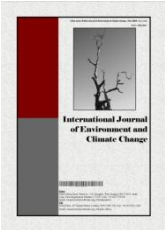

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Effect of Nitrogen Levels and Planting Methods on Growth and Yield of Black Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Compared to other types of rice, black rice has the highest protein content vitamins and minerals. Black rice contains essential amino acids like lysine, tryptophan; vitamins such as vitamin B1, vitamin B2, folic acid; and it is a good source of minerals including iron, zinc, calcium, phosphorus and selenium.
Objectives: Impact of nitrogen levels and planting methods on black rice growth and production.
Methods: A field experiment was conducted during kharif season of 2021, at crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj in North Eastern plains of Eastern Uttar Pradesh. under randomized block design comprising of 9 treatments of which treatments (T1-T9) with different combination of nitrogen along with different planting meathods which are replicated thrice.
Conclusion: The treatment Nitrogen at 75 kg/ha nitrogen + SRI method recorded maximum. Plant height (118.13 cm), number of tillers/hill (11.00), plant dry weight (31.62 g/plant), number of

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panicles per hill (10.83), number of grains per panicle (196.70), number of filled grains per panicle (116.33), grain yield (4.61 t/ha) and straw yield (11.38 t/ha). Because the findings are based on research conducted during a single season, they may be repeated for further confirmation.

Keywords: Black rice; growth; nitrogen; planting methods; yield.

1. INTRODUCTION

Rice is a genus of cereal grasses in the Gramineae family, with the species *Oryza sativa* L. It is a staple food for many cultures and countries providing one-fifth of all calories consumed by humans. Rice is important because it provides some of the primary nutrients needed for human health, such as protein, carbohydrates, fibre, and minerals. There are many different varieties of rice. Some of the most popular types include white, brown, red, black, and purple. Among all this varieties black rice is one kind of rice that is getting more popular recently and is consumed as functional food due to its health benefits. There are a total of more than 200 types of black rice widely grown in South, and Southeast Asian counties such a China, Sri Lanka, India, Indonesia, and Thailand with China considered the highest black rice production country [1]. Black rice contains higher levels of proteins, vitamins and minerals than common white rice. It contains the highest number of antioxidants, protein and dietary fibre than of all rice varieties. Black rice has the highest content of total anthocyanin (327.60 mg 100 g^{-1}) among all of the studied coloured grains [2]. However, yield of black rice is low as 10% as compared to other varieties.

Among the major nutrient elements, nitrogen (N) is the most limiting nutrient for rice crop growth and yield which is required in higher amounts compared to other nutrients [3]. Nitrogen increases rice yield by playing major role in the photosynthesis, biomass accumulation, effective tillering, and spikelets formation [4]. In addition, improper planting methods have an impact on crop yield and yield component, as well as profitability due to increased production costs. As a result, increasing rice crop output, productivity, and profitability is attainable by adopting appropriate planting methods [5]**.** Rice can be cultured using three different methods: transplanting, direct sowing, and SRI. In irrigated lowland rice, transplanting is perhaps the most superior and traditional way of establishment. Pandey and Valesco [6] claimed that direct seeded rice can be grown in locations where wages are high but water is scarce. It requires less manpower, decreases crop duration by 7-10 days, and produces grain yields comparable to transplanted crops. The yield of irrigated rice is being improved in SRI, where one seedling is used to cultivate rice. Thakur et al. [7] suggested that the rice intensification system has a lot of potential for increasing productivity. The present study was therefore, undertaken to compared and standardize nitrogen levels and planting methods best suited to black rice grower.

2. MATERIALS AND METHODS

The experiment was conducted during Kharif season 2021, at C.R.F, Department of Agronomy, Naini Agricultural Institute in Shiats Prayagraj (U.P.) at 25^{o} 39' 42" NL, 81^{o} 67' 56" EL and altitude of 98 m above MSL. By the side of Rewa road, residing on the right of Yamuna river 12km away from city. To determine the impact of nitrogen levels and planting methods on black rice growth and production. The study used a randomized block design with nine treatments that were replicated three times. Each layout for every treatment is 3m 3m long. The treatment is defined as having a recommended dose of (40kg P, 40kg K) and using Phosphorus via DAP, Potash via Muriate of Potash, and Nitrogen via Urea when used. The treatment are (T1) Nitrogen at 55 kg/ha + transplanting method, (T2) Nitrogen at 55 kg/ha + direct sowing method, (T3) Nitrogen at 55 kg/ha + SRI, (T4) Nitrogen at 65 kg/ha + transplanting method, (T5) Nitrogen at 65 kg/ha + direct sowing method, (T6) Nitrogen at 65 kg/ha + SRI, (T7) Nitrogen at 75 kg/ha + transplanting method, (T8) Nitrogen at 75 kg/ha + direct sowing method, (T9) Nitrogen at 75 kg/ha + SRI. At harvesting maturity, the black rice was harvested smartly. Plant height (cm), number of tillers, and dry weight (g) were physically recorded on five randomly selected consultant plants from each plot of each replication one at a time. After harvesting the plants from each plot were isolated and dried under solar for five days. The grains were then winnowed, cleaned, and the grain yield per hectare was computed and expressed in tonnes per hectare. The number of panicles per hill, number of grains per panicle, number of filled grains per panicle, grain yield

(t/ha), and straw yield (t/ha) were all used to examine data on yield attributes (Gomez and Gomez 1984). Statistical analysis was performed on the data gathered from the experiment at various growth stages and at harvest utilising Dry soft ICRISAT software. P=0.05 was utilised as the level of significance in the F-test. Wherever the F-test was significant, critical difference values were calculated.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height

Plant height measurements increased as crop growth progressed, as seen in Table 1. The maximum plant height (118.13cm) was recorded with treatment Nitrogen at 75 kg/ha + SRI, whereas treatment Nitrogen at 65 kg/ha + SRI, Nitrogen at 65 kg/ha + transplanting method, and Nitrogen at 75 kg/ha + transplanting method are found statistically at par with treatment Nitrogen at 75 kg/ha + SRI. Nitrogen is the main component of the protoplasm involves in various metabolic processes viz. photosynthesis, stimulation of cell division and elongation .Plant height of black rice was found significantly higher by using SRI method. This result was in conformity with the findings of Malik et al. [8].

3.1.2 Number of tillers per hill

The maximum number of tillers hill^{-1} (11.00) was recorded with treatment Nitrogen at 75 kg/ha + SRI, whereas treatment Nitrogen at 65 kg/ha + SRI, and Nitrogen at 75 kg/ha + transplanting method are statistically at par with treatment Nitrogen at 75 kg/ha + SRI. . The higher number of tillers hill^{-1} might be due to wider spacing, transplanting younger seedlings, earlier transplanting and better water management. Earlier transplanting reduces the transplanting shock at a more convenient point in the growth cycle when they could rebound faster and had little effect on tiller age [9]. Use of plastic trays for raising seedlings, and dry cultivation of the nursery was beneficial to boost the vigorous root system for early and quick growing of tillers after transplanted in SRI.

3.1.3 Plant dry weight

At harvest maximum dry weight was observed in treatment Nitrogen at 75 kg/ha + SRI, (39.62 g/plant) whereas treatment Nitrogen at 65 kg/ha + transplanting method is found to be statistically at par with treatment Nitrogen at 75 kg/ha + SRI. The increase in Plant dry weight of black rice is due to Nitrogen is the main component of the protoplasm involves in various metabolic processes viz. photosynthesis, stimulation of cell division and elongation. Due to adequate supply of nutrients in SRI which might contribute towards higher dry matter accumulation Meena et al. [10] also reported significant improvement in dry matter accumulation of rice with increasing nitrogen on account of better growth and development of the plant.

Table 1. Effect of nitrogen levels and planting methods on growth parameter

	Treatments	Plant height	Number of tillers/hill	Plant dry weight
T_1	Nitrogen at 55 kg/ha + transplanting method	114.67	9.33	28.37
T_2	Nitrogen at 55 kg/ha +direct sowing method	112.67	8.13	27.32
T_3	Nitrogen at 55 kg/ha + SRI	115.25	9.20	29.48
T_4	Nitrogen at 65 kg/ha + transplanting method	116.63	9.60	30.65
T_5	Nitrogen at 65 kg/ha +direct sowing method	114.62	8.73	29.60
T_6	Nitrogen at 65 kg/ha + SRI	116.73	10.73	29.08
T_7	Nitrogen at 75 kg/ha + transplanting method	116.60	10.13	29.82
T_8	Nitrogen at 75 kg/ha +direct sowing method	113.43	8.40	29.95
T_9	Nitrogen at 75 kg/ha + SRI	118.13	11.00	31.62
SEm (±)		2.70	0.57	0.41
CD (5 %)		NS	1.72	1.23

3.1.4 Yield attributes and yield

Data related to yield attributes and yield were taken at harvest and tabulated in Table 2. Maximum number of panicles per hill, number of grains per panicle and number of filled grains per panicle (10.83, 196.70 and 116.33) was recorded with T_9 i.e. Nitrogen at 75 kg/ha + SRI. Whereas, Nitrogen at 75 kg/ha + transplanting method noticed to be at par with T_9 i.e. Nitrogen at 75 kg/ha + SRI. However in case of yield parameter maximum grain yield (4.61 t/ha) and straw yield (11.38 t/ha) were recorded with T_9 i.e. Nitrogen at 75 kg/ha + SRI whereas Nitrogen at 65 kg/ha+ SRI and 75 kg/ha transplanting method was statistically at par with treatment 9. The increased plant spacing with SRI considerably resulted in advantage of space, light and circulatory air which might resulted in increased nutrient uptake and better dry matter assimilation leading to a consequent increase in a greater number of grains per panicle by Saju et al. [11]. Nitrogen promotes rapid growth and increased number of grains/panicle, the percentage of filled grains per panicle. The highest yield under SRI was due to adequate supply of nutrients which might contribute towards higher dry matter accumulation and better partitioning of photosynthate resulting in higher yield traits and ultimately the straw yield [12].

Table 2. Yield and yield attributes of black rice

	Treatments	Number of panicles /hill	Number grains/panicle	Number of filled grains/panicle	Grain yield (t/ha)	Straw yield (t/ha)
T_1	Nitrogen at 55 kg/ha + transplanting method	8.80	168.80	94.33	2.91	9.27
T_2	Nitrogen at 55 kg/ha +direct sowing method	8.70	163.78	89.33	2.48	6.92
T_3	Nitrogen at 55 kg/ha + SRI	9.13	171.73	96.67	2.60	6.94
T_4	Nitrogen at 65 kg/ha + transplanting method	9.03	184.37	105.67	3.22	9.76
T_5	Nitrogen at 65 kg/ha +direct sowing method	8.93	179.39	99.66	3.36	8.26
T_6	Nitrogen at 65 kg/ha + SRI	9.63	186.17	105.88	4.00	11.13
T_7	Nitrogen at 75 kg/ha + transplanting method	10.27	195.81	114.67	4.25	11.14
T_8	Nitrogen at 75 kg/ha +direct sowing method	9.37	189.17	106.33	3.79	10.33
T_9	Nitrogen at 75 kg/ha + SRI	10.83	196.70	116.33	4.61	11.38
	SEm (±)	0.42	1.11	1.91	0.04	0.11
	CD (5 %)	1.27	3.33	5.75	0.13	0.32

Picture with respected Dr. Umesha C. (Assistant Professor, SHIATS)

4. CONCLUSION

Nitrogen at 75 kg/ha + SRI treatment was found higher in plant height (118.13 cm), number of tillers per hill (11.00), plant dry weight (31.62 g/plant), number of panicles per hill (10.83), number of grains per panicle (196.70), number of filled grains per panicle (116.33), grain yield (4.61 t/ha), and straw yield (11.38 t/ha) were all recorded maximum. Because the findings are based on studies conducted over a single season, they might be replicated for additional validation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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