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Effect of planting geometry and nitrogen on growth and yield of rice (*Oryza sativa* L.) cv. Pusa Basmati - 1121

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Abstract

The field experiment titled “Effect of Planting geometry and Nitrogen on growth and yield of Rice (*Oryza sativa* L.) cv. Pusa Basmati - 1121” was conducted during *Kharif* season, 2025 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The soil of the experimental plot was sandy loam in texture, had a pH of 7.8, contained 0.720% Organic carbon, and had 178.48 kg of Nitrogen, 27 kg of Phosphorus, and 233 kg of Potassium available per hectare. The treatment details are Plant geometry (20 cm X 15 cm, 20 cm X 20 cm and 25 cm X 25 cm) and Nitrogen levels (100 kg, 120 kg and 140 kg/ha). The experiment was laid out in Randomized Block Design with Nine treatments which are replicated thrice. The Significantly higher plant height (116.51 cm), tillers/hill (18.00), plant dry weight (116.05 g/hills), effective tillers/m² (177.00), number of grains/panicle (119.33), grain yield (3.87 t/ha) and straw yield (4.87 kg/ha) was recorded in treatment -9 (25 cm X 25 cm along with Nitrogen 140 kg/ha). And maximum gross return (INR 121927.31/ha), net return (INR 83783.31/ha) and B:C ratio (2.20) were also recorded in the same treatment - 9 (25 cm X 25 cm along with Nitrogen 140 kg/ha).

Keywords: Growth, economics, nitrogen, plant geometry, rice and yield

Introduction

Rice (*Oryza sativa* L.) is the most crucial cereal food crop of India, which occupies about 24% of gross cropped area of the country. It contributes 42% of total food grain production and 45% of total cereal production of the country. India has a long history of Rice cultivation and stands first in area and second in Rice production, after China (Yadav *et al.* 2010). Rice plants have been traced back to 5000 BC, but the practice of Rice growing is believed to have originated in areas of China, and southern & eastern Asia, in about 2000 BC. Rice cultivation is considered to have begun simultaneously in many countries over 6500 years ago. Most believe the roots of Rice come from 3000 BC India, where natives discovered the plant growing in the wild began to experiment with it. The UN/FAO forecasts that global food production will need to increase by over 40% by 2030 and 70% by 2050 (FAO, 2009). Thus, Rice production in India as well as in several other Asian countries must be doubled by the year 2025 to meet the requirement of the increasing population. India is major Rice growing country in world with an area of 407.34 lakh hectares, having production 1132.59.79 lakh tonnes and productivity of 2780 kg/ha (DES 2023- 24). In Uttar Pradesh 57.32 lakh ha and production 158.65 lakh tonnes with an average productivity of 2768 kg/ha (USDA 2022 -23). Rice is the most crucial cereal food crop of India, which occupies about 24% of gross cropped area of the country. It contributes 42% of total food grain production and 45% of total cereal production of the country. India (2010) yield of Rice was 120.62 MT 44 M ha followed by China (197.21 MT) and in year 2025-25 the Area, Production, Productivity in Uttar Pradesh and India was 5.73 million ha., 15.86 million tonnes, 2768 kg/ha and 40.73 million Hectares, 11.32 million tonnes, 2780 kg/ha respectively (Anonymous 2023-24).

Pusa Basmati 1121 (PB 1121) is a landmark Basmati rice variety having Basmati quality traits intro grassed from traditional Basmati varieties such as Basmati 370 and Type 3. It was released for commercial cultivation in 2003. It possesses extra-long slender milled grains (9.00 mm), pleasant aroma, and an exceptionally high cooked kernel elongation ratio of 2.5

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with a cooked kernel length of up to 22 mm, volume expansion more than four times, appealing taste, good mouth feel and easy digestibility Halder *et al.* (2023) ^[7]. Owing to its exceptional quality characteristics, it has set new standards in the Basmati rice market. Compared to 9-10 quintals for traditional tall basmati were reported by Singh *et al.* (2018) ^[20]. It requires relatively less water and matures earlier than traditional Basmati cultivars. Well known for its extraordinary kernel (grain) length, which can be as much as 9 millimeters (0.35 in) for a single grain, Pusa Basmati 1121 has very high kernel elongation ratio ranging from 2 to 2.5. Kernel elongation ratio is calculated as the ratio between length of cooked rice kernel and length of uncooked milled kernel Parveen *et al.* (2022).

Crop geometry plays a significant role for optimization of Rice yield due to efficient utilization of solar radiation as well as nutrients in Rice (Siddiqui *et al.*, 1999) ^[19]. Closer spacing hampers intercultural operations and as such more competition arises among the plants for nutrients, air and light as a result, plant becomes weaker and thinner producing lower yield. The plant geometry and spatial configuration exploit the initial vigor of the genotypes with enhanced soil aeration creating congenial condition for better establishment (Shukla *et al.*, 1996) ^[18].

Spacing in Rice cultivation is crucial for optimizing yield and resource utilization. Proper spacing ensures adequate access to sunlight, nutrients, and water, promoting vigorous growth and tillering. It also facilitates efficient weed control and allows for better air circulation. Reducing the risk of diseases. Additionally, optimal spacing enables easy management practices such as irrigation and fertilization, leading to uniform crop development and higher yields. The length and dry weight of seedlings, number and length of roots, and growth of seedlings increased significantly by increasing the fertility level in the nursery. Increased seedling vigour and nutrient concentration in the Rice plant during early growth stage were shown to be important for improving subsequent plant growth and final grain yield was reported similar to Ram *et al.*, (2014) ^[15] and Singh *et al.* (2015) ^[21].

Nitrogen is an essential nutrient and key limiting factor in crop production of different agro ecosystems. It is considered as one of the most important plant nutrients for growth and development of crop plant. It also plays an important role in synthesis of chlorophyll and amino acids that contribute to the building unit of protein and thus, growth of plants. It helps in early establishment of leaf area capable of photosynthesis Rajput *et al.* (2020) ^[14]. It promotes leaf and stem growth rapidly which consequently increase the yield and its quality. Nitrogen to some extent enhances the utilization of phosphorus and potassium. Nitrogen is most commonly deficient nutrient in Indian soil and gives considerable response in Rice crop (Bhuva *et al.* 2018) ^[2].

Material and Methods

An experiment was conducted during the *Kharif* season of 2025. It was conducted in alluvial soil at the Department of Agronomy. The experiments were carried out at Crop Research Farm, Department of Agronomy, NAI, SHUATS, Prayagraj, U.P. At a depth of 0-30 cm, a composite soil sample was taken. It underwent crushing, air drying, and physical and chemical testing. The soil of the experimental plot was sandy loam in texture, had a pH of 7.8, contained

0.720% Organic carbon, and had 178.48 kg of Nitrogen, 27 kg of Phosphorus, and 233 kg of Potassium available per hectare. The treatment details are Plant geometry (20 cm X 15 cm, 20 cm X 20 cm and 25 cm X 25 cm) and Nitrogen levels (100 kg, 120 kg and 140 kg/ha). The experiment was laid out in Randomized Block Design with Nine treatments which are replicated thrice. Viz., T₁- 20 cm × 15 cm + 100 kg Nitrogen /ha, T₂ - 20 cm × 15 cm + 120 kg Nitrogen/ha , T₃ - 20 cm × 15 cm + 140 kg Nitrogen /ha, T₄ - 20 cm × 20 cm + 100 kg Nitrogen /ha, T₅ - 20 cm × 20 cm + 120 kg Nitrogen /ha, T₆ - 20 cm × 20 cm + 140 kg Nitrogen /ha, T₇ - 25 cm × 25 cm + 100 kg Nitrogen /ha, T₈ - 25 cm × 25 cm + 120 kg Nitrogen /ha, and T₉ - 25 cm × 25 cm + 140 kg Nitrogen /ha. To apply nutrients as a spreading method, 4-5 cm deep furrows were dug along the seed rows using a hand hoeing. Ten days after sowing, the gaps were filled by transplanting nursery. In order to reduce crop density, weed competition, intercultural operations were carried out between 25- and 45-days intervals. At regular intervals from germination to harvest, plant growth parameters such as plant height (cm), number of tillers/hill, dry weight (g/hill), CGR (g/m²/day) were assessed. Whereas, at harvest, yield metrics such as effective tillers/hills and grain yield (t/ha). Analysis of variance (ANOVA), as it relates to randomized block design, was used to statistically examine the observed data of ten treatments (Gomez and Gomez, 1984).

Results and Discussions

Growth parameter

Plant height (cm)

The data of growth parameter are presented in Table 1. At harvest, maximum plant height was recorded (116.51 cm) was recorded in treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha). Whereas, treatment - 8 (25 cm x 25 cm along with Nitrogen 120 kg/ha) were shown statistically at par with treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha).

The results obtained that among Rice in respect of other growth attributes such as plant height was recorded significantly higher with (25 cm x 25 cm) over rest of planting geometry. This might be due to the availability of more plant for utilize resources such as solar energy, air movement and availability of more nutrients from the larger area Rasool *et al.* (2013) ^[16]. Nitrogen (N) is crucial for basmati Rice, acting as a structural component of chlorophyll and proteins that drives vegetative growth, tiller production, and grain yield. Optimal N application enhances leaf area, photosynthesis, and plant height, with higher doses of Nitrogen per hectare commonly required depending on the planting method. Excessive nitrogen can cause lodging and lower quality, while deficiencies cause yellowing and stunted growth was reported by Kanthi *et al.* (2014) ^[8].

Number of tillers per hill

At 80 DAT, the significantly highest number of tillers per hill (18.00) was recorded under Treatment 9 (25 cm × 25 cm spacing + 140 kg kg/ha). However, it was statistically at par with Treatment 6 (20 cm × 20 cm spacing + 140 kg/ha), Treatment 7 (25 cm × 25 cm spacing + 100 kg kg/ha), and Treatment 8 (25 cm × 25 cm spacing + 120 kg kg/ha).

The higher number of tillers per hill under the wider spacing (25 cm × 25 cm) may be attributed to reduced competition among plants for essential growth resources such as light,

moisture, nutrients, and space. The wider spacing also provided better aeration and promoted extensive root development, which enhanced nutrient uptake and supported vigorous vegetative growth, resulting in increased tiller production. Similar findings on the positive effect of wider planting geometry on tillering were reported by Praveen *et al.* (2015)^[13]. The superior tillering observed with the application of 140 kg Nitrogen/ha may be attributed to the crucial role of nitrogen in promoting vegetative growth through enhanced chlorophyll synthesis, cell division, leaf expansion, and photosynthetic activity. Adequate nitrogen availability ensures a continuous supply of assimilates for the initiation and development of tillers, thereby increasing the number of productive tillers per hill. These findings are in agreement with the reports of Kumar *et al.* (2002)^[9], Patra and Haque (2011)^[10], and Aggarwal and Singh (2015)^[1]^[21], who also observed that adequate nitrogen nutrition significantly improved tiller production in rice.

Plant dry weight (g/hill)

At harvest, maximum higher plant dry weight (116.05 g) was recorded in treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha). Whereas, treatment - 8 (25 cm x 25 cm along with Nitrogen 120 kg/ha) were shown statistically at par with treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha). The results obtained that among Rice in respect the dry matter production was significantly higher under in the order of significance. Kumar *et al.*, (2002)^[9] and Aggarwal and Singh (2015)^[1] reported the similar results. Further results revealed that among Rice in respect of other growth attributes such as dry matter was recorded significantly higher with (25 cm x 25 cm) over rest of planting geometry. This might be due to the availability of more plant for utilize resources such as solar energy, air movement and availability of more nutrients from the larger area. Similar findings related to dry matter were reported Pawar (2017)^[11].

Crop Growth Rate (g/m²/day)

During 100 - at harvest, significant and higher crop growth rate (63.66 g/m²/day) was recorded in treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha). Whereas, treatment - 2 (20 cm x 15 cm along with Nitrogen 120 kg/ha) was shown statistically at par with treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha). The significantly higher CGR under this treatment may be attributed to the combined effect of wider plant spacing and a higher nitrogen dose, which likely enhanced light interception, nutrient availability, and photosynthetic efficiency, resulting in greater dry matter accumulation per unit area during the final growth stage Kumar *et al.*, (2002)^[9]. Adequate nitrogen availability promotes chlorophyll formation, leaf area development, and sustained photosynthetic activity, thereby increasing biomass production. However, Treatment 2 (20 cm x 15 cm spacing + 120 kg Nitrogen /ha) was statistically at par with Treatment 9, indicating that the closer spacing coupled with a moderate nitrogen level was equally effective in maintaining crop growth during the later stages of development. The higher plant population under closer spacing may have compensated for the relatively lower nitrogen dose by contributing to greater collective dry matter production per unit area was reported by Ghuraiya *et al.* (2021)^[5].

Yield attributes

The data pertaining to effective tillers/m² affected by different, Nitrogen and planting geometry are provided in table 2. At harvest, treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha) was recorded significant and maximum effective tillers/m² (177.00) which was superior over all other treatments. However, treatment - 7, (25 cm x 25 cm along with Nitrogen 100 kg/ha) and treatment - 8 (25 cm x 25 cm along with Nitrogen 120 kg/ha) were shown statistically at par with treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha). The significant and higher number of effective tillers/m² attributed to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings than the older seedlings. Singh *et al.* (2018)^[20] reported similar results. Further the results revealed that among Rice in respect of other seed/plant such as plant height was recorded significantly higher with (25 cm x 25 cm) over rest of planting geometry. This might be due to the availability of more plant for utilize resources such as solar energy, air movement and availability of more nutrients from the larger area. Similar findings related to dry matter were reported Singh (2002), Singh *et al.* (2012)^[23] and Rasool *et al.* (2013)^[16].

Number of grains per panicle

At harvest, the significantly highest number of grains per panicle (119.33) was recorded under Treatment 9 (25 cm x 25 cm spacing + 140 kg N ha⁻¹), which was superior to all other treatments. However, it was statistically at par with Treatment 7 (25 cm x 25 cm spacing + 100 kg N ha⁻¹) and Treatment 8 (25 cm x 25 cm spacing + 120 kg N ha⁻¹). The higher number of grains per panicle under wider spacing may be attributed to reduced competition among plants, which improved the availability of light, moisture, nutrients, and growing space, thereby enhancing photosynthetic activity and the translocation of assimilates to developing panicles. In addition, the application of 140 kg N ha⁻¹ promoted vigorous vegetative growth, better panicle development, and increased grain formation. These findings are in agreement with the reports of Rasool *et al.* (2013)^[16], and Vishwakarma *et al.* (2015), who also observed that optimum planting geometry and adequate nitrogen application significantly improved grains per panicle in rice.

Grain yield (t/ha)

At harvest, treatment- 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha) was recorded significantly maximum grain yield (3.87 t/ha) which was superior over all other treatments. Whereas, treatment - 8 (25 cm x 25 cm along with Nitrogen 120 kg/ha) were shown statistically at par with treatment - 9 (25 cm x 25 cm along with Nitrogen 140 kg/ha). The significant and higher grain yield attributed to the fact that the trauma of root damage received during uprooting and transplanting of the seedlings was comparatively less under young seedlings (24 days old) than the older seedlings. Chaudhari *et al.*, (2015)^[3] and Vishwakarma *et al.*, (2015) reported similar results. Further the results revealed that among Rice in respect of other seed yield such as plant height was recorded significantly higher with (25 cm x 25 cm) over rest of planting geometry. This might be due to the availability of more plant for utilize resources such as solar energy, air movement and availability of more nutrients

from the larger area. Similar findings related to dry matter were reported Singh *et al.* (2018) [20].

Table 1: Effect of Planting geometry and Nitrogen on growth attributes of Rice

S. No.	Treatments	Plant height (cm)	Number of tillers/hills	Dry weight (g/hill)	Crop Growth Rate (g/m ² /day)
		At harvest	80 DAS	At harvest	100 DAS - at harvest
1	20cm x 15cm + Nitrogen 100 kg/ha	107.78	13.27	98.96	45.87
2	20cm x 15cm + Nitrogen 120 kg/ha	110.57	12.87	101.34	50.51
3	20cm x 15cm + Nitrogen 140 kg/ha	114.00	12.60	101.22	40.46
4	20cm x 20cm + Nitrogen 100 kg/ha	108.70	14.07	106.49	45.47
5	20cm x 20cm + Nitrogen 120 kg/ha	111.00	13.60	112.92	50.43
6	20cm x 20cm + Nitrogen 140 kg/ha	115.87	16.87	105.46	44.01
7	25cm x 25cm + Nitrogen 100 kg/ha	112.84	17.31	114.96	51.54
8	25cm x 25cm + Nitrogen 120 kg/ha	115.06	16.85	115.21	42.69
9	25cm x 25cm + Nitrogen 140 kg/ha	116.51	18.00	116.05	63.66
F-test		S	S	S	S
SEm(+)		0.69	0.85	2.72	5.70
CD (P= 0.05)		2.06	2.56	8.16	17.08

Table 2: Effect of Planting geometry and Nitrogen on yield attributes of Rice

S. No.	Treatments	Yield attributes		
		Effective tillers/m ²	No. of Grains /Panicles	Seed yield (t/ha)
1	20cm x 15cm + Nitrogen 100 kg/ha	164.23	107.00	3.35
2	20cm x 15cm + Nitrogen 120 kg/ha	167.00	109.00	3.42
3	20cm x 15cm + Nitrogen 140 kg/ha	159.00	108.67	3.43
4	20cm x 20cm + Nitrogen 100 kg/ha	162.33	114.33	3.34
5	20cm x 20cm + Nitrogen 120 kg/ha	161.00	112.67	3.35
6	20cm x 20cm + Nitrogen 140 kg/ha	171.00	113.33	3.67
7	25cm x 25cm + Nitrogen 100 kg/ha	173.33	118.33	3.63
8	25cm x 25cm + Nitrogen 120 kg/ha	175.00	117.67	3.73
9	25cm x 25cm + Nitrogen 140 kg/ha	177.00	119.33	3.87
F-test		S	S	S
SEm(+)		1.64	1.29	0.14
CD (P= 0.05)		4.92	3.86	0.44

Conclusion

It is concluded that application of 25 cm x 25 cm planting geometry along with Nitrogen 140 kg/ha in (T₉) was recorded highest growth attributes and grain yield in Rice crop.

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