40, and 60 days after transplanting. Soil and weather data were documented, and growth, yield, and biochemical parameters were evaluated.

Data Collection and Statistical Analysis

Parameters observed included plant height (cm), number of leaves, number of tillers hill⁻¹, root length, dry matter accumulation, leaf area (ds cm^2), 50% flowering and maturity, no of panicles $hill^{-1}$, length of panicle (cm), no of grains $panicle^{-1}$, weight of grains $panicle^{-1}$ (g), 1000 grains weight (g), fertility% grain yield, straw yield, biological yield. Economic returns were computed based on local market prices and input costs.

Results and Discussion

Table 1: Periodical mean of growth parameter of rice as influenced by different treatments

Treatment	Plant height (cm)	No. of leaves	Number of tillers $hill^{-1}$	Root length (cm)	Leaf area (ds cm^2)	Dry Matter (g)	Days to 50 percent flowering	Days to maturity
	At harvest	At harvest	At harvest	90 DAT	At harvest	At harvest		
A) Main Plot: Spacings								
S_1: 20 cm x15 cm	86.71	31.19	7.01	18.58	0.98	16.51	87.22	116.83
S_2: 25 cm x 15 cm	87.84	31.88	8.71	19.28	0.97	17.92	87.22	117.22
S_3: 30 cm x 15 cm	90.16	32.49	8.55	20.69	1.00	19.35	88.17	117.83
SEm±	0.36	0.47	7.86	0.40	0.04	0.26	0.49	0.41
C.D. at 5%	1.40	NS	8.15	1.57	NS	1.00	NS	NS
B) Sub plot: Nutrient levels								
N_1: 100% RDF	88.72	31.99	9.37	19.85	0.98	18.25	87.41	117.15
N_2: 75% RDF	87.75	31.72	8.73	19.18	0.98	17.61	87.67	117.44
SEm ±	0.28	0.48	0.13	0.19	0.02	0.08	0.21	0.26
C.D. at 5%	0.97	NS	0.43	0.65	NS	0.28	NS	NS
C) Sub sub plot: Bio stimulant levels								
B_1: Control	85.61	28.88	8.75	17.22	0.089	15.59	89.22	118.83
B_2: Irradiated chitosan @ 50 ppm	90.86	36.37	9.37	21.85	1.06	20.60	85.56	115.33
B_3: Irradiated chitosan @ 100 ppm	88.24	30.31	9.03	19.49	1.00	17.59	87.83	117.72
SEm±	0.48	0.66	0.16	0.30	0.03	0.24	0.28	0.33
C.D. at 5%	1.41	1.93	0.47	0.89	0.09	0.70	0.81	0.98

The results of the study indicated that plant height, number of leaves, number of tillers hill⁻¹, root length, leaf area, days to 50% flowering, and days to maturity were influenced variably by spacing, nutrient levels, and bio-stimulant application.

Among the different spacings, plants grown at 30 cm × 15 cm (S_3) attained the maximum plant height (90.16 cm) Kandil *et al.* (2010) [14] and Banjade *et al.* (2023) [3], number of leaves (32.49) Nwokwu (2015) [20] and Ishfaq *et al.* (2018) [13], root length (20.69 cm also reported increased root length at wider spacing and leaf area (1.00 ds cm^2), whereas the highest number of tillers hill⁻¹ (8.71) was recorded under 25 cm × 15 cm spacing (S_2) reported by Moro *et al.* (2016) [16].

Spacing had a significant effect on plant height and root length, with wider spacing (S_3) showing superiority, while the number of leaves, leaf area, days to 50% flowering, and days to maturity were statistically at par among treatments.

Regarding nutrient levels, 100% RDF (N_1) resulted in higher plant height (88.72 cm), number of leaves (31.99), number of tillers hill⁻¹ (9.37), root length (19.85 cm), and leaf area (0.98 ds cm^2) compared to 75% RDF (N_2). The differences were significant for plant height, number of tillers hill⁻¹, and root length, whereas other traits remained non-significant. The similar results are reported by Durga *et al.* (2015) [8], Sorour *et al.* (2021) [22], Ali *et al.* (2023) [2].

Application of bio-stimulants significantly influenced all growth parameters except days to flowering and maturity. Irradiated chitosan @ 50 ppm (B_2) recorded the highest plant height (90.86 cm) Sunarpi *et al.* (2010) [23], Nayak *et al.* (2020) [19] and Deepana *et al.* (2021) [7], number of leaves (36.37), number of tillers hill⁻¹ (9.37) Baviskar *et al.* (2024) [6], root length (21.85 cm), and leaf area (1.06 ds cm^2), followed by irradiated chitosan @ 100 ppm (B_3). The control (B_1) consistently produced the lowest values for these parameters.

The data on dry matter accumulation in leaves, shoots, and roots of rice at harvest revealed significant variation due to spacing, nutrient levels, and bio-stimulant application.

Among the different spacings, the widest spacing of 30 cm × 15 cm (S_3) recorded the highest dry matter accumulation in (19.35 g) which was significantly superior over the closer spacings. The superiority of wider spacing could be attributed to reduced intra-specific competition, allowing better resource availability (light, nutrients, moisture), thereby improving biomass accumulation. Sridhara *et al.* (2011) [21]. In nutrient levels, the application of 100% RDF (N_1) resulted in significantly greater dry matter accumulation (18.25 g) compared to 75% RDF (N_2) which recorded lower values in all components. This reported by Gautam *et al.* (2013) [9] and Mondal *et al.* (2019) [17]. Bio-stimulant application also had a marked influence on dry matter accumulation. Foliar spray of irradiated chitosan @ 50 ppm (B_2) produced the highest values (20.60 g) dry matter, significantly outperforming both the control (B_1) and irradiated chitosan @ 100 ppm (B_3). The control consistently recorded the lowest values of dry matter (15.59 g) result reported by Nayak *et al.* (2020) [19] and Deepana *et al.* (2021) [7].

Overall, wider spacing (30 cm × 15 cm), application of 100% RDF, and foliar spray of irradiated chitosan @ 50 ppm proved most effective in enhancing dry matter accumulation in rice at harvest.

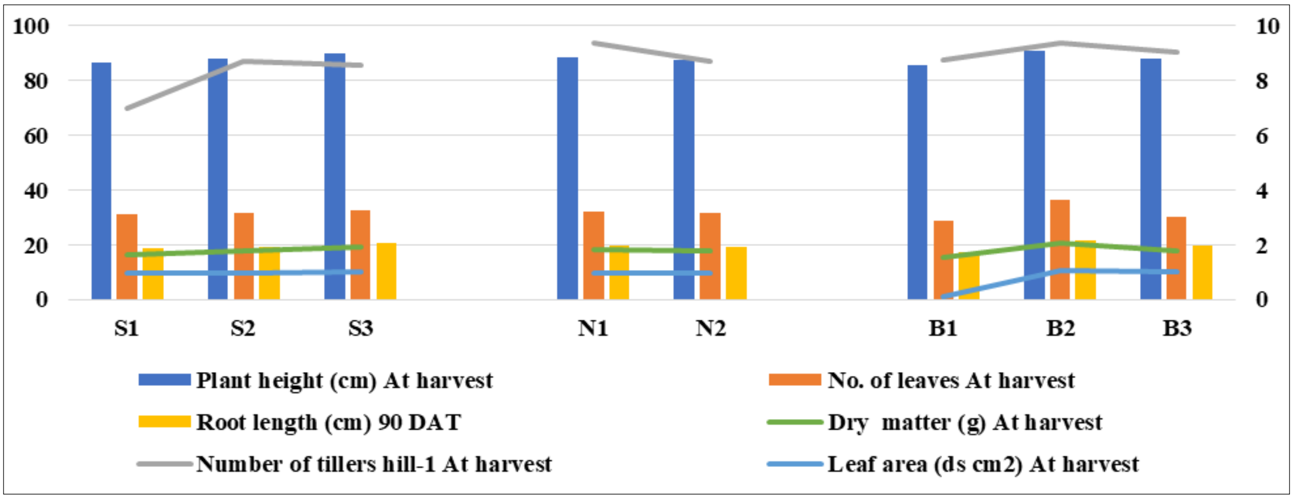

Fig 1: Periodical mean of growth parameters of rice as influenced by different treatments

Table 2: Mean yield contributing characters of rice as influenced by different treatments

Treatment	No. of panicles hill^{-1}	Length of panicle (cm)	Number of grains panicle^{-1}	Weight of grains panicle^{-1} (g)	1000 grain weight (g)	Fertility%
A) Main Plot: Spacings						
S_1: 20 cm x 15 cm	4.48	23.16	128.13	3.02	22.99	74.23
S_2: 25 cm x 15 cm	5.49	24.05	132.43	3.10	22.60	77.60
S_3: 30 cm x 15 cm	7.39	24.44	137.16	3.25	23.80	79.71
SEm±	0.04	0.10	0.98	0.02	0.25	1.19
C.D. at 5%	0.15	0.41	3.86	0.06	NS	NS
B) Sub plot: Nutrient levels						
N_1: 100% RDF	5.97	24.07	133.88	3.20	23.19	77.77
N_2: 75% RDF	5.60	23.69	131.27	3.05	23.07	76.59
SEm±	0.08	0.06	0.74	0.04	0.24	0.71
C.D. at 5%	0.27	0.22	2.55	0.12	NS	NS
C) Sub sub plot: Bio stimulant levels						
B_1: Control	5.71	22.23	127.82	2.97	22.80	71.80
B_2: Irradiated chitosan @ 50 ppm	6.06	25.58	138.71	3.34	23.66	82.56
B_3: Irradiated chitosan @ 100 ppm	5.59	23.84	131.19	3.06	22.94	77.18
SEm±	0.13	0.09	0.73	0.04	0.26	1.49
C.D. at 5%	0.38	0.25	2.14	0.10	NS	4.34

The yield-attributing characters of rice, namely number of panicles hill^{-1}, panicle length, number of grains panicle^{-1}, weight of grains panicle^{-1}, 1000-grain weight, and fertility percentage, were influenced by spacing, nutrient levels, and bio-stimulant application.

Among the spacings, the widest spacing of 30 cm × 15 cm (S_3) recorded the maximum number of panicles hill^{-1} (7.39) Similar findings are in agreement with Kandil *et al*. (2010) [14], Adhikari *et al*. (2012) [1], Moro *et al*. (2016) [16] and Kashkool *et al*. (2020) [16], panicle length (24.44 cm) result founded by Adhikari *et al*. (2022) [1] and Ghodke *et al*. (2022) [11], number of grains panicle^{-1} (137.16) These results are in agreement with those Kandil *et al*. (2010) [14], Moro *et al*. (2016) [16] and weight of grains panicle^{-1} (3.25 g), which were significantly higher than the narrower spacings. However, 1000-grain weight and fertility percentage did not differ significantly among spacings, though S_3 recorded numerically higher values (23.80 g and 79.71%, respectively).

With respect to nutrient levels, application of 100% RDF (N_1) resulted in significantly higher values for number of panicles hill^{-1} (5.97), panicle length (24.07 cm), number of grains panicle^{-1} (133.88), and weight of grains panicle^{-1} (3.20 g) compared to 75% RDF (N_2). Differences in 1000-grain weight and fertility percentage between nutrient levels were not significant.

Application of bio-stimulants showed a marked influence on yield parameters. Foliar spray of irradiated chitosan @ 50 ppm (B_2) produced the highest number of panicles hill^{-1} (6.06), longest panicles (25.58 cm), maximum grains panicle^{-1} (138.71), and highest grain weight panicle^{-1} (3.34 g), along with the highest fertility percentage (82.56%). These values were significantly superior to both the control (B_1) and irradiated chitosan @ 100 ppm (B_3). The control consistently recorded the lowest values for all parameters.

Overall, wider spacing (30 cm × 15 cm), application of 100% RDF, and foliar spray of irradiated chitosan @ 50 ppm proved most effective in improving yield-attributing traits of rice under the experimental conditions.

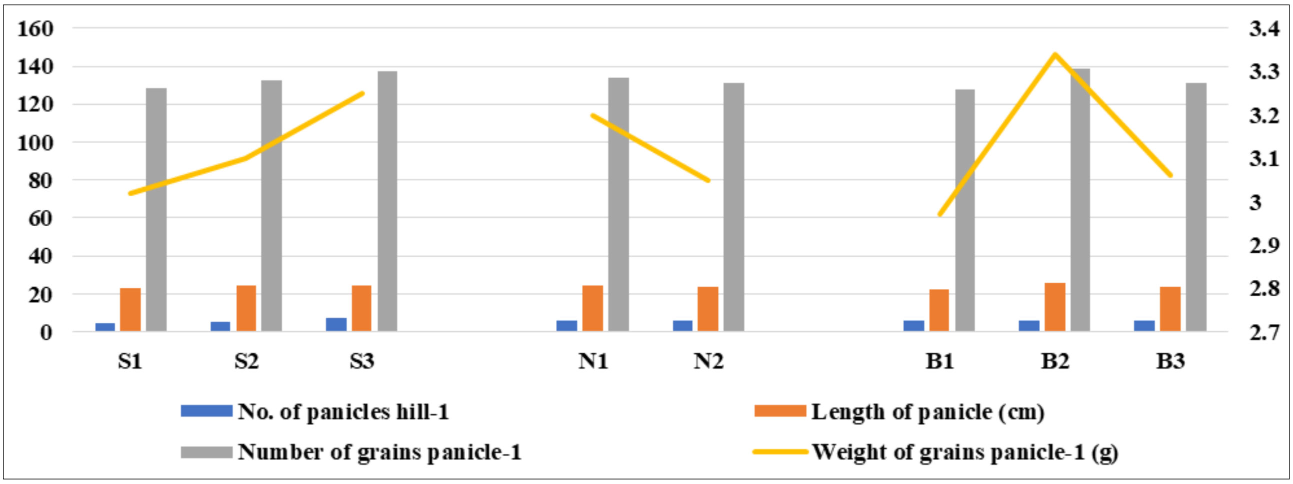

Fig 2: Mean yield contributing characters of rice as influenced by different treatments

Table 3: Mean grain yield, straw yield, biological yield of rice as influenced by different

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
A) Main Plot: Spacings			
S_1: 20 cm x15 cm	4.09	5.59	9.67
S_2: 25 cm x 15 cm	4.18	5.61	9.78
S_3: 30 cm x 15 cm	4.35	6.03	10.38
SEm±	0.05	0.04	0.06
C.D. at 5%	0.19	0.16	0.23
B) Sub plot: Nutrient levels			
N_1: 100% RDF	4.30	5.96	10.26
N_2: 75% RDF	4.11	5.52	9.63
SEm±	0.05	0.10	0.14
C.D. at 5%	0.19	0.35	0.48
C) Sub sub plot: Bio stimulant levels			
B_1: Control	3.97	5.45	9.42
B_2: Irradiated chitosan @ 50 ppm	4.38	6.10	10.48
B_3: Irradiated chitosan @ 100 ppm	4.25	5.67	9.93
SEm±	0.07	0.13	0.18
C.D. at 5%	0.21	0.37	0.52

The results on grain yield, straw yield, and biological yield of rice as influenced by different treatments are presented below.
Among the spacings, 30 cm × 15 cm (S_3) recorded the highest grain yield (4.35 t ha^{-1}). Higher grain yield with 30 cm x 30 cm spacing was due to higher production of productive tillers and also favours cono weeder on the both sides which in turn helps in better aeration by providing more energy to roots. These results are similar with Sridhara *et al*. (2011) [21], Gautam *et al*. (2013) [9], Moro *et al*. (2016) [16], Adhikari *et al*. (2022) [1] and straw yield (6.03 t ha^{-1}), and biological yield (10.38 t ha^{-1}), which were significantly superior over 20 cm × 15 cm (S_1) and 25 cm × 15 cm (S_2). The differences among treatments were statistically significant with C.D. values of 0.19, 0.16, and 0.23 t ha^{-1} for grain, straw, and biological yields, respectively.
Regarding nutrient levels, 100% RDF (N_1) produced significantly higher grain yield (4.30 t ha^{-1}), straw yield (5.96 t ha^{-1}), and biological yield (10.26 t ha^{-1}) compared to 75% RDF (N_2), which recorded 4.11, 5.52, and 9.63 t ha^{-1}, respectively. The corresponding C.D. at 5% was 0.19, 0.35, and 0.48 t ha^{-1} for the three yield parameters. Gautam *et al*. (2013) [9] and Banjare *et al*. (2022) [4].
In the case of bio-stimulant application, irradiated chitosan @ 50 ppm (B_2) resulted in the maximum grain yield (4.38 t ha^{-1}), straw yield (6.10 t ha^{-1}), and biological yield (10.48 t ha^{-1}), which were significantly higher than the control (B_1) and irradiated chitosan @ 100 ppm (B_3). The control treatment recorded the lowest yields (3.97, 5.45, and 9.42 t ha^{-1} for grain, straw, and biological yields, respectively). The treatment differences were significant with C.D. values of 0.21, 0.37, and 0.52 t ha^{-1} for grain, straw, and biological yields, respectively. Baviskar *et al*. (2024) [6] and Hugar *et al*. (2025) [12].

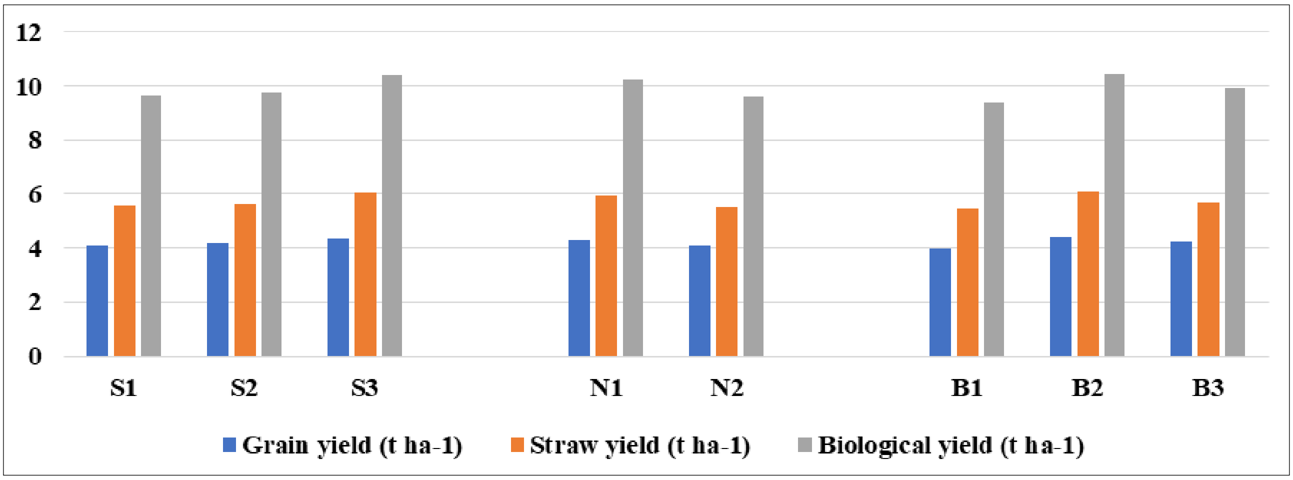

Fig 3. Mean grain yield, straw yield, biological yield of rice as influenced by different

Table 5: Economic analysis of rice influenced by different treatments

Gross returns		Cost of cultivation ($Rs.\ ha^{-1}$)		Net returns ($Rs.\ ha^{-1}$) at		B: C ratio at ($Rs.\ ha^{-1}$) at	
		Total cost	Input cost	Total cost	Input cost	Total cost	Input cost
A) Main plot: Spacing							
S_1: 20 cm x15 cm	110828	131516	98977	-20688	11851	0.84	1.12
S_2: 25 cm x 15 cm	112941	128802	96264	-15861	16677	0.88	1.17
S_3: 30 cm x 15 cm	117927	117772	85768	155	32159	1.00	1.38
SEm±	--	--	--	--	--	--	--
C.D. at 5%	--	--	--	--	--	--	--
B) Sub plot: i) Nutrient levels							
N_1: 100% RDF	116415	129868	96695	-13454	19719	0.90	1.21
N_2: 75% RDF	111383	122191	90644	-10809	20739	0.91	1.24
SEm±	--	--	--	--	--	--	--
C.D. at 5%	--	--	--	--	--	--	--
ii) Bio stimulant							
B_1: Control	107532	125647	94270	-18115	13262	0.86	1.15
B_2: Irradiated chitosan @50 ppm	118957	126534	93369	-7577	25587	0.95	1.29
B_3: Irradiated chitosan @100 ppm	115207	125909	93369	-10701	21838	0.92	1.24
SEm±	--	--	--	--	--	--	--
C.D. at 5%	--	--	--	--	--	--	--
General Mean	1,13,899	1,26,030	93,670	-12,131	20,229	0.91	1.22

The economic evaluation of treatments indicated that spacing, nutrient levels, and bio-stimulant application influenced gross returns, net returns, and benefit-cost (B:C) ratio. Among the spacings, the widest spacing of 30 cm × 15 cm (S_3) recorded the highest gross returns (117,927 ha^{-1}) and net returns over input cost (32,159 ha^{-1}), with a B:C ratio of 1.00 on a total cost basis and 1.38 on an input cost basis. This was followed by 25 cm × 15 cm (S_2), while the narrowest spacing of 20 cm × 15 cm (S_1) registered the lowest economic returns and profitability.

With respect to nutrient levels, 75% RDF (N_2) achieved a slightly higher B:C ratio (0.91 on total cost basis and 1.24 on input cost basis) than 100% RDF (N_1) (0.90 and 1.21, respectively), despite lower gross returns, owing to reduced cultivation costs. Net returns over input cost were marginally higher with N_2 (20,739 ha^{-1}) compared to N_1 (19,719 ha^{-1}).

In the case of bio-stimulant application, irradiated chitosan @ 50 ppm (B_2) produced the highest gross returns (118,957 ha^{-1}) and net returns over input cost (25,587 ha^{-1}), along with a superior B:C ratio of 0.95 (total cost) and 1.29 (input cost). The control (B_1) exhibited the lowest economic performance, while irradiated chitosan @ 100 ppm (B_3) showed intermediate values.

On average across treatments, the gross returns, cost of cultivation, and net returns over input cost were 1,13,899 ha^{-1}, 1,26,030 ha^{-1}, and `20,229 ha^{-1}, respectively, with mean B:C ratios of 0.91 on a total cost basis and 1.22 on an input cost basis. Similar results are reported by Tanjeem (2023) [24], Gharieb (2021) [10], Nayak *et al.* (2020) [19], Kang *et al.* (2019) [15], Baradhan *et al.* (2019) [5].

Conclusion

For obtaining better growth and grain yield attributing characters in rice crop fertilized with 100 percent recommended dose of fertilizer. The foliar spray of irradiated 50 ppm irradiated chitosan produced better growth and yield attributing characters in the rice crop. Wider spacing S_3:(30 cm x 15 cm) application of 100% RDF with four foliar sprays (at nursery, 20 DAT, 40 DAT, 60 DAT) of irradiated chitosan irradiated @ 50 ppm significantly recorded higher growth and yield attributing characters in rice crop. Application of 75% RDF with four foliar sprays (at nursery, 20 DAT, 40 DAT, 60 DAT) of irradiated chitosan @ 50 ppm significantly recorded gross returns, net returns and highest the B:C ratio.

Thus, it can be concluded that the *kharif* season rice crop was fertilized with 75 percent recommended dose of fertilizer (75:37.5:37.5 kg ha^{-1} N: P_2O_5:K_2O) along with four foliar sprays (at nursery, 20 DAT, 40 DAT, 60 DAT) of irradiated chitosan @ 50 ppm obtaining, higher grain yield and economic returns.

References

1. Adhikari M, Neupane P, Bahadur RL, Poudel SR, Marahatta S. Effect of plant spacing and genotype on growth, yield, and yield related traits in rice (*Oryza sativa* L.). Russian Journal of Agricultural and Socio-Economic Sciences. 2022;3(123):89-99.
2. Ali MI, Monira S, Hossen MA, Islam MW, Das RC. Effect of elevated nitrogen levels on the growth and yield performance of late T. aman rice cultivars. Journal of Bioscience and Agriculture Research. 2023;30(1):2520-2526.
3. Banjade D, Khanal D, Shrestha A, Shrestha K. Effects of seedling and plant spacing on the system of rice intensification (SRI) for spring rice (*Oryza sativa* L.). Agro Environmental Sustainability. 2023;1(3):229-235.
4. Banjare L, Banwasi R, Jataw GK, Shrivastav LK. Effect of seaweed extract on yield and nutrient uptake of rice in a vertisol. The Pharma Innovation Journal. 2022;11(3):2193-2198.
5. Baradhan G, Suresh Kumar SM, Murugan S, Sathiya Narayanan G, Ramesh Kumar S, Latha K, *et al*. Influence of Modulin as a foliar treatment on growth, yield and gene expression of calmodulin in rice along with lower NPK levels. Plant Archive. 2019;19(2):3283-3289.
6. Baviskar S, Patil S, Kamdi S, Madke V, Shende P. Effect of chitosan on breaking yield barrier of soybean Agriculture. Association of Textile Chemical and Critical Reviews Journal. 2024;12(1):67-70.
7. Deepana P, Sathiya Bama K, Santhy P, Sivasankari Devi T. Effect of seaweed extract on rice (*Oryza sativa* L. var. ADT53) productivity and soil fertility in Cauvery delta zone of Tamil Nadu. Indian Journal of Applied and Natural Science. 2021;13(3):1111-1120.
8. Durga KK, Rao PS, Raju K. Effect of seedling age and spacing schedule on the productivity and quality traits of rice under system of rice intensification (SRI). Journal of Cereals and Oilseeds. 2015;6(3):15-19.
9. Gautam P, Sharma GD, Rana R, Lal B, Joshi E. Evaluation of integrated nutrient management and plant density on productivity and profitability of rice (*Oryza sativa* L.) under system of rice intensification in mid-hills of Himachal Pradesh. Indian Journal of Agronomy. 2013;58(3):421-423.
10. Gharieb AS. NPK compound fertilizer foliar application impacts productivity and grain quality of rice. Alexandria Journal of Agricultural Sciences. 2021;66(1):13-21.
11. Ghodake S, Thorat T, Rajemahadik V, Bodake P, Khobragade NH, Desai S, *et al*. Effect of foliar application of bio-stimulants on growth, yield and yield attributing characters of rice (*Oryza sativa* L.). The Pharma Innovation Journal. 2022;11(11):2134-2137.
12. Hugar AY, Prashant GS, Chethan, Shruthi SH. Effect of different bio stimulants on nutrient uptake and yield of rice. International Journal of Advanced Biochemistry Research. 2025;9(4):175-180.
13. Ishfaq M, Akbar N, Khan I, Anjum SA, Zulfiqar U, Ahmad M, *et al*. Optimizing row spacing for direct seeded aerobic rice under dry and moist fields. Pakistan Journal of Agricultural Research. 2018;31(4):291-299.
14. Kandil AA, El-Kalla SE, Badawi AT, El-Shayb OM. Effect of hill spacing, nitrogen levels and harvest date on rice productivity and grain quality. Crop Environment. 2010;1(1):22-26.
15. Kang JS, Kaur J, Sandhu SS. Performance of mechanically transplanted basmati rice under different age of seedlings and planting densities. Indian Journal of Agronomy. 2019;64(2):200-203.
16. Kashkool HR, Radhi NJ, Hassan WF. Effect of plant spacing system and soil amendment in growth and yield of rice plants (*Oryza sativa* L.). Plant Archives. 2020;20(1):2710-2714.
17. Mondal R, Goswami S, Mandi SK, Goswami SB. Quality seed production of rice (*Oryza sativa* L.) as influenced by nutrient management during kharif season in the lower Indo-Gangetic plains. Environment and Ecology. 2019;37(1A):274-280.
18. Moro B, Nuhu I, Martin E. Effect of spacing on grain yield and yield attributes of three rice (*Oryza sativa* L.) varieties grown in rain-fed lowland ecosystem in Ghana. International Journal of Plant Soil Science. 2016;9(3):1-10.
19. Nayak P, Biswas S, Dutta D. Effect of seaweed extracts on growth, yield and economics of kharif rice (*Oryza sativa* L.). Journal of Pharmacology and Phytochemicals. 2020;9(3):247-253.
20. Nwokwumo GN. Performance of lowland rice (*Oryza sativa* L.) as affected by transplanting age and plant spacing in Abakaliki, Nigeria. Journal of Biology Agriculture Healthcare. 2015;5(9):165-172.
21. Sridhara CJ, Ramachandrappa BK, Nanjappa HV, Mavarkar NS. Effect of genotypes, planting geometry and methods of establishment on growth and yield of aerobic rice. Mysore Journal of Agricultural Science. 2011;45(3):501-505.
22. Sorour SGR, Metwally TF, Badawy SA, Saleh MM, Salem KF, El-Abd MA. Evaluation of genetic variation and diversity of grain yield and quality traits in rice (*Oryza sativa* L.) genotypes for low input NPK fertilizers. Research Square. 2021;3:1-25. doi:10.21203/rs.3.rs-1049255/v1.
23. Sunarpi, Jupri A, Kurnianingsih R, Julianiah NI, Nikmatullah A. Effect of seaweed extracts on growth and yield of rice plants. Bioscience. 2010;2(2):73-77.
24. Tanjeem A. Effect of different doses and stages of bio stimulant application on yield of transplanted rice [doctoral dissertation]. Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur: The Pharma Innovation Journal; 2022. 12(12):494-503.