Eco. Env. & Cons. 30 (August Suppl. Issue) : 2024; pp. (S79-S84)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i05s.013

Effect of crop geometry and nitrogen rates on growth, yield, and economics of submerged rice

Brijesh Kumar[1,2], S. K. Prasad[2], Rekha Rana[2], Ajay Kumar[2], Stuti Kumari[1], Birendra Kumar[1] , and Sharandeep Cheema[3]

[1]Agronomy Section, ICAR-National Dairy Research Institute, Karnal, Haryana 132001
[2]Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India
[3]Geeta University, Panipat, Haryana 132 145

(Received 17 September, 2023; Accepted 29 March, 2024)

ABSTRACT

An experiment was conducted during the *Kharif* season at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh). The experiment was carried out in Factorial RBD and replicated thrice, the treatments were taken as three crop geometry levels (G_1=15 × 15, G_2=20 × 11.25, G_3=25 ×9 cm^2), and four nitrogen rates (N_0=0, N_1=75, N_2=150, N_3=225 kg ha^{-1}). In the experiment, the rice variety Swarna Sub-1 was used. After the harvest, the crop growth parameters were studied and correlation was showed that yield was dependent on plant height, crop growth rate, leaf area index, SPAD value, and dry matter accumulation. Maximum higher grain yield (3932.49 kg ha^{-1}), gross return (84658.69 ha^{-1}), net return (44153.70 ha^{-1}), B:C ratio (1.09) recorded with crop geometry (20 cm × 11.25 cm). The significantly higher grain yield (4274.78 kg ha^{-1}), straw yield (5440.20 kg ha^{-1}), gross return(90157.98 ha^{-1}), net return (49124.24 ha^{-1}), and B:C ratio (1.20) was recorded with nitrogen rate 150 kg ha^{-1}. The interaction effect of crop geometry and nitrogen rates was found to be non-significant.

Key words: *Crop geometry, Correlation, Crop growth and yield, Economics, Nitrogen.*

Introduction

Rice (*Oryza sativa* L.) is a staple food of one-third population of the world. Rice is a major cereal crop growing in the world after wheat. India and world rice demand increase day by day with the increasing world population and therefore meeting the increasing demand great challenge with the shrinkage of natural resources (Singh *et al*., 2016). When the crop is grown in the field most of the factorsaffect crop growth, development, yield, and quality (Peng *et al*., 2021). Among the different factors crop geometry and nitrogen also affected crop growth, development, yield, and quality. Crop geometry playsa considerable role in yield, crop growth, quality, and resource utilization (sun radiation, vitamins, and water, and many others)(Kumar *et al.*, 2021). Maintaining the ideal crop geometry increases the light interception efficiency in the plant canopy which increases the photosynthetic rate and biomass production (Boote and Loomis, 1991). Sustainable rice production is difficult in less fertile soil because extensive cultivation of plants in soil decreases the fertility of the soil. The level of essential plant nutrients in soil decreases, in addition to nutrients in the soil, improving the production and excellent growth of the rice (Thakur *et al*., 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 color, small grain size, protein, and vitamins (Kichey *et al.*, 2007).

Materials and Methods

The experiment was conducted during the *Kharif* season at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. It is located in 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 MSL. The experiment was conducted in field number A/9 of Research Farm. Normally the rainfall received in the *Kharif* season in Varanasi is 800-1000 mm. The average rainfall received during crop season is 777.7 mm, average temperature 20.9 ^oC to 31.78 ^oC, mean evaporation 3.16 mm day^{-1}, and mean relative humidity 73.68%. The soil characteristic of the experimental site was alluvial soil, texture (sand 56.26%, silt 24.30%, clay 19.44%) low in available nitrogen (188.1 kg ha^{-1}), medium in available phosphorus (22.6 kg ha^{-1}), potassium (218.2 kg ha^{-1}) and basic pH value 7.2. The experiment was carried out with a factorial RBD design with three replications, three crop geometry levels (G_1=15 × 15, G_2=20 × 11.25, G_3=25 ×9 cm^2), and four nitrogen rates (N_0=0, N_1=75, N_2=150, N_3=225 kg ha^{-1}). In the experiment rice variety, Swarnasub-1 was used. It is the most suitable variety grown in the northeastern state and under submerged conditions. It takes 140-150 days to mature in the *Kharif* season. The application of 50 % nitrogen as basal, 25 % nitrogen at tillering stage, and 25% nitrogen at flag leaf unfolded stage. Application 60 kg P_2O_5 and 60 kg K_2O per hectare were applied in all plots in the form of single super phosphate (SSP) and Muriate of potash (MOP). The crop was grown in irrigated conditions and all the recommended practices were adopted as per the need of the crop. The observation was recorded at regular intervals from the net plot area randomly selected tagged plants. Studied the correlation between growth and yield parameter using the SPSS (Statistical Package for Social Science)software to analyze the data.

Results and Discussion

Growth attributes

The growth of rice plants was notably influenced by both crop geometry and nitrogen application rates, as reported by Gautam *et al.* 2008. This influence stemmed from the competition among rice plants for light, space, and nutrients, both within and among them. In terms of crop geometry, different spacings were tested, including 15 x 15 cm^{-2}, 20 x 11.25 cm^{-2}, and 25 x 9 cm^{-2}. Among these configurations, it was found that the crop geometry of 20 x 11.25 cm^{-2} exhibited superior results in terms of plant height at 90 days after transplanting (DAT). Regarding nitrogen application rates, it was observed that the amount of nitrogen applied significantly affected the growth of transplanted rice. Notably, the highest plant height, measuring 93.45 cm,

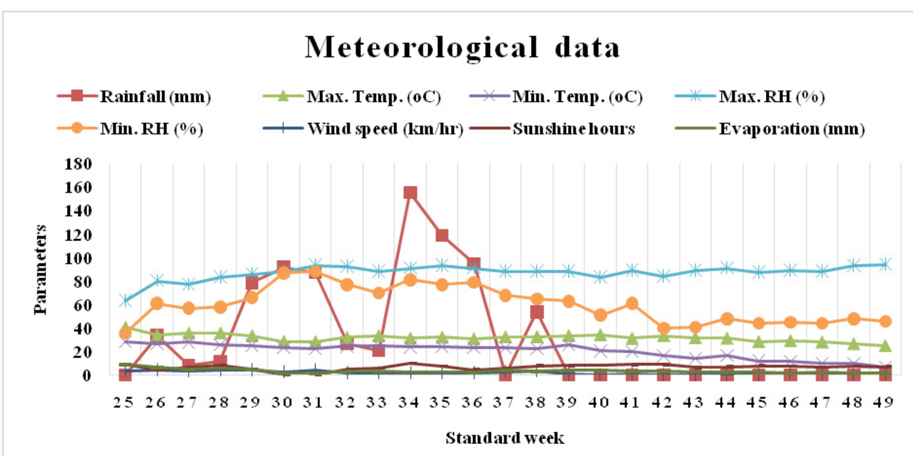

Fig. 1. Meteorological data from an experiment conducted during the *Kharif* season (2018)

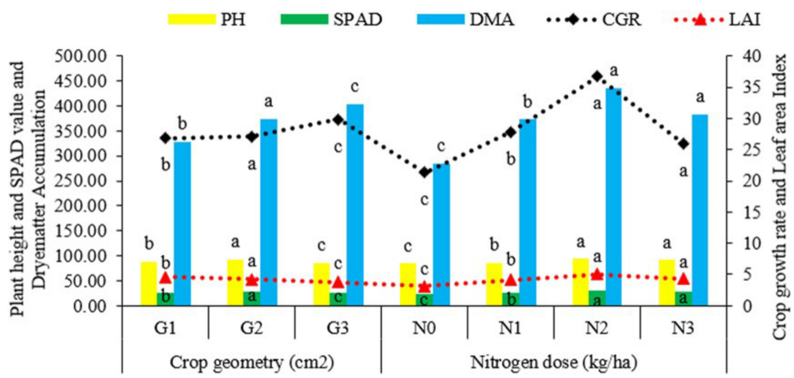

Fig. 2. Effect of crop geometry and nitrogen rates on grain and straw yield of rice.

was achieved with an application of nitrogen150 kg ha^{-1} at 90 DAT. Interestingly, this result was statistically comparable to the performance achieved with an application of nitrogen 225 kg ha^{-1}. Similar types of results were recorded by Mahato *et al.* (2017); Yadav *et al.* (2016); Bezbaruha *et al.* (2011). Variations in SPAD value due to crop geometry were non-significant at all the growth stages. The nitrogen rates had an influence on SPAD value and increased up to 60 DAT later it decreased at 90 DAT. A significantly higher SPAD value (39.92) was obtained with 150 kg N ha^{-1} at 60 DAT. However, itwas statistically at par with 225 kg N ha^{-1} at 60 DAT. The lowest SPAD value (29.44) was recorded with control.A similar type of finding is reported by Pragya *et al.* (2015). The dry matter accumulation had an influence by different levels of crop geometry recorded at 90 DAT. The significantly higher drymatter accumulation was recorded with 20 cm x 11.25 cm crop geometry at all the stages of observation at 90 DAT. The minimum dry matter accumulation was recorded with 15 cm x 15 cm crop geometry. Similar types of findings were recorded by Hasanuzzaman *et al.* (2009); and Keerthi *et al.* (2015). The dry matter accumulation in plants is significantly influenced by nitrogen ratesat different growth stages and maximum dry matter accumulation at 90 DAT maximum dry matter accumulation (435.11 g m^{-2}) with 150 kg N ha^{-1}. However, it was statistically at par with 225 kg N ha^{-1}. The lowest dry matter accumulation was recorded with control. The crop growth rate depends on different factor and crop geometry also affect it. The significantly higher CGR (29.96 g m^{-2} day^{-1}) was recorded with crop geometry 20 cm × 11.25 cm at 90 DAT. The lowest CGR was recorded with a crop geometry level 15 cm × 15. Similar types of findings were recorded by Mahato *et al.* (2017). The crop growth rate in plants was influenced by nitrogen rates at different growth stages and maximum CGR (36.74 g m^{-2} day^{-1}) was recorded with 150 kg N ha^{-1} at 90DAT. However, it was statistically at par with 150 kg N ha^{-1} at 90 DAT. However, it was statistically at par with 225 kg N ha^{-1}. The lowest CGR was recorded with control at all growth stages.

Table 1. Estimate of correlation between grain yield with different growth parameters

Correlations						
Parameter	GY	PH	CGR	LAI	SPAD	DM
GY	1					
PH	.568	1				
CGR	.119	.278	1			
LAI	.740**	.606*	.470	1		
SPAD	.703*	.827**	.349	.669*	1	
DM	.429	.340	.709**	.406	.668*	1

Where: GY=Grain yield, PH= plant height, CGR= Crop growth rate, LAI=Leaf area index, SPAD= SPAD Value, DM= Dry matter accumulation**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Correlation between different crop growth parameters

The correlation studies showed that the crop growth and yield parameters have a significant and non-significant relationship with each other (Table 1), Results revealed that plant height (r=.568) and crop growth rate (r=.119) had a positive correlation, leaf area index (r=.740**) and SPAD value (r=.703**) had a significantly positive correlation, and dry matter accumulation had positive correlation (r=.429)with grain yield. This shows the grain yield dependency on growth parameters. The crop growth rate (r=.278) and dry matter accumulation (r=.340) had a positive correlation, and leaf area index (r=.606*) and SPAD value (r=.827**) had a significantly positive correlation with plant height. Leaf area index (r=.470) and SPAD value (r=.349) had a positive correlation but dry matter accumulation (r=.709**) had a significantly positive correlation with crop growth rate. SPAD value (r=.669*) had a significantly positive correlation but dry matter accumulation (r=.406*) had a positive correlation with leaf area index. Dry matter accumulation (r=.668*) had a significantly positive correlation with SPAD value. Similar types of results were reported by Al-Salim *et al*. (2017); Hossain *et al*. (2015); Tiwari *et al.,* (2019).

Yield of rice

The yields of rice depend on different management factors and crop geometry is also affected (Figure 3). The significantly higher grain yield (3932.49 kg ha^{-1}) was recorded with 20 cm x 11.25 cm crop geometry at harvesting and it was at par with 15 cm × 15 cmcrop geometry, and it was superior over the 25 cm × 9 cm crop geometry. The minimum grain yield (3362.35 kg ha^{-1}) was recorded with 25 cm × 9 cmcrop geometry at harvesting. The effect of crop geometry was recorded as non-significant with straw yield. A similar type of result was reported by Moro *et al.* (2016); Dwivedi *et al.* (2015); BR *et al.* (2021). Yield is the combined result of all growth and management factors. A significantly higher grain yield (4274.78 kg ha^{-1}) was produced with 150 kg N ha^{-1}. However, it was superior to the rest of the other treatments. The lowest grain yield (3113.87 kg ha^{-1}) was obtained with control. A significantly higher straw yield (5440.20 kg ha^{-1}) was produced with 150 kg N ha^{-1} and it was at par with 225 kg N ha^{-1}. The lowest straw yield (4396.15 kg ha^{-1}) was recorded with control. A similar type of result was recorded by Pramanik and Bera, (2013).

Economics of rice

The cost of cultivation was influenced by nitrogen rates. The gross return which is related to the crop and its market price differed noticeably under different treatments and this accompanied by the cost of cultivation influenced the overall net return and B:C ratio (Table 2). The gross return, the net return, and the cost of cultivation were significantly influenced by nitrogen rates. The maximum gross return (84658.69 ha^{-1}) was recorded with the crop geometry of 20 cm × 11.25 cm and it was at par with the 15 cm × 15 cm crop geometry. The lowest gross return (71871.25 ha^{-1}) was recorded with the crop geometry of 15 cm × 15 cm and the maximum gross return (90157.98 ha^{-1}) was recorded with 150 kg N ha^{-1}. The maximum net return (44153.70 ha^{-1}) was recorded with the crop geometry of 20 cm × 11.25 cm and it was at par with the 15 cm × 15 cm crop geometry. The lowest net return (31366.26ha^{-1}) was

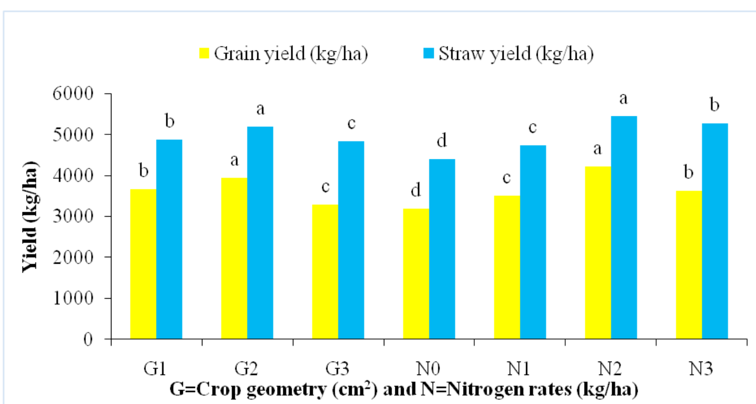

Fig. 3. Effect of crop geometry and nitrogen rates on grain and straw yield of rice.

Table 2. Effect of crop geometry and nitrogen rates on the economics of rice.

Treatments	Cost of cultivation (ha^{-1})	Gross return (ha^{-1})	Net return (ha^{-1})	Benefit-cost ratio
Crop geometry (cm^2)				
15 × 15	38918.74	78806.01	38301.02	0.94
20 × 11.25	38918.74	84658.69	44153.70	1.09
25 ×9	38918.74	71871.25	31366.26	0.77
SE(m) ±	-	2895.42	2895.42	0.07
CD (P=0.05)	-	8491.99	8491.99	0.21
Nitrogen rates (kg ha^{-1})				
0	38918.74	68847.87	29929.13	0.77
75	39976.24	75671.19	35694.95	0.89
150	41033.74	90157.98	49124.24	1.20
225	42091.24	79104.23	37012.99	0.88
SE(m) ±	-	3343.35	3343.35	0.08
CD (P=0.05)	-	9805.71	9805.71	0.24

recorded with the crop geometry of 25 cm × 9 cm. The maximum gross return (90157.98ha^{-1}) net return (49124.24 ha^{-1}) was recorded with 150 kg N ha^{-1}in comparison rest of the other treatments. A critical analysis of data onthe B:C ratio revealed that the maximum B:C ratio (1.09) was recorded with the crop geometry of 20 cm × 11.25 cm and it was at par with the 15 cm × 15 cm crop geometry. The lowest B:C ratio (0.77) was recorded with the crop geometry of 25 cm × 9 cm. The maximum B:C ratio (1.20) was recorded with 150 kg N ha^{-1}. The minimum B:C ratio (0.77) was recorded with the control (Sathyamoorthy *et al*., 2019; Pramanik and Bera, 2013).

Conclusion

The research trial conducted with different crop geometries and nitrogen rates significantly affected crop growth, yield, and economics of rice. The correlation studies showed that the yield of crops is dependent on crop growth parameters. The crop geometry of 20 cm × 11.25 cm and nitrogen rate of 150 kg N ha^{-1} were found to be optimum for getting proper crop growth, yield, and a higher, gross return, net return, and benefit-cost ratio of the transplanted crop.

Conflict of Interest- None

Acknowledgement

I sincerely acknowledge our respected VC and Director of Agriculture, 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

Al-Salim, S.H.F., Saleh, M.M., ALbourky, R.H. and Abdurahman, A.L. 2017. Correlation and regression analysis in sorghum under different levels of nitrogen. *Journal of Scientific Agriculture.* 1: 69-78.

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. Modeling Crop Photosynthesis from Biochemistry to Canopy (pp. 109-140). Madison, Wisconsin: Crop Science Society of America.

BR, P., Lathwal, O., Dhaka, A., Garhwal, R., Kashyap, S. and Singh, M. 2021. Effect of nitrogen on growth, yield and yield attributes of scented rice (*Oryza sativa* L.) under different planting geometry. *Annals of Plant and Soil Research*. 23(4): 402-406.

Dwivedi, S.K., Meshram, M.R., Pal, A.S.H.O.K. and Kanwar, P. C. 2015. Effect of planting geometry and seedling density on growth and yield of scented rice under SRI based cultivation practices. *The Bioscan.* 10(1): 455-458.

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.

Gautam, A.K., Kumar, D., Shivay, Y.S. and Mishra, B.N. 2008. Influence of nitrogen levels and plant spacing on growth, productivity and quality of two inbred varieties and a hybrid of aromatic rice. *Archives of Agronomy and Soil Science.* 54(5): 515-532.

Hasanuzzaman, M., Nahar, K., Roy, T.S., Rahman, M.L., Hossain, M.Z. and Ahmed, J.U. 2009. Tiller dynamics and dry matter production of transplanted rice as affected by plant spacing and number of seedling per hill. *Academic Journal of Plant Sciences.* 2(3): 162-168.

Hossain, S., Haque, M. and Rahman, J. 2015. Genetic variability, correlation and path coefficient analysis of morphological traits in some extinct local Aman rice (*Oryza sativa* L). *Journal of Rice Research*. 3(158): 2.

Kichey, T., Hirel, B., Heumez, E., Dubois, F. and Le Gouis, J. 2007. In winter wheat (*Triticum aestivum* L.), post-anthesis nitrogen uptake and remobilisation to the grain correlates with agronomic traits and nitrogen physiological markers. *Field Crops Research*. 102(1): 22-32.

Keerthi, M.M., Babu, R., Joseph, M. and Amutha, R. 2015. Optimizing plant geometry and nutrient management for grain yield and economics in irrigated greengram. *American Journal of Plant Sciences*. 6(08): 1144.

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.). *The Pharma Innovation Journal*. 10(9): 1134-1136.

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.

Moro, B., Nuhu, I. and Martin, E. 2016. Effect of spacing on grain yield and yield attributes of three rice (*Oryza sativa* L.) Varieties Grown in Rain-fed Lowland Ecosystem in Ghana. *Int. Journal of Plant and Soil Science*. 9(3) : 1-10.

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.

Pramanik, K. and Bera, A.K. 2013. Effect of seedling age and nitrogen fertilizer on growth, chlorophyll content, yield and economics of hybrid rice (*Oryza sativa* L.). *International Journal of Agronomy and Plant Production.* 4(5): 3489-3499.

Peng, J., Feng, Y., Wang, X., Li, J., Xu, G., Phonenasay, S., Luo, Q., Han, Z. and Lu, W. 2021. Effects of nitrogen application rate on the photosynthetic pigment, leaf fluorescence characteristics, and yield of indica hybrid rice and their interrelations. *Scientific Reports*. 11(1): 7485. doi: 10.1038/s41598-021-86858-z.

Sathyamoorthy, N., Gurusamy, A.,Ragavan, T., Prabhaharan, J. and Prakash, P. 2019. Effect of irrigation regime and crop geometry on water use and economics of different rice genotypes under aerobic ecosystem. *Agricultural Research Journal*. 56(1): 175-178.

Singh, V.P., Singh, S.P., Dhyani, V.C., Banga, A., Kumar, A., Satyawali, K. and Bisht, N. 2016. Weed management in direct-seeded rice.

Thakur, A.K., Rath, S. and Mandal, K.G. 2013. Differential responses of system of rice intensification (SRI) and conventional flooded-rice management methods to applications of nitrogen fertilizer. *Plant and Soil*. 370: 59-71.

Tiwari, D.N., Tripathi, S.R., Tripathi, M.P., Khatri, N. and Bastola, B.R. 2019. Genetic variability and correlation coefficients of major traits in early maturing rice under rainfed lowland environments of Nepal. *Advances in Agriculture*.

Yadav, A.S., Ram, H. and Srivastava, D.S. 2016. Productivity of hybrid rice (*Oryza sativa* L.) as affected by nitrogen levels and plant geometry under transplanted situation in eastern Uttar Pradesh. *New Agriculturist*. 27(1) : 125-134.