

Original Research Article

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## Influence of Planting Geometry and Nitrogen Levels on Growth and Yield of Rice (*Oryza sativa* L.) under Eastern Uttar Pradesh Condition

Pradeep Rajput<sup>1\*</sup>, A. K. Singh<sup>1</sup>, Ravindra Kumar Rajput<sup>2</sup> and Prithvi Raj<sup>1</sup>

<sup>1</sup>Department of Agronomy, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, U.P., India

<sup>2</sup>Department of Soil Science & Agricultural Chemistry, Matter specialist (soil science), KVK Mathura, U.P., India, India

\*Corresponding author

### ABSTRACT

Field experiment was conducted during *kharif*-2017 at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad, Uttar Pradesh, to study the effect of planting geometry and nitrogen levels on growth of rice (*Oryza sativa* L.). In this experiment, 4 planting geometry (15x10cm, 15x15cm, 20x10cm and 20x15cm) and 4 Nitrogen levels (0, 60, 120 and 180 kg ha<sup>-1</sup>) were tested in SPD with 3 replications. The crop received a total rainfall of 804.9mm while the evaporation was 126.1 mm during the entire crop season. The results showed that the plant height, number of tillers m<sup>-2</sup>, leaf-area index and dry matter accumulation m<sup>-2</sup>, being at par with 20x15 cm spacing were significantly higher under 20x10 cm than rest of the planting geometry. Nitrogen is also responsible for more leaf area and dry matter production due to higher rate of cell division and cell elongation. The application of nitrogen @ 120 kg N ha<sup>-1</sup>, being at par with 180 kg N ha<sup>-1</sup> significantly improved the plant height, number of tillers m<sup>-2</sup>, leaf area index and dry matter accumulation m<sup>-2</sup> than rest of the Nitrogen levels. The highest grain and biological yields were also noticed at 20x10 cm spacing and 180 kg N ha<sup>-1</sup>.

#### Keywords

Planting geometry, Growth, Yield, Nitrogen levels, Rice, Dry matter, Flowering and Harvest Index.

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### Introduction

Rice (*Oryza sativa* L.) is a most important cereal crop, grown under semi-aquatic condition and mostly under submergence or variable ponding conditions. It is a most important staple food of about more than 60% of total world population. Rice is a nutritious

cereal crop, mainly used for human consumption. It is the main source of energy and is an important source of protein providing substantial amounts of the recommended nutrients intake of zinc and niacin. Planting geometry of a crop affects the interception of solar radiation, crop canopy coverage, dry matter accumulation and crop

growth rate (Anwar *et al.*, 2011). The closer planting geometry causes competition among plants for light, water and nutrients which consequently slowed down the crop growth. Optimum planting geometry ensures the proper growth of aerial as well as underground plant parts by efficient utilization of solar radiation, nutrients and water (Miah *et al.*, 1990). Nitrogen is also responsible for more leaf area and dry matter production due to higher rate of cell division and cell elongation. Inadequate nitrogen application adversely affects the grain production while excess nitrogen may lead to relatively higher crop growth. The height of a rice plant is positively correlated to the length of the maturation cycle. A taller plant is more susceptible to lodging and responds less to nitrogen application (Tanaka *et al.*, 1966).

Increasing the nitrogen application level could significantly increase the rice production within limits. The highest nitrogen uptake is observed at the tillering stage followed by the young panicle developmental stage. Both planting geometry and nitrogen levels are major causes of growth reduction in rice, which also affect its dry matter and tillers production and ultimately the yield. Salahuddin *et al.*, (2009) the lowest number of grains/panicle was given by 0 kg N/ha irrespective of plant spacing. Grain yield/ha increased with increasing level of nitrogen up to 150 kg/ha irrespective of plant spacing. Keeping above points in mind the present investigation was conducted in rice.

## **Materials and Methods**

The experiment was conducted during *kharif*-2017 at Agronomy Research Farm of NDU A&T, Kumarganj (26.47° N latitudes, 82.12° E longitudes and 113 meters above mean sea level), Faizabad, U.P. (India). The field was well drained, leveled and having good soil conditions. The soil of the experimental field

was silt loam in texture with pH of 8.10, low in organic carbon (0.43 %) and available nitrogen (160 kg ha<sup>-1</sup>), medium in phosphorus (16.5 kg ha<sup>-1</sup>) and potassium (260 kg ha<sup>-1</sup>). Four planting geometry viz., 15x10, 15x15, 20x10 and 20x15cm<sup>2</sup> and 4 Nitrogen levels (0, 60, 120 and 180 kg ha<sup>-1</sup>) were tested in a split-plot design, keeping as main and sub-plots, respectively with 3 replication. The gross and net plot size was 6.0m×3.0m and 4.8m×2.40m, respectively.

During the crop season weekly mean minimum and maximum temperature ranged from 16.7 to 28.7°C and 29.9 to 37.8°C, respectively. The total rainfall and evaporation during the entire crop season was 804.9 and 126.1 mm, respectively. However, the diurnal variation among relative humidity and evaporation rate was 43.5 to 86.1 per cent and 4.3 to 7.2mm, respectively.

The standard procedure was followed in rising of the seedlings in the nursery. Healthy and bold seeds of rice variety NDR-359 were used @ 40 kg ha<sup>-1</sup> for nursery rising in puddled soil. Transplanting was done as per treatment with 25 days old plants and 2seedlings/hill was used for transplanting. Phosphorus and potassium was applied @ 60 and 40 kg ha<sup>-1</sup> through SSP (16% P<sub>2</sub>O<sub>5</sub>) and Muriate of potash (60% K<sub>2</sub>O) as basal, at the time of pudding/leveling of the field, respectively. The nitrogen was applied through urea (46% N), as per treatment. Zinc sulphate (21% Zn) was also applied @ 25 kg ha<sup>-1</sup> as micro-nutrient in the rice field at the time of pudding.

The half dose of nitrogen was applied before transplanting of seedlings, plot wise and the rest amount of nitrogen was top-dressed in two equal splits first at 30DAT (tillering stage) and second at 55 DAT (panicle initiation stage). During the year of experimentation, there were occurrence of

sufficient rains during vegetative stage, however, there was occasional moisture stress during reproductive phase, hence 3 irrigations were given at different stages *viz.*, flowering, milking and grain filling stage of crop growth. Data were subjected to analysis of variance (ANOVA) using Online Statistical Analysis Package (OPSTAT, Computer Section) at 5% level of significance (P=0.05).

## Results and Discussion

### Growth attributes

The maximum plant height (106.0cm) was observed with wider spacing of 20 cm x 10 cm (S<sub>3</sub>) followed by S<sub>4</sub> i.e. 20 cm x 15 cm (102.2cm), although there was no significant difference between them. However, the shortest plants (93.5cm) were recorded by S<sub>1</sub> planting geometry. The tallest plants were noticed with wider planting geometry (S<sub>3</sub>) as compared to closer spacing (S<sub>2</sub> and S<sub>1</sub>) because of creation of an optimum condition for light interception, water and nutrient

consumption that leads to lesser competition among plants. Similar results were also found by Devi and Sumathi (2011) and Bhowmik *et al.*, (2012). It is evident from the results that plant height increased with the increasing level of N from 0 to 180kg ha<sup>-1</sup>, irrespective of planting geometry. Regarding the nitrogen levels, the maximum plant height (112.7cm) was recorded with highest level of nitrogen (180 kg ha<sup>-1</sup>), though statistically at par with N<sub>2</sub> (109.9cm), receiving 120 kg nitrogen ha<sup>-1</sup> and highly significant to N<sub>1</sub> (94.5cm) and N<sub>0</sub> (79.0cm), receiving 60 kg nitrogen ha<sup>-1</sup> and 0 kg nitrogen ha<sup>-1</sup> respectively.

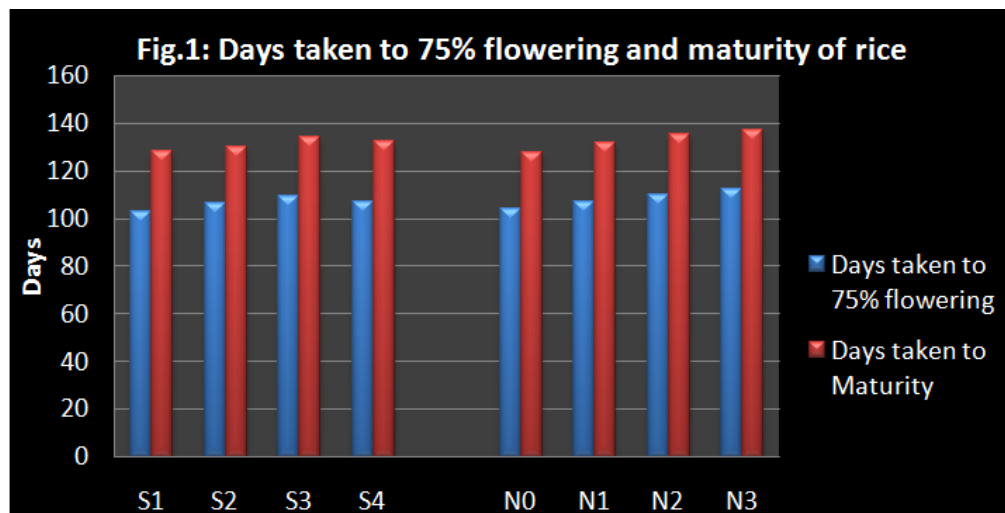
The increased plant height with increasing nitrogen levels might be attributed to the role of nitrogen which encourage and improve plant growth and accelerate cell division which was reflected in the increased plant height (Mohadesi *et al.*, 2011). Singh and Sharma (1987) also reported that application of 180 kg N ha<sup>-1</sup> resulted in higher plant height of rice.

**Table.1** Effect of planting geometry and nitrogen levels on growth attributes of rice

Treatments	Plant height (cm) (At harvest)	Tillers (m <sup>-2</sup> ) (At harvest)	LAI (At 90 DAT)	DMA (g m <sup>-2</sup> ) (At harvest)
<b>Planting geometry (cm)</b>				
15x10	93.5	291.4	3.5	1099
15x15	95.4	297.6	3.7	1177
20x10	106.0	331.7	4.2	1298
20 x15	102.2	319.3	3.9	1236
CD at 5%	8.7	26.9	0.4	111
<b>Nitrogen levels (kg ha<sup>-1</sup>)</b>				
0	79.0	248.0	3.1	893
60	94.5	294.5	3.8	1145
120	109.9	344.1	4.2	1235
180	112.7	356.4	4.3	1337
CD at 5%	5.7	18.0	0.2	70

**Table.2** Effect of planting geometry and nitrogen levels on yields of rice

Treatments	Grain yield (qha <sup>-1</sup> )	Straw yield (qha <sup>-1</sup> )	Harvest index (%)
<b>Planting geometry (cm)</b>			
15x10	46.2	63.7	41.4
15x15	48.9	68.7	41.3
20x10	54.0	75.7	41.8
20 x15	51.7	71.9	41.6
CD at 5%	4.4	6.1	NS
<b>Nitrogen levels (kg ha<sup>-1</sup>)</b>			
0	35.1	54.1	39.3
60	45.2	69.2	39.5
120	51.7	71.8	41.8
180	56.7	76.9	42.4
CD at 5%	3.1	4.3	NS



**Fig.1** Days taken to 75% flowering and maturity of rice

Wider planting geometry (S<sub>3</sub>) resulted into maximum tillers m<sup>-2</sup> (331.7) which was at par with S<sub>4</sub> (319.3 m<sup>-2</sup>) and significantly more than the other planting geometry. Among the nitrogen levels, maximum tillers m<sup>-2</sup> (356.4) were recorded under N<sub>3</sub> being at par with 120 kg/ha (N<sub>2</sub>) (344.1) and significantly higher over rest of the treatments. Similar results were also observed by Gupta *et al.*, (2014) and Mahato and Adhikari (2017) in rice.

Leaf area and dry matter accumulation also influenced by different planting geometry and

nitrogen levels at 90 DAT and harvesting, respectively. Wider planting geometry (20cm x 10cm) resulted into maximum values of both leaf area index and dry matter accumulation which was at par with (20cm x 15cm) and highly significant with the other planting geometry. This treatment (S<sub>3</sub>) had 18.1 and 10.2 % more dry matter accumulation over S<sub>1</sub> and S<sub>2</sub>, respectively.

The maximum leaf area and dry matter accumulation was recorded with 180 (N<sub>3</sub>) being at par with 120 kg<sup>-1</sup> (N<sub>2</sub>) and

significantly higher over rest of the treatments. This might be due to the role of nitrogen in cell division and elongation that improves the plant height and photosynthetic area which led to higher LAI and DMA in these treatments. Similar results were also observed by Wang Hai Qin (2007) and Yadav *et al.* (2016).

### **Days taken to 75% flowering and maturity of rice**

Various planting geometry had significant effect on days taken to 75% flowering. The highest days (109.5) were taken to attain 75% flowering under  $S_3$  and lowest days (103.2) were taken under 15cm x10cm ( $S_1$ ) spacing. Various nitrogen levels had significant effect on days to 75% flowering.

The maximum days (112.5) were taken to 75% flowering under 180 kg N ha<sup>-1</sup> ( $N_3$ ) and minimum days (104.5) were taken under 0 kg N ha<sup>-1</sup> (control). The crop took highest days (134.5) to attain maturity under wider spacing ( $S_3$ ) and lowest days (128.5) were taken under  $S_1$  treatment. Among nitrogen levels the maximum days (137.4) were taken to attain maturity with 180 kg N ha<sup>-1</sup> ( $N_3$ ) and minimum days (128.1) under 0 kg N ha<sup>-1</sup> ( $N_0$ ).

### **Grain yield**

A spacing of 20 cm x 10 cm produced higher grain yield (54.0qha<sup>-1</sup>) as compared to wider spacing 20 cm x 15 cm (51.7qha<sup>-1</sup>). However, very close spacing  $S_1$  (15 cm x 10 cm) was undesirable for obtaining higher yield due to more competition and less availability of resources. Although, the pace of increment was 14.4 and 4.2 %, respectively.

Further Wells and Faw (1978) reported that close spacing decrease the light interception and CO<sub>2</sub> assimilation which in turn limit the

rice yield. Namba (2003) reported that the increase in grain yield with optimum plant spacing might be attributed to increased number of tillers per unit area and filled grains per panicle after which plant growth slows down if it exceed the optimum level.

Each successive application of 60 kg nitrogen in rice resulted into significant improvement in grain yield upto 180 kg Nha-1. Though, the highest grain yield (56.7 qha<sup>-1</sup>) was obtained with 180 kg N ha<sup>-1</sup>( $N_3$ ) which was statistically superior over  $N_2$  (51.7 qha<sup>-1</sup>),  $N_1$  (45.2qha<sup>-1</sup>) and  $N_0$  (35.1 qha<sup>-1</sup>). This treatment out fielded control,  $N_1$  and  $N_2$  by 21.6, 11.5 and 5.0 qha<sup>-1</sup>, respectively. It was due to better nutrient uptake leading to higher dry matter production and its translocation towards sink leading to increased percentage of filled grains and number of tillers m<sup>-2</sup> (Mandal *et al.*, 1986).

### **Straw yield**

A spacing of 20 cm x 10cm ( $S_3$ ) recorded highest straw yield (75.7qha<sup>-1</sup>) as compared to closer spacing ( $S_1$ ) (63.07qha<sup>-1</sup>) and wider spacing ( $S_4$ ) (71.9qha<sup>-1</sup>) which might be due to reduce plant height and lesser plant population respectively. Similar observation was reported by Mahato *et al.*, (2006). Maximum straw yield (76.9 qha<sup>-1</sup>) was recorded with 180 kg ha<sup>-1</sup> nitrogen ( $N_3$ ) but was statistically at par with ( $N_2$ ) (71.8 qha<sup>-1</sup>) followed by ( $N_1$ ) (69.2qha<sup>-1</sup>) and ( $N_0$ ) (54.1qha<sup>-1</sup>). This might be due to vigorous growth with increase in N level resulted in higher straw yield (Chopra and Chopra, 2004). Planting density greatly influenced the straw yield. However, the interaction effects were not significant. The increase in yield of rice due to N fertilization was attributed directly by the significant improvement of all the yield attributing traits viz. tiller m<sup>-2</sup>, filled grains panicle<sup>-1</sup> and test weight (Banerjee and Pal, 2011).

## Harvest index

The harvest index was not significantly influenced either by the spacing or by nitrogen application, though it was varied from 41.3-41.8 and 39.3- 42.4%, respectively.

Therefore, it can be concluded that treatment combination of 180 kg nitrogen ha<sup>-1</sup> along with planting geometry of 20 cm x 10 cm could be recommended for cultivation of Transplanted rice in eastern Uttar Pradesh.

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