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INFLUENCE OF DIFFERENT ROW SPACING AND NITROGEN LEVELS ON YIELD ATTRIBUTES OF LOWLAND BLACK RICE (*Oryza sativa* L.)

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ABSTRACT

Field experiment was conducted at School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland during *kharif* season of 2022. Supply of nutrients in adequate amounts coupled with optimum row spacing are essential requirements for good crop production. Black rice being a tall cultivar does not require excess of nitrogen and due to large above ground structure needs proper spacing. Hence, an experiment was aimed to find out nitrogen dose required for proper growth and the suitable row spacing of black rice.The experiment consisted of 12 treatment combinations. The different row spacing (R_1: 10 cm × 10 cm), (R_2: 20 cm × 10 cm), (R_3: 30 cm × 10 cm), were adopted along with nitrogen levels (N_0: Control, N_1: 15 kg ha^{-1},N_2:30 kg ha^{-1} and N_3: 45 kg ha^{-1}). The experimental design was split plot.Wider row spacing recorded highest plant height while greater plant density recorded significant yield attributes *viz.,* number of effective tillers m^{-2}, number of grains panicle^{-1}, grain yield and straw yield (kg ha^{-1}). Highest nitrogen level of 45 kg ha^{-1} showed significance in lowland black rice. The study showed that combination of row spacing of 20 cm × 10 cm and nitrogen level of 45 kg ha^{-1} was found to induce satisfactory yield response from the cultivated lowland black rice. Therefore, these can be adopted for higher yield of black rice.

(Key words: Black rice, nitrogen levels, row spacing, yield)

INTRODUCTION

The major global population consumes rice (*Oryza sativa* L.) as the staple food with China as the leading producer followed by India. Among the different varieties of rice, black rice (*Oryza sativa* L.) is one known for its aroma along with associated benefits in relation to nutrition which has been gaining economic importance. With high concentration of anthocyanin, black rice is purplish-black in colour and sources minerals like iron, zinc, calcium, magnesium, vitamins such as vitamin B1, and vitamin B2. Additionally, black rice is recognised to offer several health advantages such as boosting eye and heart health, protection against certain forms of cancer as it is highly antioxidant. The yield of black rice is substantially lower than other rice varieties. In northeast India, black rice is commonly cultivated in Manipur and indigenously called “chakhao”. As the yield is very poor (about 2.5 tons hectare^{-1}), Chakhao is grown in very limited acreage by farmers in Manipur only for ceremonial and cultural purposes (Sultana and Ningthoujam, 2023). Since black rice being a nutritious food and its cultivation continues to grow, it is necessary to explore wider techniques to increase its yield. Black rice is a healthier alternative to white rice. There are great prospects to promote black rice cultivation in major rice-growing states of India and doing so will help our country to achieve nutritional security (Saha *et al*., 2022).

Rice yield production is influenced by several factors out of which optimum density and nitrogen fertilizer are two crucial elements affecting rice population, growth, canopy and yield formation (Lin *et al.,* 2014). An important nutrient that influences rice yield is nitrogen (Jiang *et al.,* 2020). Nitrogen is a key component of many organic compounds. Improved yields and minimization of excessive chemical fertilizer application can be achieved with use of N fertilizer based on variety of crop and climatic conditions (Jahan *et al.,* 2020).

Another key agronomic parameter that influences crop growth performance and crop yield is optimum plant spacing (Reuben *et al.,* 2016). It is necessary to maintain optimum density of plant population unit^{-1} area for obtaining maximum yields as a thick population of crop may have limitations in the maximum availability of crucial factors.

Hence, study was made with the aim to assess the productivity of lowland black rice influenced by spacing and nitrogen.

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MATERIALS AND METHODS

The research was conducted in the experimental field of School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland during the *kharif* season of 2022.The experimental site was located at 310 m above sea level with geographical location of 25°45′45′′North latitude and 93°51′45′′East longitude in the foothills of Nagaland.The soil condition was sandy loam and strongly acidic. Split Plot Design (SPD) was adopted with three replications comprising row spacing R_1 (10 cm × 10 cm), R_2 (20 cm × 10 cm) and R_3 (30 cm × 10 cm) under main plot, while the sub-plot comprised nitrogen levels N_0 (Control), N_1 (15 kg ha^{-1}), N_2 (30 kg ha^{-1}) and N_3 (45 kg ha^{-1}). Poireiton, a local cultivar from Manipur was used for the experiment. The seedlings were sown on 15th June 2022 and transplanted after two weeks at different row spacing. Nitrogen levels were applied at different levels through urea in two split doses- first dose before the last puddling followed by the remaining dose at active tillering. P_2O_5 through SSP @ 15 kg ha^{-1} and K_2O through MOP @ 30 kg ha^{-1} were applied fully as basal doses. Five plants from each treatment were randomly tagged to observe various plant growth and yield attributes required for data analysis. The plant height at 30 and 75 DAT, number of effective tillers, length of panicle, number of grains panicle^{-1}, grain yield and straw yield were recorded.

Soil parameters on pH, organic carbon, available N, available P_2O_5 and available K_2O were recorded. Soil pH was determined using digital pH meter (Jackson, 1973). Organic carbon was determined using Walkley and Black rapid titration method as framed by Piper (1966) and expressed in %. Available N was determined using alkaline potassium permanaganate method (Subbiah and Asija, 1956) and expressed in kg ha^{-1}. Available P_2O_5 was determined using Bray's No. 1 method (Bray and Kurtz, 1945) and expressed in kg ha^{-1}. Available K_2O from 5 g soil was extracted with the help of 25 ml neutral normal ammonium acetate solution (Hanway and Heidal, 1952). The extract was used to determine potassium concentration by flame photometer and the result was expressed in kg ha^{-1}.

Data were statistically analyzed by applying the approach of analysis of variance (ANOVA) by Gomez and Gomez (1976) and significant difference of variations were tested with the help of F-test expressed at 5% level.

RESULTS AND DISCUSSION

Spacing of row and nitrogen showed significant effect on different attributes of black rice. Data recorded on height of plant at 35 DAT (81.75 cm) and 70 DAT (154.79 cm), showed highest significant plant height from row spacing of 30 cm × 10 cm (Table 1). This might be due to better access to resources like nutrients, water and solar radiation that enhanced growth and development under this condition. Escasinas and Zamora, (2011) also found in their research that plants at wider spacing (40 cm × 40 cm) were significantly taller compared to those plants at closer spacing. Among the nitrogen levels applied, nitrogen level 45 kg ha^{-1} gave maximum height of plant (84.61 cm, and 156.57 cm) at 35 and 70 DAT, respectively.

In yield attributes, the highest number of effective tillers m^{-2} (405) was recorded from row spacing of 10 cm × 10 cm which was followed by row spacing of 20 cm × 10 cm (292). The lowest value was recorded under row spacing of 30 cm × 10 cm (162). The highest number of effective tillers under lesser row spacing was mainly due to higher density maintained at closer row spacing. However, the length of panicle was recorded highest under row spacing of 30 cm × 10 cm (24.36 cm) which was at par with the length of panicle obtained under row spacing of 20 cm × 10 cm (24.27 cm) while row spacing of 10 cm × 10 cm recorded the lowest length of panicle. The lower plant density at wider spacing might have created a favourable environment allowing the plants to capture sufficient light and adequate amount of nutrients which further aided in promoting reproductive growth.Patel *et al*. (2023) also found that wider row spacing (60 cm) increased the plant height, number of branches plant^{-1} in soybean due to sufficient availability of sunlight and nutrients. The number of grains panicle^{-1} obtained under row spacing of 20 cm × 10 cm was highest which was followed by the number of grains panicle^{-1} obtained under row spacing of 30 cm × 10 cm and were found to be at par. Chaitanya *et al.*(2020) also in their research recorded maximum number of grains panicle^{-1} from row spacing of 20 cm. Significantly highest grain yield (1156.08 kg ha^{-1}) and straw yield (2398.93 kg ha^{-1}) were recorded under row spacing of 20 cm × 10 cm which was followed by row spacing of 30 cm × 10 cm. The difference in plant density obtained under row spacing of 20 cm × 10 cm and 30 cm × 10 cm resulted in the gap between yield of rice grain even though the number of grains panicle^{-1} were very close. Sanap *et al*. (2019) through their research found that higher grain yield (26.64 q ha^{-1}) and straw yield of rice (39.91q ha^{-1}) was obtained at 25 cm row spacing than row spacing of 20 cm but was at par with 30 cm spacing. Patel *et al*. (2022) found significantly higher seed and haulm yield of green gram under row spacing of 30 cm over 45 cm. This might be due to proper plant population which reduced the competition between intra row plants.

On perusal of data, among the nitrogen levels applied, application of 45 kg ha^{-1} produced significantly highest effective tillers m^{-2} (328) which was followed by the application of 30 kg ha^{-1} This might have resulted from higher production of tillers during active vegetative development at higher nitrogen level ultimately giving rise to higher number of effective tillers and simultaneous higher availability of nutrients in the soil sourced by higher dose of applied nitrogen facilitating better nutrient uptake. Similarly, application of 45 kg ha^{-1} nitrogen resulted in highest panicle length (24.47 cm) which was at par with the application of 30 kg ha^{-1} nitrogen. Highest grains panicle^{-1} (178.39) was observed under nitrogen application of 45 kg ha^{-1} which was at par with the application of 30 kg ha^{-1} nitrogen as well as 15 kg ha^{-1}. It was observed that with increasing nitrogen levels, there was a significant increment in grain yield where the highest grain yield (1382.71 kg ha^{-1}) and straw yield (2639.43 kg ha^{-1}) was obtained from nitrogen level of 45 kg ha^{-1} which was closely followed by application of 30 kg ha^{-1} nitrogen. Kaur *et al*. (2023) also found that yield of direct seeded basmati rice was highest with the application of 60 kg ha^{-1} N (40.06 q ha^{-1}) and was statistically at par with the application of 50 kg ha^{-1} N (38. 90 q ha^{-1}). This might be due to higher absorption of nitrogen and adequate partitioning of the nutrient deposits to reproductive plant parts at higher level of applied nitrogen which ultimately reflected on the grain and straw yield of rice. Javeed *et al*. (2018) also reported increase in straw yield with the increase in nitrogen levels. Jesiya *et al.* (2022) reported similar line of results where increase in nitrogen dose to 75 kg ha^{-1} recorded maximum plant height (118.13 cm), number of grains panicle^{-1} (196.70), grain yield (4.61 t ha^{-1}) and straw yield (11.38 t ha^{-1}).

The soil nutrient status studied after harvest (Table 2) showed the row spacing did not inluence pH and organic carbon (%), however, the highest available N (287.02 kg ha^{-1}), P_2O_5 (22.81 kg ha^{-1}) and K_2O (119.36 kg ha^{-1}) was observed at row spacing of 30 cm × 10 cm which was followed by row spacing of 20 cm × 10 cm. This outcome might be due to low plant density under this spacing where nutrient depletion from soil by crop plants was lesser compared to higher plant density under closer spacing . Gohil *et al*. (2017) recorded highest available N, available P_2O_5, and available K_2O in the soil after harvest under 30 cm row spacing. Among the levels of nitrogen applied, it showed only significant effect on available N while no significance was recorded for pH, organic carbon, available P_2O_5 and K_2O (kg ha^{-1}). It was found that 45 N kg ha^{-1} recorded the highest N after harvest which might have rendered the soil with suffifient nitrogen which gradually improved available N and resulted in maximum available N (301.96 kg ha^{-1}). Kaur *et al.* (2023) also reported significantly higher available nitrogen in soil through application of 60 kg N ha^{-1} as compared to other lower levels of application.

Data regarding interaction effect of the parameters studied showed significant effect in plant height, number of effective tillers m^{-2}, grain yield, straw yield and available nitrogen in soil which are presented in Table 3. The row spacing of 30 cm × 10 cm and nitrogen level of 45 kg N ha^{-1} showed highest significant interaction effect on black rice at different stages.

Highest number of effective tillers m^{-2} was obtained from treatment combination of row spacing of 10 cm × 10 cm and nitrogen level of 45 kg N ha^{-1} which was followed by row spacing of 20 cm × 10 cm and nitrogen level of 45 kg N ha^{-1}. The higher plant density in closer spacing alomg with application of higher dose of nitrogen might have resulted in high number of effective tillers m^{-2}. Interaction effect of row spacing of 20 cm × 10 cm and nitrogen level of 45 kg N ha^{-1} showed significantly highest grain yield and straw yield which was followed by row spacing of 10 cm × 10 cm and nitrogen level of 45 kg N ha^{-1}. Even, if the competition between plants were lesser in higher row spacing of 30 cm × 10 cm , the higher plant density coupled with higher nitrogen dose was optimum to result in highest grain as well as straw yield. In the case of available nitrogen content in soil, spacing of 30 cm × 10 cm and nitrogen level of 45 kg N ha^{-1} showed the highest N content followed by nitrogen level of 30 kg N ha^{-1} under the same spacing. These results concord with the results found by Rajput *et al.* (2020) where the yield- attributing

Table 1. Effect of row spacing and nitrogen levels on plant height and yield attributes

Treatments	Plant height (cm)		No. of effective tillers (m^{-2})	Length of panicle (cm)	No. of grains panicle^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Spacing	35 DAT	70 DAT					
R_1-10 cm×10 cm	77.32	141.95	405	22.95	157.10	1065.48	2158.00
R_2-20 cm×10 cm	78.90	148.35	292	24.27	180.02	1156.08	2398.93
R_3-30 cm×10 cm	81.75	154.79	162	24.36	174.89	973.54	2141.84
S E m ±	0.52	0.74	2.99	0.16	2.96	8.69	37.35
CD (P=0.05)	1.54	2.19	8.88	0.48	8.79	25.80	110.92
Nitrogen levels							
N_0 - Control	74.66	140.67	250	22.81	160.65	828.92	1750.07
N_1 - 15 kg ha^{-1}	77.32	145.39	271	23.70	171.69	955.91	2083.88
N_2 - 30 kg ha^{-1}	80.69	150.82	297	24.46	171.94	1092.59	2458.33
N_3 - 45 kg ha^{-1}	84.61	156.57	328	24.47	178.39	1382.71	2639.43
S E (m) ±	0.25	0.48	4.15	0.23	2.84	16.56	29.85
CD (P=0.05)	0.74	1.42	12.33	0.69	8.44	49.21	88.68

Table 2. Effect of row spacing and nitrogen levels on soil nutrient status after harvest

Treatments	**pH**	**Organic carbon (%)**	Soil nutrient status after harvest		
			Available N(kg ha^{-1})	**Available P_2O_5 (kg ha^{-1})**	**Available K_2O (kg ha^{-1})**
Spacing					
R_1-10 cm×10 cm	4.63	0.82	250.77	20.86	115.52
R_2-20 cm×10 cm	4.65	0.85	258.61	22.64	117.77
R_3-30 cm×10 cm	4.60	0.83	287.02	22.81	119.36
Sem±	0.02	0.01	1.15	0.41	0.20
CD (P=0.05)	-	-	3.42	1.22	0.59
Nitrogen levels					
N_0 -Control	4.61	0.84	232.63	22.31	117.53
N_1 -15 kg ha^{-1}	4.62	0.85	253.72	22.08	117.99
N_2 -30 kg ha^{-1}	4.68	0.83	273.56	21.99	117.60
N_3 -45 kg ha^{-1}	4.60	0.80	301.96	22.04	117.08
SE (m)±	0.02	0.03	2.09	0.42	0.26
CD (P=0.05)	-	-	6.21	-	-

Table 3. Interaction effect of row spacing and nitrogen levels on number of effective tillers, grain yield, straw yield and available N

Treatment combinations	Plant height (cm)		No. of effective tillers (m^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Available N (kg ha^{-1})
	35 DAT	70 DAT				
R_1N_0	99.67	136.11	352.67	865.08	1741.33	213.87
R_1N_1	98.33	138.88	394.00	891.53	2010.21	235.43
R_1N_2	100.00	144.47	421.33	1079.36	2261.90	256.78
R_1N_3	99.33	148.32	451.00	1425.92	2418.57	297.01
R_2N_0	49.67	138.99	248.00	791.00	1731.11	230.67
R_2N_1	49.33	145.21	266.00	1031.75	2249.20	248.59
R_2N_2	50.00	151.22	305.00	1171.96	2636.90	261.39
R_2N_3	49.33	157.97	350.33	1629.63	2945.19	293.81
R_3N_0	33.00	146.91	150.67	830.69	1498.58	253.36
R_3N_1	33.00	152.07	154.00	944.44	1838.72	277.15
R_3N_2	31.67	156.76	163.33	1026.45	2142.85	302.52
R_3N_3	32.67	163.41	181.33	1092.59	2221.18	315.07
SE(m)±	0.38	0.83	7.19	28.69	51.70	3.62
CD (P=0.05)	1.13	2.46	21.35	85.21	153.56	10.75

REFERENCES

Bray, R.H. and L.T. Kurtz, 1945. Determination of soil organic and available form of phosphorus in soil, Soil Sci. **59** : 39-45.

Chaitanya, A., N.D. Parlawar, V.S. Khawale, P.C. Pagar and D.J. Jiotode, 2020. Influence of genotypes and row spacings on yield attributes, yield and economics in paddy under drilled condition, J. Soils and Crops, **30**(1) 90-93.

Escasinas, R.O. and O.B. Zamora, 2011. Agronomic response of lowland rice PSB Rc 18 (*Oryza sativa* L.) to different water, spacing and nutrient management. Philipp J. Crop Sci.**36**(1): 37-46.

Gohil, K.O., S.Kumar and A.L.Jat, 2017. Protein yield and nutrient uptake of summer green gram [(*Vigna radiata* L.) Wilczek] as influenced by seed priming with plant geometry and nutrient management. Int. J. Agri. Sci. 9(49): 4832-4834.

Gomez, K.A. and A.A. Gomez, 1976. Statistical procedure for agricultural research. Wiley International Science Publication, New York. pp. 660.

Hanway, J. and H.S. Heidal, 1952. Soil testing laboratory procedures, Jowa Agriculture, **57**: 1-37.

Jackson, M.L. 1967. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Jahan, M.S., S. Sultana and M.Y. Ali, 2014. Effect of different nitrogen levels on the yield performance of aromatic rice varieties. Bull. Insti. Tropi. Agri. **37**: 47-56.

Javeed, A., M.Gupta and V.Gupta, 2018. Effect of graded levels of N,P &K on growth, yield and quality of fine rice cultivars (*Oryza sativa* L.) under subtropical conditions. SSARSC, **3**(1): 2349-6975.

Jesiya, K., C. Umesha, M.R. Meshram and K. Akash, 2022. Effect of nitrogen levels and planting methods on growth and yield of black rice (*Oryza sativa* L.). Int. J. Environ. Clim.**12**(10): 578-583.

Jiang, M., P. Xu, W. Zhou, M. Shaaban, J. Zhao, T. Ren, Z. Lu and R. Hu, 2020. Prior nitrogen fertilization regulates CH_4 emissions from rice cultivation by increasing soil carbon storage in a rapeseed-rice rotation. Appl. Sci. Eco. **155**:103633.

Kaur, R., G.S.Chhina and A. Singh, 2023. Influence of nitrogen and phosphorus on yield, availability in soil and uptake under direct seeded Basmati Rice. J.Soils and Crops, **33** (2): 420-424.

Lin, H.X., C.R. Peng, X.L.Lei, Z.Q. Yuan, Y.P. Xiao, R.G. Liu, Q.F. Hu and J.G. Zhang, 2014. Effects of ratio of row spacing to intrarow spacing on yield and top three leaves of super high-yielding early and late rice. Agri. Sci. Tech.**15**(1): 52-56.

Patel, H.S., V.Surve, S.M.Bambhaneeya and A.D. Raj, 2023. Effect of time of sowing and row spacing on growth.yield and economics of soybean (*Glycine max* L.) J.Soils and Crops, **33** (1): 111-114.

Patel, P.T., A.D.Raj and V.R.Jinjale, 2022. Effcet of row spacing, variety and foliar spray on qulaity, nutrient content and upatke of summer green gram (*Vigna radiata*) under South Gujarat Condition. J.Soils and Crops, **32** (1): 37-44.

Piper, C.S. 1966. Soil and plant analysis, Hans Publishers, Bombay. pp. 368.

Rajput, P., A.K. Singh, R.K. Rajput and A. Singh, 2020. Effect of nitrogen levels on yield and yield attributes of rice (*Oryza sativa* L.) grown under different planting geometry. Indian J. Agron. **65**(2): 235-237.

Reuben, P., F.C. Kahimba, Z. Katambara, H.F. Mahoo, W. Mbungu, F. Mhenga, A. Nyarubamba, and M. Maugo, 2016. Optimizing plant spacing under the systems of rice intensification (SRI). Agri. Sci.**7**: 270-278.

Saha, S., S.Vijayakumar, S. Saha, A. Mahapatra, R. M. Kumar and R. M. Sundaram, 2022. Black rice cultivation in India prospects and opportunities. Chronicle Bioresource Manage. **6** : 44-48.

Sanap, K.V., N.D.Parlawar, P.T.Gaidhane and A.R.Jadhao, 2019. Effect of seed rate and spacing on grain yield of rice under aerobic situation (*Oryza sativa* L.) J.Soils and Crops, **29** (1): 121-125.

Subbiah, B.V. and G.L Asija, 1956.A rapid procedure for the estimation of available nitrogen in soils, Curr. Sci.**25**: 256-260.

Sultana, S. and D. S . Ningthoujam, 2023. Evaluation of plant growth promoting potential and biocontrol activities of *Bacillus sp. strain CA2*, a rhizobacteria from *Chakhao amubi*, J. Soils and Crops, **33**(1) : 78-84.

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