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Effect of different planting density and nitrogen levels on growth characters and yield of rice (*Oryza sativa*) grown under eastern Uttar Pradesh

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Abstract
The experimental result revealed that different planting geometry and level of nitrogen had a remarkable influence on almost all the growth characters and yield of rice. Growth characters, *viz*. plant height, number of tillers/m^2, Leaf area index, dry matter accumulation/m^2 were increased significantly with the increasing level of nitrogen from 0 to 180 kg/ha in both of year. On the other hand, plant spacing (20cm x 10cm) and produced significantly higher grain yield (3.95 t/ha in 2017 and 4.65 t/ha in 2018). The highest grain and straw yields were recorded with the treatment of 20 cm × 10 cm plant spacing and 180 kg N/ha in 2017 and 2018 respectively.

Keywords: Nitrogen, planting geometry, rice, growth and yield

Introduction
Rice (*Oryza sativa* L.) is the foremost staple food for more than 60% of the world's population providing major source of the food energy. It is grown in 114 countries across the world on an area about 160 million hectares with annual production of 494.3 million tones, and total supply of 711.5 million tones. Globally, total rice consumption was recorded 491.5 million metric tonnes in 2014-15 (Anonymous, 2015-16). More than 90% of the world's rice is produced and consumed in Asia. It is the important crop in the country's food security accounting about 44% of the total food grain production and holds about 20% share in national agricultural GDP and provides 43% calorie requirement for more than 70% of Indians. In India rice covers highest area by a single crop and it is also maximum area among all rice growing countries. It is an important crop in India which occupied 43.9 million hectares with the annual production of 103.6 million tonnes (Ministry of Agriculture, Directorate of Economics and Statistics, 2015). It is estimated that by the year 2025, the world's farmers should produce about 60% more rice than at present to meet the food demands of the expected world population at that time and by 2035, 114 million tones additional milled rice need to produce (Kumar and Ladha, 2011) [2].
Agronomic management practices such as spacing and nitrogen application are two major factors influencing the growth and yield of rice. Optimum dose of nitrogen fertilization plays a vital role in growth and development and grain formation as a result of higher yield of rice plant. Excessive nitrogen fertilization encourages excessive vegetative growth which makes the plant susceptible to insect, pest and diseases, which ultimately reduces yield whereas less than optimum rate affects both yield and quality of rice to remarkable extent. So, it is essential to find out the optimum rate of nitrogen application for its efficient utilization by the plants for better yield. Optimum plant spacing ensures plants to grow properly both in their aerial and underground parts through utilization of solar radiation and nutrients, therefore proper manipulation of planting density may lead to increase in the economic yield of transplanted rice (Sampath *et al*., 2017) [7]. Planting geometry determines the planting density or plant population in unit area thereby influencing the input use efficiency and yield of the crop. Plant spacing is a major non monetary input which plays a significant role in achieving greater nutrient use efficiency with higher growth and yield of the crop. Salahuddin *et al*. (2009) [6] reported that the lowest number of grains/panicle was produced under control (0 kg N/ha) irrespective of the plant spacing. Though, grain yield /ha increased with increasing level of nitrogen up to 180 kg/ha, irrespective of plant spacing. Keeping above points in mind the present investigation was carried out to assess the effect of nitrogen in transplanted rice under varying plant spacing in a sandy loam soil.

Materials and Methods

The field experiment was conducted during Kharif 2017 and Kharif 2018 at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.). The experimental site is located at Kumarganj which is situated 40 km away from Ayodhya city on Ayodhya Raibarely road. Geographically the experimental site is situated at 264.47̍North latitude and 815.12̍East longitude with is an altitude of 114 m. from mean sea level in the Indo Gangatic Plain Zone of Eastern Uttar Pradesh. The climate in this region is sub humid. The soil is sandy loam with a pH of 8.2. It was low in organic carbon (0.43%) and available nitrogen (166 kg/ha), medium in available phosphorus (17.5 kg/ha) and available potassium (265 kg/ha). Four planting geometry *viz*., 15cm×10cm, 15cm×15cm, 20cm×10cm and 20cm×15cm and 4 Nitrogen levels (0, 60, 120 and 180 kg/ha) were tested in a split-plot design, keeping as main and sub-plots, respectively with 3 replications. The Ayodhya district falls under sub humid climate, receiving a mean annual rainfall of about 1063 mm, out of which about 90 percent of the total rainfall is received during south-west monsoon period (June to September) with few showers (4%) in winter season. Rainfall during monsoon season mostly occurred between July to September while mid-September onwards, there was very low intensity of rain or almost no rain for certain period which coincides with the flowering stage of rice. The meteorological observation like maximum and minimum temperature, relative humidity and rainfall and sunshine hours during the crop season was recorded at the meteorology observatory of the university situated in the main campus of Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya.

Result and Discussion

Plant spacing had significant effect on plant height, number of tillers/m^2, Leaf area index, dry matter accumulation/m^2 (Table 1). Significantly longest plant height (105.3 cm in 2017) and (106.8 cm in 2018), highest number of tillers/m^2 (411.4 in 2017 and 419.8 in 2018), Highest leaf area index (4.26 in 2017 and 434 in 2018) and maximum dry matter accumulation/m^2 (1099.8 g/m^2 in 2017 and 1049.3 g/m^2 in 2018) were observed with 20 cm x 10 cm spacing (S3) as compared to rest of the treatments. However it was found statistically at par with S4 followed by S2. This might be due to the fact that higher plant population/unit area can be achieved at closer spacing. The improvement in all growth characters was might be due to the fact that supply of more food materials, moisture and light for the plant under optimum/wider spacing which ultimately resulted in better environment for growth and development of the crop (Uddin *et al*., 2011) [9]. Further, plant height, number of tillers/m^2, Leaf area index, dry matter accumulation/m^{2}also significantly increased with the increase of nitrogen rate up to 180 kg N /ha, being highest in N4 which was statistically at par with N3. Similar results were reported by Padmaya and Reddy, 1998 Nayak *et al*., 2003 [5, 3].

Table 1: Effect of planting geometry and nitrogen levels on growth characters of rice

Treatments	Plant height (cm)		Number of tillers/m^2		Leaf area index		Dry matter accumulation/m2	
	2017	2018	2017	2018	2017	2018	2017	2018
Planting Density								
15cmx10cm	94.5	93.8	240.1	245.1	3.53	3.59	850.8	885.2
15cmx15cm	101.4	103.1	320.1	326.5	4.02	4.01	966.3	1001.2
20cmx10cm	105.3	106.8	411.4	419.8	4.26	4.34	1099.8	1049.3
20cmx15cm	94.5	96.0	292.2	298.7	3.81	3.89	949.5	900.4
S.Em+	2.49	2.60	8.64	8.81	0.09	0.10	29.2	30.4
CD (P=0.05)	8.61	8.99	29.91	30.51	0.34	0.34	101.3	105.2
Nitrogen levels (kg/ha)								
0	78.7	79.8	269.6	275.0	3.12	3.18	683.3	713.5
60	93.5	94.8	322.6	328.5	3.82	3.90	998.0	937.2
120	109.2	110.8	331.0	339.2	4.30	4.38	1040.1	1094.6
180	112.2	113.8	336.1	343.2	4.37	4.46	1104.3	1110.9
S.Em+	2.03	2.04	4.18	5.30	0.08	0.08	25.7	26.7
CD (P=0.05)	5.92	5.95	12.20	15.47	0.23	0.23	75.2	78.1

The highest grain yield of 39.5 q/ha and 46.5 q/ha was recorded during 2017 and 2018 year respectively with planting geometry of 20×10cm spacing which was at par with 15×15cm spacing while significant over rest both of the treatments. Planting geometry of 20×10cm spacing increased the grain yield by 5.6%, 10.4% and 6.3% & 2.2%, 21.7% and 15.1% over 15×15cm, 15×10cm and 20×15cm respectively during 2017 and 2018 year of investigation of rice. Application of N with 180 kg/ha recorded higher grain yield which was at par with 120 kg N/ha while significant over rest both of the N level of rice. The highest straw yield of 67 and 69.6 q/ha was recorded during 2017 and 2018 respectively with planting geometry of 20×10cm spacing which was at par with 15×15cm spacing while significant over 15×10cm and 20×15cm spacing as compared to other treatments under study. An examination of data revealed that the application of different level of nitrogen had significant effect on straw yield during both the years. Application of 180 kg/N ha recorded higher straw yield which was at par with 120 kg N /ha while significant over rest both of the nitrogen levels of present study. Higher harvest index was found significantly with 20x10 cm planting geometry as compared to 15x10 cm spacing during both the years of investigation. Increase in N availability increased the harvest index of transplanted rice during both the years of investigation. Higher harvest index with the value of 42.6% and 42.7% were recorded during 2017 and 2018 respectively under 180 kg N/ha which was at par with 120 kg N/ha while significant over rest i.e., control and 60 kg N/ha during both the years of investigation. Similar observations were reported by Shivay and Singh (2003) [8] and Mahato *et al.* (2006). The vigorous growth under heavily N fertilization in rice crop which intern resulted into higher straw yield (Chopra and Chopra, 2004) [1].

Table 2: Influence of planting geometry and nitrogen levels on Grain (q/ha), Straw yield (q/ha) and Harvest index of transplanted rice

Treatments	Grain Yield(q/ha)		Straw Yield(q/ha)		Harvest Index (%)	
	2017	2018	2017	2018	2017	2018
Planting Geometry						
15cmx10cm	35.4	36.4	53.6	57.1	41.2	39.8
15cmx15cm	37.3	45.5	65.6	68.4	41.7	41.5
20cmx10cm	39. 5	46.5	67.0	69.6	41.9	41.8
20cmx15cm	37.0	39.5	55.2	66.5	41.7	41.0
S.Em+	1.2	1.2	1.7	1.7	0.1	0.1
CD (P=0.05)	4.2	4.4	5.9	6.1	0.4	0.4
Nitrogen levels kg/ha						
0	30.9	32.2	47.4	49.1	39.4	39.5
60	40.8	41.5	57.9	60.2	41.9	40.9
120	44.3	44.7	62.7	65.7	42.5	42.6
180	45.0	45.5	63.4	66.5	42.6	42.7
S.Em+	1.09	1.1	1.47	1.52	0.1	0.20
CD (P=0.05)	3.1	3.3	4.29	4.4	0.3	0.58

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