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Response of planting methods and micronutrient on growth and yield of rice (*Oryza sativa* L.) North East plan zone Prayagraj

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Abstract
The research work was conducted at the Agronomy Research Field, United University, Prayagraj (U.P.) during *Kharif* season from June to December, 2023 to study the effect of planting methods and Micronutrient on the growth and yield of rice. The experiment consisted of three planting methods treatments *viz.* SRI method, Line sowing method and Transplanting method and three Micronutrient *viz.* $FeSo_4$ (5%), Zn + B (5%) and Seaweed sap (10%). The experiment was laid out in randomized block design with three replications. The highest plant height (104.19 cm), Number of tiller/hill (32.03), Plant dry weight (64.98 g/plant), Yield attributes No. of panicle/hill (15.37), panicle length (32.24 cm), No. of grain/panicle (140.57), days to maturity (137.23) and Test weight (27.63 g) was recorded in treatment T_9 (Transplanting method + Seaweed sap (10%)) while highest Seed yield (5.31 t/ha), Straw yield (12.96 t/ha), Biological yield (18.27 t/ha) was recorded in treatment T_9 (Transplanting method + Seaweed sap (10%)) of rice. The highest economics was computed under treatment T_9 (Transplanting method + Seaweed sap (10%)) i.e. net return (123089.46 Rs/ha), gross return (178635.50 Rs/ha), highest cost of cultivation (55546.04 Rs/ha) and (B: C ratio) (2.22). The lowest plant height (84.33 cm), Number of tiller/hill (27.30), Plant dry weight (45.23 g/plant), Yield attributes, No. of panicle/hill (10.34), panicle length (23.46 cm), No. of grain/panicle (105.93), Test weight (22.33 g), Seed yield (3.98 t/ha), Straw yield (9.71 t/ha), Harvest index (29.20 t/ha), of rice. The lowest net return was computed under T_{10} (100% RDF Control) and net return (81035.46 Rs/ha), gross return (133831.50 Rs/ha), lowest cost of cultivation (52796.04 Rs/ha) recorded in (B: C ratio) (1.53) Therefore, T_{10} (Control) obtaining the highest grain and straw yields of rice.

Keywords: Planting methods, micronutrient, rice, growth, yield and economics

Introduction
Rice (*Oryza sativa* L.) is one of the most important food grain crops of more than 60 percent of the world's population. About 90 percent of all rice grown in the world is produced and consumed in the Asian region. It is the world's leading food crop in terms of area and production. Among the rice growing countries, India has the largest area followed by China and Indonesia. India ranks second in production after China. Andhra Pradesh, Bihar, Uttar Pradesh, Madhya Pradesh and West Bengal are leading states in the area of rice. (Anonymous 2023). **(**Basha, 2016) [4]. It is a highly prized and internationally acclaimed rice variety known for its unique aroma, slender grains, and exceptional taste. In India, West Bengal is top producing state followed by Uttar Pradesh, Punjab and Orissa. In India, it is grown over an area of 43.90 million hectares having production of 114.45 million tones with average yield of 2607 kg/ha. In Uttar Pradesh, it is grown on 5.70 million hectares area with production of 11.72 million tones and yield of 2679 kg/ha. (Agricultural Statistics at a Glance 2022, Department of Agriculture & Farmer Welfares).
Division of Crop growth rate, dry matter accumulation, crop canopy coverage, and solar radiation interception are all impacted by the planting geometry of the crop. Plants compete with one another for nutrients, water, and light as a result of the closer planting geometry, which slows down both growth and grain yield. Proper growth of both aerial and subsurface plant components is ensured by optimal planting geometry, which makes optimum use of solar

radiation, nutrients, and water. The rice yield per unit area is determined by the planting geometry, which also affects the tillering habit and the development of spikelet's per panicle. Therefore, it is important to optimize planting geometry and plant spacing while taking various cropping management approaches into consideration. Therefore, the purpose of this study was to look at how different planting geometries affect the growth of rice types that can withstand drought. Rice requires nitrogen as a key nutrient since it is essential for the growth of green foliage, stem elongation, and grain formation. Sufficient nitrogen increases the number of tillers, encourages rapid vegetative growth, and increases the biomass of the plant overall. (Ranjitha *et al.*, 2013) [13]. However, Micronutrient zinc helps rice crops resist disease and produce more. It is important for both of these processes. One of the significant micronutrients needed for plant growth is zinc. Soluble zinc salts and zinc complex can also enter the plant system directly through the leaf. Zinc is absorbed by plant roots as the ion zinc 2+ and as a component of manufactured and natural molecular complexes. Lowland rice generally has zinc shortage in nearly neutral to alkaline soils, primarily calcareous soils. Transplanted rice seedlings may also perish or directly sown seeds may not sprout in a severe instance of zinc deficiency. In most instances, though, symptoms appear two to three weeks after transplanting, and a spontaneous recovery from the deficiency may also occur six to eight weeks following soil submergence. The second-ranking low-vitamin in the rice tract that is significantly affecting crop yield is boron. Research on fertilizing rice with boron revealed that the yield of rice increased steadily as boron was applied. Additionally, boron can increase sugar availability, respiration, and enzymatic activity-all of which contribute to an advanced pollen bloom. When there is a severe boron shortage, the flora's root boom stops, which eventually results in the death of the root tips. (Singh and Singh 2018) [16].

Materials and Methods

Rice was used in a field experiment at United University's Agriculture Research Farm in Prayagraj, Uttar Pradesh, in the *Kharif* season of 2023. With a pH of 8.1, organic carbon of 0.41%, EC of 0.26 dSm^{-1}, available P_2O_5 of 16.9%, and available K2O of 255.00 kg/ha, the soil type was silty loam. The experiment consisted of three planting methods *viz.* SRI method, Line sowing method and Transplanting method and three Micronutrient *viz.* $FeSo_4$ (5%), Zn + B (5%) and Seaweed sap (10%). The experiment was laid out in randomized block design with three replications. The experiment in Randomize Block Design (RBD) with three replications of 16 m^2 plots. N, P and K were applied at the fertilizer of through Urea, di ammonium phosphate DAP, SSP and Muriate of potash (MOP). Full P and K applied as basal dose. N was applied treatment wise in three splits i.e. 50% at basal dose, 25% at maximum tillering and 25% at panicle initiation. The rice variety TAJ (Basmati hybrid) is released from U. P., in year 2007 which is suitable for irrigated ecosystem. This is a semi dwarf variety (105-110 cm) with medium and small grains. The duration of variety is 115 days with an average production of 50-55 quintals per hectare. The experimental field was ploughed with the help of tractor drawn plough followed by two harrowing and planking. After this flooding and puddling operation was carried out with help of rotavator. In order to field preparation, the experimental field was ploughed once 20 -25cm deep by tractor drawn soil turning plough in summer to expose the stubbles of previous crop, rhizomes of weeds and egg of harm-full insect pests and fallowed by two to three cross harrowing. Observations were recorded for yield attributes *viz.*, Number of panicle/hills, Panicle length (cm), Number of grains per panicle, Number of productive tillers/hills, Test weight, Seed yield (t/ha), Straw yield (t/ha) Biological yield (t/ha) and Harvest index (%) for each replication. Grain yield was reported at 14-15% moisture content. Plant N was determined by Kjeldhal method, while P and K contents were estimated in di-acid digests using vanado molybdo phosphoric yellow colour method and flame photometer, respectively (Jackson, 1973) [9].

Results and Discussions

Growth parameters

Plant height

During at harvest, significantly higher plant height (104.19 cm) was recorded with the treatment T_9 (Transplanting method + Seaweed sap (10%). However, the treatments T_8 (Transplanting method + Zn+B (5%)), T_5 (Line sowing method + Zn+B (5%) and T_2 (SRI method + Zn + B (5%) was found to be statistically at par with T_9 (Transplanting method + Seaweed sap (10%). When younger seedlings are gently transplanted by maintaining the roots upright (guaranteeing that the roots do not develop a 'J' shape), a vigorous and deeper root system is promoted, resulting in more prolific and taller plants in SRI. Shekhar *et al.*, 2009 [14] also reported the similar result. When compared to conventional transplanting (CT) and mechanized transplantation (MT), the height was much higher in SRI. This could be owing to more room, sunlight, and nutrients accessible in SRI due to the wider spacing (Thakur *et al.*, 2010) [20]. During at harvest, significantly higher number of tillers $hill^{-1}$ (32.03) was recorded with the treatment T_9 (Transplanting method + Seaweed sap (10%). However, the treatments T_8 (Transplanting method + Zn +B (5%)), T_5 (Line sowing method + Zn +B (5%) and T_2 (SRI method + Zn + B (5%) was found to be statistically at par with T_9 (Transplanting method + Seaweed sap (10%). In comparison to the other treatments, the SRI approach determined a much higher maximum number of tillers. Wider planting, transplanting younger seedlings, earlier transplanting, and proper water management could all contribute to the larger number of tillers/hills. Transplanting earlier in the growth cycle reduces transplant trauma by allowing them to rebound faster and have a smaller impact on tiller age (Uphoff, 2002) [21]. In comparison to conventional transplanting, Nissanka and Bandara (2004) [11]. During At harvest, significantly higher dry weight (64.98 g) was recorded with the treatment T_9 (Transplanting method + Seaweed sap (10%). However, the treatments T_8 (Transplanting method + Zn+ B (5%), T_5 (Line sowing method + Zn+ B (5%) and T_2 (SRI method + Zn + B (5%) was found to be statistically at par with T_9 (Transplanting method + Seaweed sap (10%). The probable reason for maximum dry matter accumulation depends upon the photosynthesis and respiration rate, which finally increases the plant growth with respect to increased plant height, dry weight and tillers $hill^{-1}$ etc. Thus, the treatment which attained maximum growth, also accumulated higher dry matter similar result have also been reported by Kumar (2016) [22]. The other reason of high dry matter accumulation in might be due to the significant increase in morphological parameters which responsible for the photosynthetic capacity of the plant thereby increasing the straw yield. The result conformed to Bozorgi *et al.*, (2011) [23].

Yield Parameters

Panicle length

Significantly higher panicle length was observed with the T9 (Transplanting method + Seaweed sap (10%) which was (32.24

cm) over rest of the treatments except T_8 Transplanting method + Zn+ B (5%), T_7 (Transplanting method + Fe (5%) (28.82) and T_6 (Line sowing method + Seaweed sap (10%) (29.09 cm) which are statistically at par with T_9 (Transplanting method + Seaweed sap (10%). The nitrogen level exerted significant effect of on panicle length in hybrid rice. The significant differences in panicle length among the hybrid rice varieties could be attributed to their genetic make-up. The results confirm the findings of Rahman *et al.,* (2013) [12]. The young seedlings recorded better root growth, cell division and cell enlargement due to increased photosynthetic rate subsequently increasing the plant height. Singh and Singh (2018) [16]. Significantly higher number of grain per panicle was observed with the T_9 (Transplanting method + Seaweed sap (10%) which was (140.57) over rest of the treatments except T_8 Transplanting method + Zn +B (5%) (137.80), T_7 (Transplanting method + Fe (5%) (132.13) and T6 (Line sowing method + Seaweed sap (10%) (130.82) which are statistically at par with T_9 (Transplanting method + Seaweed sap (10%). The favorable reason might be that hybrid rice produces long roots and broad leaves that enable them to take up more nutrients and produce more grains. It is suited to existing climatic condition of the place especially during the grain-filling stage of the panicle development. Similar results have also been reported by Budiono *et al.,* (2021) [6]. Significantly higher number of test weight was observed with the T_9 (Transplanting method + Seaweed sap (10%) which was (27.63 g) over rest of the treatments except T_8 Transplanting method + Zn +B (5%) (26.61 g), T_7 (Transplanting method + Fe (5%) (26.33 g) and T_6 (Line sowing method + Seaweed sap (10%) (25.53 g) which are statistically at par with T_9 (Transplanting method + Seaweed sap (10%). The increase in test weight might be attributed due to supply of S, Zn and B to plants as they take part in energy formation and translocation from sink to source. Babu *et al.,* (2014) [3], and Bhaskar *et al.,* (2012) [5], also reported that application of S + Zn + B applied singly or in combination give higher 1000 grain weight over RDF. Kumar *et al.,* (2017) [10], also reported significant increase in test weight of rice with application of 25 kg ZnSO4 ha^{-1}. Subehia *et al.,* (2012) [19]. Significantly higher grain yield was observed with the T_9 (Transplanting method + Seaweed sap (10%) which was (5.31) over rest of the treatments except T_8 Transplanting method + Zn+ B (5%) (5.26), T_7 (Transplanting method + Fe (5%) (5.23) and T_6 (Line sowing method + Seaweed sap (10%) (5.21) which are statistically at par with T_9 (Transplanting method + Seaweed sap (10%). The increase in grain yield might be attributed due to supply of S, Zn and B to plants as they take part in energy formation and translocation from sink to source. Das *et al.,* (2017) [8], also reported that application of S + Zn + B applied singly or in combination give higher 1000 grain weight over RDF also reported significant increase in test weight of rice with application of 25 kg ZnSO4 ha^{-1}. Chaudhary *et al.,* (2016) [7]. Significantly higher grain yield was observed with the T_9 (Transplanting method + Seaweed sap (10%) which was (12.96) over rest of the treatments except T_8 Transplanting method + Zn +B (5%) (12.73), T_7 (Transplanting method + Fe (5%) (12.68) and T_6 (Line sowing method + Seaweed sap (10%) (11.65) which are statistically at par with T_9 (Transplanting method + Seaweed sap (10%). Rice straw yield was likewise highest where the rice crop was established using the SRI approach and then transplanted using other methods. Transplanting seedlings at an early stage gives enough nutrients for vegetative growth as well as the production phase, resulting in enhanced plant height and yield qualities, and hence greater straw yield.

Economics

The price of growing rice is shown in, this price (55546.04 ₹/ha) was determined after accounting for all costs involved in growing the crop. The price of transplanting increased the expense of farming. The gross return of rice has been presented. Maximum gross return (₹178635.50 /ha) was obtained from treatment (Transplanting method + Seaweed sap (10%), which could be due to highest grain yield. The net return of hybrid rice has been presented. The treatment Transplanting method + Seaweed sap (10%), recorded the highest net return (₹123089.46/ha). Maximum benefit cost ratio of 2.22 was recorded in the treatment nine (transplanting method + Seaweed sap (10%), because of higher net return.

Table 1: Effect of planting methods and Micronutrient on growth of rice.

Tr. No.	Treatment combination	Growth parameters				
		Plant height (cm)	No. of tillers	Dry weight (g)	CGR	RGR
T_1	SRI method + $FeSo_4$ (5%)	86.83	27.80	49.78	13.11	0.0082
T_2	SRI method + Zn + B (5%)	91.69	28.96	54.68	12.56	0.0070
T_3	SRI method + Seaweed sap (10%)	96.56	29.73	57.31	11.39	0.0084
T_4	Line sowing method + Fe (5%)	98.99	29.96	57.95	11.00	0.0066
T_5	Line sowing method + Zn+B (5%)	99.23	31.06	58.48	14.06	0.0082
T_6	Line sowing method + Seaweed sap (10%)	99.93	31.16	59.75	9.67	0.0063
T_7	Transplanting method + Fe (5%)	100.26	31.20	61.78	10.39	0.0071
T_8	Transplanting method + Zn+B (5%)	102.56	31.60	63.91	12.39	0.0069
T_9	Transplanting method + Seaweed sap (10%)	104.19	32.03	64.98	13.44	0.0086
T_{10}	100% RDF (Control)	84.33	27.30	45.23	10.58	0.0058
	F-test	S	S	S	S	NS
	Sem±	3.98	0.95	2.59	1.04	0.0018
	CD (P=0.05)	11.84	2.82	7.69	3.11	0.0055

Table 2: Effect of planting methods and Micronutrient on yield of rice.

Tr. No.	Treatment combination	Yield and yield parameters					
		Panicle length (cm)	No of grain per panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
T_1	SRI method + $FeSo_4$ (5%)	26.13	109.69	22.90	4.50	10.60	29.76
T_2	SRI method + Zn + B (5%)	27.06	114.13	23.80	4.63	10.77	30.05
T_3	SRI method + Seaweed sap (10%)	27.57	117.47	23.95	4.76	11.36	29.53
T_4	Line sowing method + Fe (5%)	28.31	126.77	24.60	4.90	11.48	29.91
T_5	Line sowing method + Zn+B (5%)	28.61	127.14	24.73	4.98	11.51	30.26
T_6	Line sowing method + Seaweed sap (10%)	28.71	130.82	25.53	5.21	11.65	30.90
T_7	Transplanting method + Fe (5%)	28.82	132.13	26.33	5.23	12.68	29.27
T_8	Transplanting method + Zn+B (5%)	29.09	137.80	26.61	5.26	12.73	29.28
T_9	Transplanting method + Seaweed sap (10%)	32.24	140.57	27.63	5.31	12.96	29.28
T_{10}	100% RDF (Control)	23.46	105.93	22.33	3.98	9.71	29.20
	F-test	S	S	S	S	S	NS
	Sem ±	1.23	7.40	0.75	0.19	0.56	1.48
	CD (P=0.05)	3.67	22.00	2.23	0.56	1.67	4.40

Fig 1: Field view of a respectful study trial with advisor Dr. Lalit Kumar Sanodiya

Conclusion

The maximum planting methods and Micronutrient was found in treatment T_9 Transplanting method + Seaweed sap (10%) produced significantly highest plant height (cm), No. of tiller/hill, Plant dry weight (g/plant), and in yield No. of panicle/hill, Panicle length(cm), No. of productive tiller/hill, and Test weight (g). Highest Seed yield (t/ha), Straw yield (t/ha) and biological yield (t/ha), Harvest index (%). The economics analysis of test crop as influenced due to different treatments like- cost of cultivation (55546.04 Rs/ha), gross returns (178635.50 Rs/ha), net returns (123089.46 Rs/ha) and benefit: cost ratio (2.22) were calculated on the basis of current market prices of inputs and outputs during the yearfound in treatment T_9 Transplanting method + Seaweed sap (10%) and treatment T_{10} (Control) produces lowest among all.

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