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To study the influence of planting geometry and nitrogen level on quality attributes nitrogen uptake and economics of rice (*Oryza sativa* L.) under upper gangetic plains region of India

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Abstract
A field experiment was conducted for two years during kharif season of 2017 and 2018 at Agronomy research Farm, N.D. University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) on sandy loam soil with a pH of 8.1 to study the Influence of planting geometry and nitrogen levels on rice (*Oryza sativa* L.)". The experiment was laid out in split plot design (SPD) with three replications Sixteen treatment combinations; comprised of four planting geometry, viz. (S_1) 15x10 cm, 15x15 (S_2),20x10 (S_3) and 20x15 (S_4) were kept in main plot and four nitrogen level, viz. 0kg/ha (N_0), 60kg/ha (N_1), 120kg/ha (N_2) and 180kg/ha (N_3) were kept in sub plot. Protein content of rice grain was not significantly affected due to planting geometry and N level during both the years of investigation, whereas plant spacing of 20×10cm recorded higher nitrogen uptake in grain which was at par with 15×15cm spacing while significant over rest both of the planting geometry. Cost of cultivation was recorded highest (Rs. 35435/ha) under S_1N_3 under planting geometry of 15×10cm spacing applied with 180kg N/ha followed by (Rs.35045/ha), while application of 120kg nitrogen/ha given in 20×10cm spacing recorded highest gross return Rs.102140/ha followed by Rs. 101845/ha in 15×15cm spacing applied with 180kg N/ha due to higher yield.

Keywords: Planting geometry, nitrogen level, *Oryza sativa* L.

Introduction
Rice (*Oryza sativa* L.) is the primary staple food of India as well as world. More than 60% of the world's population providing major source of the food energy. Globally, total rice consumption was recorded 491.5 million metric tonnes in 2014-15 (Anonymous, 2015-16) [1]. 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.

It is grown in 114 countries across the world on an area about 160 million hectares with annual production of 494.3 million tonnes, and total supply of 711.5 million tonnes (Anonymous, 2015-16) [1]. Plant spacing is also an important factor that needs to be considered during transplanting of rice. Rice plants compete among themselves for space, nutrients, water, sunlight, air. Proper spacing may help to increase maximum leaf Area Index (LAI), light interceptions etc. which are required for better photosynthesis as well as yield of rice.

Nitrogen plays a key role in rice production and it is required in large amount. It is one of the most important limiting nutrient in rice production and has heavy system losses when applied as inorganic sources in puddled field. Nitrogen has a positive influence on the production of effective tillers per plant, yield and yield attributes. It is necessary to find out the suitable dose of nitrogen for efficient management and better yield of rice. A suitable planting geometry and dose of nitrogen is necessary for better yield.

Material 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.). Geographically the experimental site is situated at $26^0.47'$ North latitude and $81^0.12'$ East longitude with is an altitude of 113 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 sandyloam with a pH of 8.1. Sixteen treatment combinations; comprised of four planting geometry, viz. (S_1) 15x10 cm, 15x15 (S_2),20x10 (S_3) and 20x15 (S_4) were kept

in main plot andfour nitrogen level, viz. 0kg/ha (N_0), 60kg/ha (N_1), 120kg/ha (N_2) and 180kg/ha (N_3) were kept in sub plot. The experiment was conducted in split plot design (SPD) and replicated three times.

Results and Discussion

Under quality attributes protein content presented in Table-1 of rice grain was not significantly affected due to planting geometry and N level during both the years of investigation.

Data pertaining to nitrogen uptake in grain as affected by planting geometry and nitrogen levels have been presented in Table-3. Various planting geometry brought significant influence on nitrogen uptake in grain during both the years of investigation. Plant spacing of 20×10cm recorded higher nitrogen uptake in grain which was at par with 15×15cm spacing while significant over rest both of the planting geometry. The higher nitrogen uptake was attributed due to the higher grain yield of rice in said treatments.

Different nitrogen level had significant influence on the nitrogen uptake in grain during both the years of investigation. It is evident from the data that increase in N level increased the N uptake in grain. Higher N uptake in grain was recorded under nitrogen application of 180kg /ha which was at par with 120kg N/ha while significantly superior over rest both of the nitrogen level. This was mainly due to increase of nitrogen content in grain and their respective yields with increasing levels of nitrogen.

Nitrogen uptake (kg/ha) in straw as affected by planting geometry and nitrogen levels have been presented in Table- 3 Various planting geometry brought significant influence on nitrogen uptake in straw during both the years of investigation. Plant spacing of 20×10cm recorded higher nitrogen uptake in straw which was at par with 15×15cm spacing while significant over rest both of the planting geometry might be due to higher nitrogen contented straw yield in respective treatments.

Different nitrogen level had significant influence on the nitrogen uptake in straw during both the years of investigation. Increase in N level increased the N uptake in straw. Higher N uptake in straw was recorded under nitrogen application of 180kg /ha which was at par with 120kg N/ha while, significantly superior over rest both of the nitrogen level. Higher N uptake in higher dose of nitrogen application might be due to higher straw yield and their N content.

Total N uptake(kg/ha) as affected by planting geometry and nitrogen levels have been presented in Table-3 Various planting geometry brought significant influence on total N uptake during both the years of investigation. Plant spacing of 20×10cm recorded higher value of total nitrogen uptake which was at par with 15×15cm spacing mainly due to higher grain and straw yield and their content in said treatments of wider spacing.

Different nitrogen level had significant influence on the total nitrogen uptake during both the years of investigation. Increase in N level increased the total N uptake. Higher total N uptake was recorded under nitrogen application of 180kg/ha which was at par with 120kg N/ha while, significantly superior over rest both of the nitrogen level due to higher yield of both (grain and strain) and N content under wider spacing.

Interaction between S×N on grain yield of rice and straw were found significant during both the years of investigation Increase in N level increased successively the yield of rice of all the planting geometry. Over all highest yield was recorded in S_3 N_3 which was at par with S_3N_2, S_2N_3, S_4N_3 and S_2N_2 while significant over rest of the treatment combination. Higher yield under said treatment might be due to better translocation of photosynthates from source to sink under wider spacing supplied with adequate availability of nitrogen which led to increased mobilization of nutrients and hence resulted in higher yield in said treatment combinations.

Cost of cultivation was recorded highest (Rs. 35435/ha) under S_1N_3 under planting geometry of 15×10cm spacing applied with 180kg N/ha followed by(Rs.35045/ha) S_3N_3 i.e., plant spacing of 20×10cm spacing under same N level due to higher plants/m^2 and N level. The lowest cost of cultivation Rs. 30,665/ha was recorded in S_4N_0 (i.e. 20x15 cm spacing grown without the use of nitrogen) mainly due to lowest plant population grown without the use of N.

Application of 120kg nitrogen/ha given in 20×10cm spacing recorded highest gross return Rs.102140/ha followed by Rs. 101845/ha in 15×15cm spacing applied with 180kg N/ha due to higher yield. The lowest gross return Rs. 57,900/ha was recorded under 15x10 cm spacing grown without the use of nitrogen application (S_1N_0)Shekara *et al*, 2011 and Gupta *et al*, 2014 [2] also reported similar results.

Application of 120kg nitrogen/ha applied in 20×10cm spacing recorded highest net return Rs.68415/ha followed by Rs. 66950/ha in 15×15cm spacing applied with 180kg N/ha due to higher gross return relative to cost of cultivation. Like gross return; the lowest net return Rs. 26,425/ha was recorded in S_1N_0. Murthy *et al*, 2015 [4] and Shukla *et al*, 2015 [3] also reported similar results.

Application of 120kg nitrogen/ha applied in 20×10cm spacing recorded highest net return per rupee invested 2.02 followed by 1.91 in 15×15cm spacing fertilized with 180kg N/ha due to higher Net return in comparison to cost of cultivation. The lowest net return per rupee invested 0.83 was recorded in 15x10 cm spacing grown without the use of nitrogen (S_1N_0). (Shekara *et al*, 2011 and Murthy *et al*, 2015) [4]

Conclusion

The data collected were subjected to statistical analysis to draw valid conclusion. Application of 120kg N/ha applied in 20cm×10cm planting geometry recorded highest gross return Rs. 102140/ha, net return Rs. 68415/ha and highest net return/rupees invested 2.02.

Table 1: Crude protein content in grain of transplanted rice at affected by planting geometry.

Treatments	Protein in grain	
	2017	2018
Planting Geometry		
15cmx10cm	7.53	7.61
15cmx15cm	7.19	7.27
20cmx10cm	7.48	7.58
20cmx15cm	7.55	7.64
SEM±	0.11	0.11
CD (P=0.05)	0.38	0.39
Nitrogen levelskgha^{-1}		
0	6.83	6.89
60	7.39	7.47
120	7.70	7.78
180	7.83	7.95
SEM±	0.06	0.07
CD (P=0.05)	0.20	0.20

Table 2: Interaction effect of planting geometry and nitrogen levels on straw yield in 2017

Nitrogen levels (kg ha^{-1})	Plant Geometry			
	15cmx10cm	**15cmx15cm**	**20cmx10cm**	**20cmx15cm**
0	43.0	48.7	50.8	48.0
60	54.0	57.4	64.6	55.8
120	70.5	74.4	82.1	72.7
180	73.8	81.7	84.8	80.1
	SEm±		CD (P=0.05)	
S at N	2.94		8.5	
N at S	3.07		9.50	

Table 3: Interaction effect of planting geometry and nitrogen levels on straw yield in 2018

Nitrogen levels (kg ha^{-1})	Plant Geometry			
	S_1	S_2	S_3	S_4
N_0	44.7	50.8	52.6	48.3
N_1	56.3	59.9	66.9	57.5
N_2	69.3	72.1	75.7	70.3
N_3	69.1	74.0	78.3	69.2
	SEm±		CD (P=0.05)	
S at N	3.05		8.92	
N at S	3.19		9.86	

Table 4: Interaction effect of planting geometry and nitrogen levels on nitrogen Uptake in grain in 2017

Nitrogen levels (kg ha^{-1})	Plant Geometry			
	S_1	S_2	S_3	S_4
N_0	35.9	39.7	41.9	37.2
N_1	61.8	64.8	82.3	63.6
N_2	70.2	81.38	96.0	79.2
N_3	75.8	90.8	100.5	82.2
	SEm±		CD (P=0.05)	
S at N	3.78		11.05	
N at S	3.99		12.36	

Table 5: Interaction effect of planting geometry and nitrogen levels on grain yield (q/ha)

Nitrogen levels (kg/ha)	2017			
	Planting Geometry			
	15cmx10cm	**15cmx15cm**	**20cmx10cm**	**20cmx15cm**
0	28.3	31.6	33.0	31.0
60	40.0	41.2	46.2	40.3
120	44.2	46.4	50.5	46.2
180	45.6	50.0	53.2	48.9
	SEm±		CD (P=0.05)	
N at S	2.17		6.36	
S at N	2.25		6.94	
Nitrogen levels (kg/ha)	**2018**			
	Planting Geometry			
	15cmx10cm	**15cmx15cm**	**20cmx10cm**	**20cmx15cm**
0	29.5	33.9	34.3	33.1
60	40.3	45.8	49.0	42.0
120	46.0	49.0	51.1	46.2
180	48.2	51.5	52.0	49.7
	SEm±		CD (P=0.05)	
N at S	2.26		6.61	
S at N	2.34		7.22	

Table 6: Interaction effect of planting geometry and nitrogen levels on straw yield (q/ha)

Nitrogen levels (kg /ha)	2017			
	Planting Geometry			
	15cmx10cm	**15cmx15cm**	**20cmx10cm**	**20cmx15cm**
0	43.0	48.7	50.8	48.0
60	54.0	57.4	64.6	55.8
120	70.5	74.4	82.1	72.7
180	73.8	81.7	84.8	80.1
	SEm±		CD (P=0.05)	
N at S	2.94		8.5	
S at N	3.07		9.50	
Nitrogen levels (kg /ha)	**2018**			
	Planting Geometry			
	S_1	S_2	S_3	S_4
N_0	44.7	50.8	52.6	48.3
N_1	56.3	59.9	66.9	57.5
N_2	69.3	72.1	75.7	70.3
N_3	69.1	74.0	78.3	69.2
	SEm±		CD (P=0.05)	
N at S	3.05		8.92	
S at N	3.19		9.86	

Table 7: Economic of various treatment combinations as affected by treatments

Treat. comb.	Common cost of cultivation (Rs. ha^{-1})	Cost due to Treatment		Total Cost of Cultivation (Rs. ha^{-1})	Gross Return (Rs. ha^{-1})	Net Return (Rs.ha^{-1})	B:C Ratio
		Seed	Nitrogen				
S_1N_0	29885	1590	0	31475	58637.5	27162.5	0.86
S_1N_1	29885	1590	1320	32795	66472.5	33677.5	1.02
S_1N_2	29885	1590	2640	34115	68402.5	34287.5	1.00
S_1N_3	29885	1590	3960	35435	64942.5	29507.5	0.83
S_2N_0	29885	1050	0	30935	80292.5	49357.5	1.59
S_2N_1	29885	1050	1320	32255	86825	54570	1.69
S_2N_2	29885	1050	2640	33575	95295	61720	1.83
S_2N_3	29885	1050	3960	34895	82335	47440	1.35
S_3N_0	29885	1200	0	31085	91800	60715	1.95
S_3N_1	29885	1200	1320	32405	96965	64560	1.99
S_3N_2	29885	1200	2640	33725	103417.5	69692.5	2.06
S_3N_3	29885	1200	3960	35045	93995	58950	1.68
S_4N_0	29885	780	0	30665	95225	64560	2.10
S_4N_1	29885	780	1320	31985	103132.5	71147.5	2.22

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