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Short Communication

Effect of different row spacing and nitrogen levels on growth attributes and nutrient uptake of lowland black rice (*Oryza sativa* L.)

KESONEIU KHUTSO, D NONGMAITHEM*, SHINGLOI H, NOYINGTHUNG KIKON, REKHA YADAV, LANUNOLA TZUDIR, A.P. SINGH, T. GOHAIN, TONGPANG LONGKUMER AND HILLEL CHISHI

Department of Agronomy, School of Agricultural Sciences, Medziphema, Nagaland 797106

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Black rice is a purplish-black coloured, aromatic variety of rice known to contain high concentration of anthocyanin, also posing as a good source of minerals like iron, zinc, calcium, magnesium, vitamins such as vitamin B1, vitamin B2. It contains high amount of antioxidants, protein and dietary fiber among other rice varieties. China globally tops in the production of black rice followed by India. Rice yield production is influenced by several factors. Nutrient supply and plant population may greatly affect the yield of the crop. Another key agronomic parameter that influences crop growth performance and crop yield is optimum plant spacing (Reuben *et al.,* 2016). With an objective to analyze the growth attributes of lowland black rice and its nutrient uptake as influenced by different row spacing and nitrogen levels, the experiment was conducted.

The experiment was conducted in the experimental field of School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland during the *Kharif* season of 2022. The experimental field was laid out in Split Plot Design (SPD) with three replications. The main plot consisted of row spacing R_1 (10 cm × 10 cm), R_2 (20 cm × 10 cm) and R_3 (30 cm × 10 cm), while the sub-plot consisted of nitrogen levels N_0 (Control), N_1 (15 kg N ha^{-1}), N_2 (30 kg N ha^{-1}) and N_3 (45 kg N ha^{-1}). The experiment consisted of twelve treatment combinations. Poireiton, a local black rice cultivar was used for this experiment and two weeks old seedlings were transplanted at different row spacing with one seedling $hill^{-1}$. Different levels of nitrogen through urea were applied in two split doses- first dose before the last puddling and remaining during active tillering stage. Full doses of P through SSP @ 15 kg ha^{-1} and K through MoP @ 30 kg ha^{-1} were applied as basal doses. Five plants were randomly selected and tagged for data collection.

Data recorded from the field readings showed significant effect on crop growth and yield attributes (Table 1) and nutrient uptake (Table 2) under the influence of row spacing and nitrogen levels. Highest plant height 35 DAT (81.75 cm) and 70 DAT (154.79 cm) was recorded from row spacing 30 cm × 10 cm while highest leaf area index (LAI), CGR and number of tillers m^{-2} were recorded from row spacing 10 cm × 10 cm at 35 and 70 DAT, respectively. A definite plant population was maintained throughout due to different row spacing used with maximum population (99) at row spacing R_1 (10 cm × 10 cm). Higher plant population at closer row spacing could have induced higher competition for space causing higher production of leaves per unit area hence the significant difference in leaf area while higher number of tillers at this row spacing could be attributed to higher plant stand at closer spacing hence the increase in number of tillers. These findings are supported by Saju *et al.* (2019) and Karkee *et al.* (2020). Increase in LAI and CGR at closer spacing than wider spacing in baby corn was also reported by Rino *et al.* (2020). Among the nitrogen levels applied, nitrogen level 45 kg ha^{-1} gave maximum plant height (84.61 cm, and 156.57 cm) at 35 and 70 DAT, respectively. Aparna *et al.* (2022) also reported similar findings. Highest LAI and number of tillers m^{-2} at 35 and 70 DAT were also exhibited from nitrogen level @ 45 kg ha^{-1}. Maximum number of tillers m^{-2} at higher level of applied nitrogen @ 120 kg ha^{-1} was reported by Arya *et al.* (2019). No significance was observed on RGR under the influence of either row spacing or nitrogen levels. The interaction effect of row spacing 10 cm × 10 cm and nitrogen level @ 45 kg ha^{-1} showed significant effect on LAI and number of tillers m^{-2}. The effect of row spacing on plant dry weight (g) was found to be significant at different stages. At 35 DAT, maximum dry weight of similar values

*Email: debikanong@gmail.com

Table 1: Effect of row spacing and nitrogen levels on growth attributes at different stages of crop growth and yield attribute

Treatments	Plant height (cm)		Plant population (m^{-2})	LAI		No. of tillers (m^{-2})		Dry weight (g $plant^{-1}$)		Crop growth rate (CGR) (g m^{-2} day^{-1})	Relative growth rate (RGR) (g g^{-1} day^{-1})	No. of panicles (m^{-2})	Grain yield (kg ha^{-1})
Spacing	35 DAT	70 DAT	70 DAT	35 DAT	70 DAT	35 DAT	70 DAT	35 DAT	70 DAT				
R_1 (10 cm × 10 cm)	77.32	141.95	99.33	1.32	3.20	385	542	2.15	13.87	20.25	0.02	404.75	1065.48
R_2 (20 cm × 10 cm)	78.90	148.35	49.58	0.62	1.64	324.23	442.49	2.18	12.54	12.87	0.03	292.33	1156.08
R_3 (30 cm × 10 cm)	81.75	154.79	32.58	0.40	0.92	198.06	345.35	1.89	11.80	8.39	0.03	162.33	973.54
SEm±	0.52	0.74	0.33	0.03	0.01	6.31	4.67	0.06	0.05	0.10	0.001	2.99	8.69
CD (P=0.05)	2.03	2.91	1.31	0.13	0.05	24.77	18.35	0.23	0.18	0.40	NS	11.74	34.14
Nitrogen levels													
N_0 (Control)	74.66	140.61	60.78	0.67	1.50	254.32	408.07	1.64	11.38	13.73	0.02	250.44	828.92
N_1 (15 kg ha^{-1})	77.32	145.39	60.22	0.75	1.91	271.82	430.00	1.94	12.31	13.75	0.03	271.33	955.91
N_2 (30 kg ha^{-1})	80.69	150.82	60.56	0.78	2.01	319	457	2.14	13.45	13.81	0.03	296.56	1092.59
N_3 (45 kg ha^{-1})	84.61	156.57	60.44	0.92	2.25	365	479	2.56	13.81	14.05	0.02	327.56	1382.71
SEm±	0.25	0.48	0.22	0.01	0.05	4.89	3.02	0.06	0.06	0.07	0.001	4.15	16.56
CD (P=0.05)	0.75	1.42	NS	0.04	0.16	14.53	8.96	0.17	0.19	0.22	NS	12.33	49.21
Interaction(R×N)													
SEm±	0.44	0.83	0.38	0.02	0.09	8.47	5.22	0.10	0.11	0.13	0.002	7.19	28.69
CD (P=0.05)	1.30	2.45	1.13	0.07	0.27	25.17	15.52	0.30	0.33	NS	NS	21.36	85.23

was obtained from row spacing R_1 (10 cm × 10 cm) and R_2 (20 cm × 10 cm), while R_1 exhibited higher dry weight at 70 DAT which may be accounted to rapid vegetative growth at this stage due to active tillering and high crop competition at closer spacing. Nitrogen levels exhibited significance at all stages of observation with maximum plant dry weight (g $plant^{-1}$) from N_3 (45 kg ha^{-1}) at both 35 and 70 DAT.

The effect of row spacing was found to be significant on number of panicles (m^{-2}). Highest number of panicles m^{-2} (404.75) was recorded in row spacing R_1 (10 cm × 10 cm) followed by R_2 (20 cm × 10 cm). The record of higher number of panicles in R_1 may be accounted to higher plant population maintained at closer row spacing and not by the number of panicles produced from individual plant. Lower number of panicles was observed in wider row spacing R_3 (30 cm × 10 cm) due to notable decrease in plant population. A similar finding by Karkee *et al.* (2020) reported that closer spacing 15 cm × 15 cm yielded higher number of tillers m^{-2}. Nitrogen applied at level N_3 (45 kg ha^{-1}) produced maximum number of panicles m^{-2}, followed N_2 (30 kg ha^{-1}). This is likely to have resulted from higher production of tillers during active vegetative development at higher nitrogen level ultimately giving rise to higher number of panicle bearing tillers. Lowest number of panicles m^{-2} was recorded from N_0 (Control). Similar results were exhibited in the research findings of Saha *et al.* (2017) and Karkee *et al.* (2020).

The effective response of the crop to different row spacing during its vegetative stage further facilitated significant grain yield potential. Row spacing 20 cm × 10 cm favoured the highest grain yield which may be attributed to adequate availability of nutrients, light and space to the plants without much competition. This result shows similarity with that of Singh *et al.* (2021). Among the nitrogen levels, highest grain yield was obtained from nitrogen level @ 45 kg ha^{-1}. The notable increase in grain yield at this level may be attributed to the overall performance of the crop with access to adequate uptake of nutrients due to more nutrient availability in the soil at higher dose of nitrogen. The interaction effect of row spacing 20 cm × 10

cm and nitrogen level @ 45 kg ha^{-1} exhibited significance on grain yield.

Table 2: Effect of row spacing and nitrogen levels on nutrient uptake (kg ha^{-1}) by grain

Treatments	NPK uptake (kg ha^{-1}) by grain		
Spacing	N	P	K
R_1	10.87	1.03	0.80
R_2	14.44	1.04	0.85
R_3	10.50	1.02	0.83
SEm±	0.12	0.002	0.01
CD (P=0.05)	0.46	0.01	0.03
	Nitrogen levels		
N_0	6.75	1.03	0.82
N_1	9.92	1.03	0.82
N_2	13.53	1.03	0.83
N_3	17.56	1.04	0.83
SEm±	0.18	0.004	0.01
CD (P=0.05)	0.53	NS	NS
Interaction(R×N)	0.92	NS	NS

Row spacing was found to significantly affect N, P and K content (%) in grain (Figure 1). Highest content of N (1.20 %), P (0.09 %) and K (0.11%) was obtained from row spacing 20 cm × 10 cm wherein optimal plant population was maintained thus ensuring adequate nutrient, light and space. Nitrogen levels caused significant effect on N content (%) in grain with the highest obtained from nitrogen level @ 45 kg ha^{-1}). This result may be attributed to the availability of higher nitrogen which promoted better vegetative and reproductive growth and furthermore, higher quality of grains. Similarly, highest N (14.44 kg ha^{-1}), P (1.04 kg ha^{-1}) and K (0.85 kg ha^{-1}) uptake by grain were obtained from row spacing 20 cm × 10 cm. A probable cause of this result could be the availability of adequate nutrient from this row spacing which facilitated higher uptake. Among the nitrogen levels, highest N uptake by grain was recorded from the highest level of applied nitrogen @ 45 kg ha^{-1} which may be ascribed to higher N content (%) obtained from this nitrogen level. This result agrees with the findings of Karkee *et al.* (2019). Increase in N uptake with increase in applied levels of nitrogen was also reported by Maurya *et al.* (2021). The interaction effect on nutrient content and uptake by grain was found to be most significant from the treatment combination of row spacing 20 cm × 10 cm and nitrogen level @ 45 kg ha^{-1}.

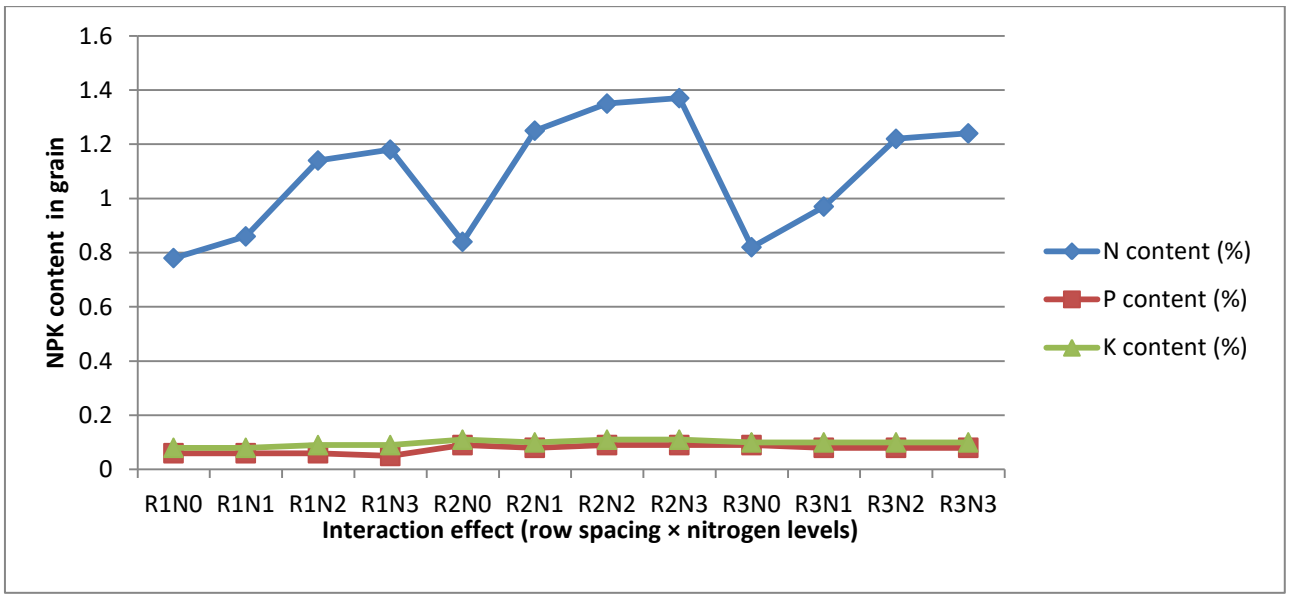

Figure 1: Interaction effect of row spacing and nitrogen levels on nutrient content (%) in grain

The influence of row spacing and nitrogen levels showed significant effect on various crop growth attributes such as plant population m^{-2}, leaf area index (LAI), number of tillers m^{-2}, and grain yield (kg ha^{-1}). Through the experiment conducted, it may be concluded that row spacing 10 cm × 10 cm imparted maximum growth response due to higher plant population while row spacing 20 cm × 10 cm imparted maximum nutrient content as well as uptake. Higher dose of nitrogen @ 45 kg ha^{-1} exhibited maximum response from all crop aspects.

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