Annals of Plant and Soil Research 25(3): 488-493 (2023)
https://doi.org/10.47815/apsr.2023.10296

Effect of crop geometry and nitrogen doses on crop growth and nutrients uptake in transplanted rice

BRIJESH KUMAR[1,2*], S.K. PRASAD[1], MAGAN SINGH[2], DEEPAK KUMAR[2], RAKESH KUMAR AND PRAVEEN B.R.[2]

[1]Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh

Received, April, 2023; Revised accepted, July, 2023

ABSTRACT

The experiment was conducted during the Kharif season of 2018 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh). Study was designed to investigate performance of submerged rice variety under the effect of crop geometry and nitrogen doses. The experiment was carried out in factorial (RCBD) design replicated thrice with treatments consisting of three crop geometry levels (15 cm × 15 cm, 20 cm × 11.25 cm, 25 cm × 9 cm) and four nitrogen rates (0, 75, 150, 225 kg N ha^{-1}). The crop geometry (20 cm × 11.25 cm) and nitrogen rates 150 kg N ha^{-1} resulted in significantly higher crop growth crop growth rate, relative growth rate, and leaf area index, nutrient contents, and uptake.

Keywords: Crop geometry, crop growth rate, nitrogen, nutrient contents, uptake

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple meal of half of the world's population. Rice is a major cereal crop growing in the world after wheat. Around the world, 21% of human calorific requirements are fulfilled by rice crops and residents of Southeast Asia fulfilled up to 76% of their calorific requirements from this crop. Rice offers dietary energy to about 4 billion populations in the world (Zhao *et al.,* 2020). Increase production of rice is an important requirement to meet the needs of over increasing population in World. With limited cultivated area it is necessary to increase the productivity per unit area. Growing of area specific rice variety is an appropriate strategy to increase the yield potentiality of rice to help the world to meet the future projected demand. When the crop is grown in the field most of the factor affects the crop growth, development, yield, and quality. Among the different factors, crop geometry and nitrogen also affected crop growth, yield, and quality (Normile, 2008). Crop geometry plays a considerable role in crop growth, yield, quality, and resource utilization (sun radiation, vitamins, water, and many others) (Singh and Singh, 2005; Kumar *et al.,* 2021). Maintaining ideal crop geometry increases the light interception efficiency in plant canopy that increase the photosynthetic rate and biomass production (Boote and Loomis, 1991) Intercultural operations are hampered by closer spacing. Closer spacing causes more competition among the plants for nutrients, air, and light. As a result, the plant grows weaker and thinner, yielding a poorer yield (Shukla *et al.,* 2014). The crop shape and spatial configuration take advantage of the genotypes' initial vigour, while improved soil aeration creates a conducive environment for better establishment (Shukla *et al.,* 2014). Sustainable rice production is difficult in less fertile soil because extensive cultivation of crops in soil decreases the fertility of the soil. The level of essential plant nutrients in the soil decreased, and in addition to nutrients in the soil, improving the production and excellent growth of rice (Morgan and Connolly, 2013). Most of the literature shows the importance of fertilizer for rice crops but they differ in the finest dose to apply. The application optimum dose of nitrogen fertilizer in rice crop is essential because rice crop requires a higher amount of nitrogen (Ebaid and Ghanem, 2000). The lack of nitrogen in soil affects the performance of crops with poor vegetative growth, stunting, pale yellow colour, small grain size, and protein and vitamins.

**Corresponding author's Email: kbrijeshkumar609@gmail.com,[2]Agronomy Section, ICAR-National Dairy Research Institute, Karnal, Haryana*

MATERIALS AND METHODS

The experiment was carried out in the *kharif* season of 2018 on the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. It is positioned inside the southeastern part of Varanasi at $25^0$18' N latitude and $83^0$03' E longitude and has an altitude of 75.7 meters above the mean sea level (MSL). Normally, average the rainfall received during *kharif* season in Varanasi is 800-1000 mm. However, during the experimental period, the average rainfall received throughout crop season was 777.7 mm, the average temperature 20.9^0C to 31.78^0C, evaporation 3.16 mm day^{-1} and relative humidity 73.68 % (Figure 1). The soil feature of the experimental site turned into alluvial soil, textural class (sand 56.26 %, silt 24.30 %, clay 19.44%) low in to nitrogen (188.1 kg ha^{-1}), medium in phosphorus (22.6 kg ha^{-1}), medium in potassium (218.2 kg ha^{-1}) with the pH 7.2.

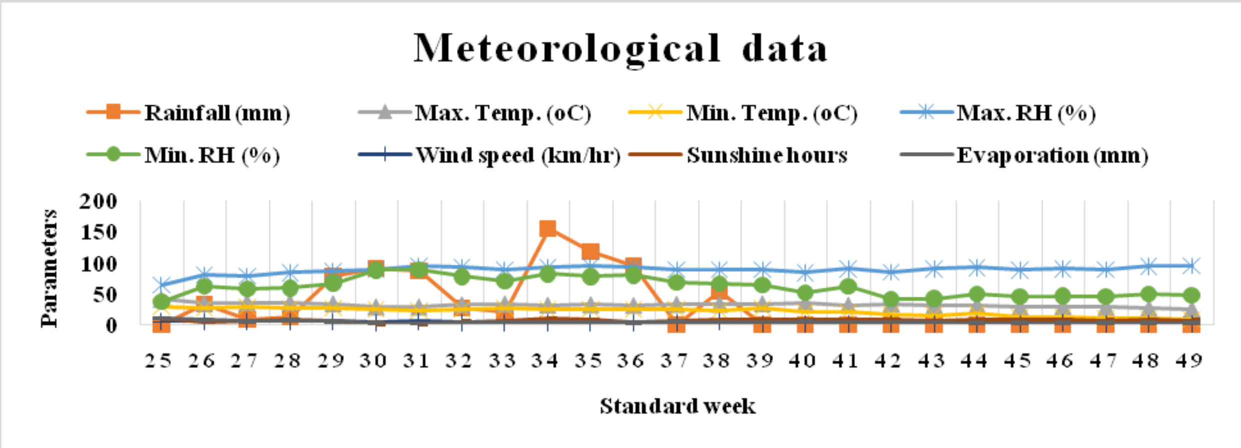

Figure1: Meteorological data from an experiment conducted during the *Kharif* season (2018)

The experiment was carried out in a factorial RBD layout and replicated thrice, three crop geometry (15 cm × 15 cm, 20 cm × 11.25 cm, 25 cm × 9 cm) and 4 nitrogen rates (0, 75, 150, 225 kg ha^{-1}). The arrangement of the plants in different rows and columns in an area to efficiently utilize the natural resources. Shape of the space available for individual plants. The crop geometry manages in the field with the help of scale. In the test, rice variety 'Swarna Sub-1' was used. It is most appropriate variety grown in the northeastern state and submerged conditions. It takes about 140-150 days to mature in *kharif* season. The N fertilizer so applied under the treatments was applied in splits viz; 50% nitrogen as basal, 25 % nitrogen at tillering stages and 25% nitrogen at flag leaf unfolded stage. Uniform application of 60 kg P_2O_5 and 60 kg K_2O per hectare to all the plots in the form of single super phosphate (SSP) and muriate of potash (MOP) was done. The crop was transplanted at different geometry in the irrigated situation and all the management practices had been followed as needed of the crop. The observations were recorded at regular intervals from the experimental plot. LAI is measured as the leaf area (m^{-2}) per ground area (m^{-2}) and is unitless. LAI is calculated for a plant or can be scaled up to give readings for a whole crop or even a region. It is one of the most important parameters to measure leaves and their activity. SPAD values of for fully expanded uppermost leaves recorded and SPAD readings were taken from five randomly selected plants in the plots at 30, 60, 90 DAT. The nutrient content and uptake of oven-dried grain and straw samples were determined using the micro-Kjeldahl method for nitrogen (Jackson, 1973). Phosphorus content in plant material was determined by the vanado-molybdo-phosphoric acid yellow color complex method as described by Jackson, (1957). Potassium content was determined by flame photometer as described by Jackson, (1973).

Nutrient uptake by grain (kg ha^{-1}) = Grain weight (kg ha^{-1}) × nutrient concentration in grain (%) /100

Nutrient uptake by straw (kg ha^{-1}) = Straw weight (kg ha^{-1}) × nutrient concentration in straw (%) /100

All the observations were recorded during the experimentation with respect to various growth, yield and laboratory studies analysis with the help of factorial randomized block design. The critical differences at 5% level of probability were calculated for testing the significance of differences between any two means wherever the F test was significant (Gomez and Gomez, 1984). The data was analyzed using the SPSS (Statistical Package for Social Science) software.

RESULTS AND DISCUSSION

CROP GROWTH

The crop growth rate (CGR) was significantly affected by crop geometry and nitrogen rates. Among the different crop geometry, significantly higher CGR (8.34 and 29.96 g m^{-2} day^{-1}) was recorded with crop geometry 20 cm × 11.25 cm at 30 and 60 DAT (Days after transplanting). Similar results were explained by Mahato *et al.,* (2017); Dongwarkar *et al.,* (2018). A significantly higher relative growth rate (RGR) (0.183 g g^{-1} day^{-1}) was recorded with crop geometry 20 cm × 11.25 cm at 30 DAT (days after transplanting). The RGR was noticed non-significantly at 60 and 90 DAT. This finding was in the agreement of Pragya *et al.,* (2015).

Table 1: Crop growth rate (CGR) and relative growth rate (RGR) affected by crop geometry and nitrogen rates

Treatments	CGR (g m^{-2} day^{-1})			RGR (g g^{-1} day^{-1})		
	30-60 DAT	60-90 DAT	90-120 DAT	30-60 DAT	60-90 DAT	90-120 DAT
Crop geometry (cm^2)						
15 × 15	6.72	22.28	26.84	0.175	0.048	0.019
20 × 11.25	8.34	29.96	29.84	0.183	0.052	0.023
25 × 9	7.59	28.19	27.14	0.180	0.050	0.019
SE(m) ±	0.41	1.12	3.21	0.002	0.002	0.002
CD (P=0.05)	1.20	3.29	NS	0.006	NS	NS
Nitrogen rates (kg ha^{-1})						
0	5.79	20.85	21.31	0.171	0.050	0.019
75	7.42	27.39	27.83	0.179	0.048	0.020
150	8.82	30.37	36.74	0.185	0.053	0.024
225	8.17	28.63	25.89	0.182	0.049	0.018
SE(m) ±	0.47	1.29	3.70	0.002	0.002	0.003
CD (P=0.05)	1.39	3.80	10.87	0.007	NS	NS

The leaf area index was influenced by different levels of crop geometry and increased up to 90 DAT. The significant maximum LAI (1.80, 4.40 and 4.58) was recorded with crop geometry 20 cm x 11.25 cm at 30, 60 and 90 DAT of observation and it was statistically at par with crop geometry 15 cm x 15 cm at 30 and 90 DAT. The effect crop geometry was found non-significant on SPAD value but grain (3932.49 kg ha^{-1}) and straw (5182.83 kg ha^{-1}) yield higher obtained with crop geometry 20 cm x 11.25 cm. The crop growth rate and relative growth rate were significantly influenced by nitrogen rates. The maximum CGR (8.82, 30.37, 36.74 g m^{-2} day^{-1}), RGR (0.185 g g^{-1} day^{-1}) with 150 kg N ha^{-1} at 30 DAT and LAI (1.85, 4.91 and 5.04) was obtained with 150 kg N ha^{-1} at 30, 60 and 90 DAT. A similar type of result was recorded by Patra *et al.,* (2018); Azapour *et al.,* (2014); Lone *et al.,* (2010). The SPAD value increases with the increased application rate of nitrogen in rice crop because nitrogen help in chlorophyll accumulation in leaves (Fang *et al.,* 2018). Among the different nitrogen rates significantly higher SPAD value (39.92) at 60 DAT, grain (4274.78Kg ha^{-1}) and straw (5440.52 Kg ha^{-1}) yield at harvest was obtained with 150 kg N ha^{-1} (Table 4).

Table 2: Leaf area index (LAI) and SPAD value affected by crop geometry and nitrogen rates

Treatments	Leaf area index (LAI)			SPAD value		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
Crop geometry (cm^2)						
15 × 15	1.78	3.82	4.22	29.92	32.89	26.62
20 × 11.25	1.80	4.40	4.58	33.24	38.79	27.09
25 ×9	1.47	3.61	3.72	31.33	33.57	26.51
SE(m) ±	0.09	0.13	0.22	1.7	1.97	0.95
CD (P=0.05)	0.27	0.40	0.64	NS	NS	NS
Nitrogen rates (Kg ha^{-1})						
0	1.30	2.78	3.16	20.25	29.44	23.44
75	1.75	3.78	4.12	31.52	32.78	25.69
150	1.85	4.91	5.04	37.51	39.92	29.46
225	1.83	4.29	4.35	36.70	38.18	28.71
SE(m) ±	0.10	0.16	0.25	2.01	2.28	1.16
CD (P=0.05)	0.31	0.47	0.74	5.90	6.69	3.41

Nutrient content and uptake

The nutrient content and uptake of rice in response to crop geometry and nitrogen rates are indicated in Table 4. The nitrogen and potassium content in grain was non-significantly affected by the crop geometry. The maximum amount of phosphorus content reported in grain (0.72%) was found with the crop geometry 20 cm × 11.25 cm which was significantly superior over the remaining crop geometries 15 cm × 15 cm and 25 cm × 9 cm. The maximum amount of nitrogen content (0.66 %), and phosphorus (0.51%) in straw was recorded with the crop geometry 20 cm × 11.25 cm it was significantly higher than the crop geometries 15 cm × 15 cm and 25 cm × 9 cm. Potassium content in straw was non-significantly affected by crop geometries.

Table 3: Nutrients contents in grain and straw affected by crop geometry and nitrogen rates

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Crop geometry (cm^2)						
15 × 15	1.38	0.57	0.61	0.39	0.25	1.41
20 × 11.25	1.44	0.66	0.72	0.51	0.26	1.49
25 ×9	1.36	0.58	0.63	0.40	0.26	1.46
SE(m) ±	0.04	0.04	0.02	0.03	0.009	0.05
CD (P=0.05)	0.13	0.11	0.08	0.11	0.02	0.17
Nitrogen rates (Kg ha^{-1})						
0	1.26	0.51	0.56	0.31	0.24	1.37
75	1.33	0.55	0.62	0.39	0.26	1.41
150	1.51	0.71	0.73	0.53	0.27	1.54
225	1.47	0.63	0.70	0.51	0.26	1.51
SE(m) ±	0.05	0.04	0.03	0.04	0.01	0.06
CD (P=0.05)	0.15	0.13	0.09	0.12	0.03	0.19

A similar kind of result was obtained by (Bezbaruha *et al.,* 2011). The nitrogen and potassium content in rice grain was found significantly higher and phosphorus content was non-significantly affected by nitrogen rates. The rate of nitrogen application was increased with an increase in the content of nitrogen and phosphorus in grain. The higher amount of nitrogen (1.51 %) and phosphorus (0.73 %) content in grain was obtained with nitrogen 150 kg ha^{-1} and it was superior over the application of nitrogen 75 kg ha^{-1} and 225 kg ha^{-1}. Devi and Sumathi, (2011) also reported the highest amount of nutrients in grain with increasing nitrogen rates. The maximum nitrogen (0.71 %), phosphorus (0.53 %) and potassium (1.54 %) content was recorded in straw with a nitrogen rate of nitrogen 150 kg N ha^{-1} application than the rest of the other nitrogen rates application. The increasing trend of nitrogen rates showed the highest amount of nitrogen, phosphorus and potassium recorded with a higher dose of nitrogen Nori *et al.,* (2008). Significance response was recorded with the crop geometry 20 cm × 11.25 cm on the nitrogen, phosphorus and potassium uptake per hectare. Significantly higher amount of nitrogen (56.63 kg ha^{-1}), phosphorus (28.31 kg ha^{-1}) and potassium (10.22 kg ha^{-1}) uptake in grain was obtained with crop geometry 20 cm × 11.25 cm than the other crop geometries i.e. 15 cm × 15 cm and 25 cm × 9 cm.

Table 4: Grain yield and nutrients uptake in grain and straw as affected by crop geometry and nitrogen rates

Treatments	Yield(kg ha^{-1})		Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	straw	Grain	Straw
Crop geometry (cm^2)								
15 × 15	3635.00	4870.07	50.16	27.76	22.17	18.99	9.09	68.67
20 × 11.25	3932.49	5182.83	56.63	34.21	28.31	26.43	10.22	77.22
25 ×9	3362.35	4729.52	45.73	27.43	21.18	18.92	8.74	69.05
SE(m) ±	155.24	143.43	2.87	3.08	1.62	2.15	0.47	2.91
CD (P=0.05)	455.32	420.66	8.44	9.04	NS	6.32	1.38	8.53
Nitrogen rates (kg ha^{-1})								
0	3113.87	4396.15	39.23	22.42	17.44	13.63	7.47	60.23
75	3512.51	4734.11	46.72	26.04	21.78	18.46	9.13	66.75
150	4274.78	5440.52	64.55	38.63	31.21	28.83	11.54	83.78
225	3671.95	5272.43	53.98	33.22	25.70	26.89	9.55	79.61
SE(m) ±	179.26	165.62	3.32	3.55	1.87	2.48	0.54	3.36
CD (P=0.05)	525.76	485.74	9.74	10.43	5.50	7.29	1.59	9.85

The nitrogen, phosphorus and potassium uptake in straw was significantly affected by crop geometry. The highest amount of nitrogen (34.21 kg ha^{-1}), phosphorus (26.43 kg ha^{-1}) and potassium (77.22 kg ha^{-1}) uptake in straw was recorded with crop geometry 20 cm × 11.25 cm than the other crop geometries as in 15 cm × 15 cm and 25 cm × 9 cm. The uptake of nitrogen, phosphorus, and potassium in grain and straw showed a significant response, and a similar result was also reported by Bezbaruha *et al.,* (2011). The significantly higher amount of nitrogen (64.55 kg ha^{-1}), phosphorus (31.21 kg ha^{-1}) and potassium (11.54 kg ha^{-1}) in grain and nitrogen uptake (38.63 kg ha^{-1}), phosphorus (28.83 kg ha^{-1}) and potassium (83.78 kg ha^{-1}) in straw was obtained with application of nitrogen 150 kg ha^{-1} than the rest of other nitrogen rates application. Respectively, the same type of findings was confirmed by Nori *et al.,* 2008; Miah and Panaullah, 1999.

CONCLUSION

Based on the experimental findings of different crop geometries and the application of nitrogen rates significantly affected crop growth, nutrient contents, and uptake. The combination of crop geometry 20 cm × 11.25 cm and nitrogen rate 150 kg ha^{-1} was found to be superior for getting proper growth (crop growth rate, relative growth rate, leaf area index, and SPAD value) nutrient contents and uptake (Nitrogen, Phosphorus, Potassium).

ACKNOWLEDGEMENT

I sincerely acknowledged my respected guide and head of the division, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh) for giving their full support for the completion of this task to complete within the time frame of my master thesis research.

REFERENCES

Azarpour, E., Moraditochaee, M., and Bozorgi, H. R. (2014) Effect of nitrogen fertilizer management on growth analysis of rice cultivars. *International Journal of Biosciences*, **4**(5), 35-47.

Bezbaruha, R., Sharma, R.C., and Banik, P. (2011) Effect of nutrient management and planting geometry on productivity of hybrid rice (*Oryza sativa* L.) cultivars. *American Journal of Plant Sciences*, **2**(03), 297.

Boote, K.J., and Loomis, R.S. (1991) The prediction of canopy assimilation. *Modeling crop photo-synthesis from biochemistry to canopy*, **19**, 109-140.

Devi, M.G., and Sumathi, V. (2011) Effect of nitrogen management on growth, yield and quality of scented rice (*Oryza sativa* L.) under aerobic conditions. *Journal of Research ANGRAU*, **39**(3), 81-83.

Dongarwar, U.R., Patke, N., Dongarwar, L.N., and Kashiwar, S.R. (2018) Effect of row spacing on growth, yield and economics of direct seeded rice in Eastern Vidharbha zone of Maharashtra, India. International Journal of Current Microbiology and Applied Sciences, **7**(7), 2930-2941.

Ebaid, R.A., and Ghanem, S.A. (2000) Productivity of Giza 177 rice variety grown after different winter crops and fertilized with different nitrogen levels. *Egyptian Journal of Agricultural Research*, **78**(2), 717-731.

Fageria, N.K. (2007) Yield physiology of rice. *Journal of plant nutrition*, **30**(6), 843-879.

Fang, X., Li, Y., Nie, J., Wang, C., Huang, K., Zhang, Y., and Yi, Z. (2018) Effects of nitrogen fertilizer and planting density on the leaf photosynthetic characteristics, agronomic traits and grain yield in common buckwheat (*Fagopyrum esculentum* M.). *Field Crops Research*, **219**, 160-168.

Gomez, K.A., and Gomez, A.A. (1984) *Statistical procedures for agricultural research*. John wiley and sons.

Jackson, M. L. (1973) Soil chemical analysis, pentice hall of India Pvt. *Ltd., New Delhi, India*, **498**, 151-154.

Lone, N.A., Mir, M.R., Khan, A.V., Hassan, A., Banday, S., Mir, S., and Payne, W.A. (2010) Effect of Applied Nitrogen on Photosynthesis and Yield Parameters of Various Rice Cultivars. *Applied Biological Research*, **12**(1), 28-32.

Kumar, B., Prasad, S.K., Maurya, S., and Kumar, S. (2021) Effect of crop geometry and nitrogen rates on growth and yield of transplanted rice (*Oryza sativa* L.).

Mahato, M., and Adhikari, B. B. (2017) Effect of planting geometry on growth of rice varieties. *International Journal of Applied Sciences and Biotechnology*, **5**(4), 423-429.

Haque, M.A., and Haque, M.M. (2016) Growth, yield and nitrogen use efficiency of new rice variety under variable nitrogen rates. *American Journal of Plant Sciences*, **7**(3), 612-622.

Morgan, J.Á., and Connolly, E.Á. (2013) Plant-soil interactions: nutrient uptake. *Nature Education Knowledge*, **4**(8), 2.

Nori, H., Halim, R.A., and Ramlan, M.F. (2009). Effects of Nitrogen Fertilization Management Practice on the Yield and Straw Nutritional Quality of Commercial Rice Varieties. *Malaysian Journal of Mathematical Sciences*, **2**(2), 61-71.

Normile, D. (2008) Reinventing rice to feed the world. *Science,* **321**, 330–333.

Patra, B., and Ray, P.K. (2018) Response of wheat to various nitrogen levels under late sown condition. *Journal of Experimental Agriculture International*, **21**(1), 1-5.

Pragya, P., Trilochan, B., and Sahaja, D. (2015) Effect of planting geometry and timing and source of nitrogen application on growth attributing characters and yield of rice (Oryza sativa L.) under system of rice intensification (SRI). *Advance Research Journal of Crop Improvement*, **6**(1), 28-33.

Shukla, U.N., Srivastava, V.K., Singh, S., Sen, A., and Kumar, V. (2014) Growth, yield and economic potential of rice (*Oryza sativa* L.) as influenced by different age of seedlings, cultivars and weed management under system of rice intensification. *Indian Journal of Agricultural Sciences*, **84**(5), 628-36.

Singh, A.K., and Singh, G.R. (2005) Effect of seedling density and planting geometry on hybrid rice (*Oryza sativa* L.), **42**(4), 327.

Zhao, M., Lin, Y., and Chen, H. (2020) Improving nutritional quality of rice for human health. *Theoretical and Applied Genetics*, **133**, 1397-1413.