Effect of crop establishment methods and nitrogen levels on growth, yield attributes and yield of coarse rice

Abstract

A field experiment was conducted during *kharif* 2020 at farm of College of Agriculture, Kaul (Kaithal) of CCS Haryana Agricultural University, Hisar to investigate the response of short duration non-scented rice variety HKR-48 to nitrogen under two different methods of crop establishment. The experiment was laid out in RBD factorial design consisting of two establishment methods *i.e.* direct seeded (DSR) and transplanted (TPR) as main plot treatments and six different levels of nitrogen (0, 30,60,90,120 and 150 kg/ha) in sub- plots with three replications.The experiment showed that plants grown under the DSR method had greater height and tiller production at all growth stages but experienced higher tiller mortality later on. DSR also resulted in higher early-stage dry matter accumulation compared to TPR, but there was no significant difference at later stages or at harvest. Although the number of effective tillers did not significantly differ between DSR and TPR, DSR had 16% more grains per panicle with the same test weight. However, the transplanted crop had a significantly higher grain yield (11.9%) compared to the direct-seeded crop. Increasing nitrogen dosage up to 120 kg N/ha positively influenced growth parameters and yield-contributing characters. There was no significant difference between 120 kg N/ha and 150 kg N/ha in respect of growth indicators. Grain yield was significantly enhanced with increased nitrogen dosage, but the difference between 120 kg N/ha and 150 kg N/ha was not significant.

Keywords: **Rice; Nitrogen; DSR; TPR**

Introduction

Rice is a crucial food crop grown extensively in many countries, particularly in Asia. In Asian countries, India has the highest area under rice (43.8 m ha) and it is the second-largest producer (121.4 mt) of rice after China in the year 2020. Though the basmati rice lured the farmers for its favorable economics in the last decade but due to availability of minimum support price of coarse rice again made the farmer's inclination towards dwarf coarse rice. Thus, coarse rice has become the preference of the farmers due to its assured output and marketing.

The traditional method of transplanting rice has resulted in excessive water usage, leading to decline in water table and negative impacts on the environment and soil. This includes increased methane emissions, the formation of a compacted layer in the soil, reduced permeability in the subsurface layer, and decreased productivity of subsequent crops. Direct seeding of rice (DSR) is considered a more sustainable and efficient method as it conserves water, reduces methane emissions, requires less labor, lowers input costs, and prevents the formation of a compacted layer, resulting in improved growth of subsequent crops. As a result, DSR is gaining popularity among rice growers, seeking maximum returns.Nitrogen is a vital nutrient for rice growth and yield, influencing factors such as tillering, panicle formation, grain development, and ultimately grain yield. Coarse rice, in particular, requires higher nitrogen levels compared to aromatic rice. Therefore, determining the most appropriate amount of nitrogen fertilizer is crucial for achieving higher yields in coarse rice cultivation.

While studying crop establishment methods, such as direct seeding, it is important to assess the response of nitrogen under the new establishment technique. Nutrient dynamics in DSR may differ from traditional transplanting methods due to alternating wetting and drying conditions. Considering these factors, the present experiment aims to study the effects of crop establishment methods and nitrogen levels on the growth, yield attributes and yield of coarse rice.

Materials and methods:

The field experiment was conducted during the Kharif season of 2020 at the Research Farm of CCS HAU, College of Agriculture, Kaul (Kaithal), Haryana. The soil in the field was sandy clay loam with moderate organic carbon content (0.52%), low available nitrogen (182 kg/ha), medium phosphorus (32 kg/ha), high potash (385 kg/ha), and slightly alkaline pH (8.1) with an electrical conductivity (EC) of 2.8 dS/m. Rice variety HKR-48 was sown. The experiment followed a randomized block design (RBD) factorial design with two establishment methods (direct seeding and transplanting) as the main plots and six nitrogen levels (0, 30, 60, 90, 120, and 150 kg/ha) as the subplots, replicated three times.

Data collection involved selecting and tagging five random hills from each plot to take measurements. Plant height was recorded at 30, 60, and 90 days after sowing (DAS) for direct-seeded rice (DSR) and days after transplanting (DAT) for transplanted rice (TPR), as well as at harvest. The height was measured from the base of the plant to the highest point of the longest tiller using a meter scale. The average height of the five plants was calculated to determine the mean plant height of each plot. The number of tillers per plot was counted at 30, 60, and 90 days and at harvest of selected five hills, and the mean number of tillers per hill was calculated. The number of tillers per square meter was obtained by multiplying the mean number of tillers per hill by 33.33, considering the crop spacing of 20 X 15 cm^2. Dry matter accumulation per square meter was assessed at 30, 60, 90 days, and at harvest. Three hills from each plot were cut down, sun-dried, and then oven-dried at 70°C for 48 hours. The average dry matter obtained from these three hills was used to calculate the mean dry matter accumulation per square meter for each plot.

The number of tiller bearing panicles was counted from five selected hills at 30, 60, 90 days, and at harvest, just before harvesting. The mean number of effective tillers per hill was calculated, and the number of tillers per square meter was determined using basic mathematical calculations. The number of grains per panicle was counted from ten randomly selected effective panicles taken from each plot, and the mean number of grains per panicle was computed for each plot by averaging the counts. Test weight was determined by weighing 1000 grains from each plot after drying them to a moisture level of 12-14%. After harvesting, paddy was threshed separately for each plot and then weighted at 14% moisture level which was then converted to grain yield (kg/ha).

Results and discussion

Growth parameters

TPR exhibited more plant height than DSR throughout all growth stages. The highest plant height was observed with a nitrogen level of 150 kg N/ha, which was significantly greater than other levels but comparable to 120 kg N/ha. This could be attributed to the fact that increased nutrient supply improved photosynthesis and facilitated efficient transport of photosynthates, resulting in enhanced plant height. In contrast, the number of tillers per square meter was significantly higher in DSR compared to TPR at all growth stages. Tillers increased until 60 DAS and then decreased until maturity regardless of the establishment methods. The application of higher nitrogen doses from the control to 120 kg N/ha significantly increased the number of tillers per square meter, which was similar to the count obtained with 150 kg N/ha. The promotion of nitrogen metabolism and protein synthesis contributed to greater vegetative growth and a higher number of tillers.

During the early stages (30 DAS and 60 DAS), dry matter accumulation was significantly higher in DSR than TPR. However, at 90 DAS and during the harvest stage, the difference was not significant, and the highest accumulation was observed at harvest, regardless of the establishment methods. Dry matter accumulation increased significantly with each increment of nitrogen doses from the control to 120 kg N/ha at 60 DAS, 90 DAS, and harvest. However, increasing nitrogen from 120 to 150 kg N/ha did not significantly improve dry matter accumulation at most stages of crop growth. The increase in nitrogen doses facilitated significant dry matter accumulation due to enhanced meristematic activity, resulting in greater plant height, a higher number of tillers, and a larger photosynthetically active leaf area. Nitrogen fertilization stimulated cell elongation and division, influencing growth parameters, as indicated by Dahipahle*et al.* (2018) and Sah*et al*. (2019). The increasing trends in the number of tillers per square meter and dry matter accumulation per square meter align with the findings of Muthry*et al*. (2012), Haque and Haque (2016), and Lama and Marahatta*et al.* (2017).

The improved growth parameters (plant height, number of tillers, and dry matter) observed in transplanted rice might be attributed to the advantages of better initial growth promoting factors (such as water, space, and nutrients) available in puddled field conditions compared to direct-seeded crop. These results support the findings of Lama and Marahatta*et al.* (2017).

Yield and yield attributes:

The various attributes of yield such as grain/panicle, test weight, grain yield, straw yield, biological yield, and harvest index, showed an increasing trend with higher nitrogen levels. The treatments receiving 150 kg N/ha, along with those receiving 120 kg N/ha, exhibited the highest values for these yield parameters and grain yield. This could be attributed to improved growth parameters, which resulted in increased production and translocation of photosynthates. The availability of more nutrients to the crop led to an increase in leaf area index, which facilitated the development of more photosynthetically active organs, ultimately leading to higher production and accumulation of assimilates in the sink, resulting in more economic yield. These findings corroborated with previous studies conducted by Ramesh *et al.* (2009), Thind*et al.* (2017) and Dahipahle*et al.* (2018).

One of the main reasons for the 11.9% higher grain yield in TPR compared to DSR was the presence of more grains per panicle. This could be attributed to the higher availability of nutrients, light, and moisture in TPR due to puddling, which reduced percolation losses. On the other hand, the lower yield in DSR was due to water loss through seepage and percolation, as well as nutrient loss through leaching. These findings are consistent with the results reported by Singh *et al*. (2015), Kumar and Batra (2017), and Mauriya*et al.* (2019).

Table 1: Plant height of coarse rice at different growth stages as affected by methods of establishment and nitrogen levels

Treatments	**Plant height (cm)**			
Methods of establishment	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
DSR	30.3	64.0	103.5	104.0
TPR	33.7	71.9	113.4	114.0
SE(m) ±	0.2	0.5	1.0	1.0
CD (P=0.05)	0.6	1.6	3.0	2.9
Nitrogen levels (kg ha^{-1})				
N_1:0	31.3	57.0	85.1	85.5
N_2:30	31.5	63.3	102.5	102.9
N_3:60	31.7	67.4	108.6	109.2
N_4:90	32.4	70.8	114.2	114.9
N_5:120	32.5	74.3	119.7	120.3

N_6:150	32.6	75.0	120.5	121.2
SE(m) ±	0.3	0.9	1.8	1.7
CD (P=0.05)	NS	2.7	5.2	5.1

Table 2: Number of tillers/m^2 of coarse rice at different growth stages as affected by methods of establishment and nitrogen levels

Treatments	**No. of tillers/m^2**			
Methods of establishment	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
DSR	47.0	285.9	269.9	264.0
TPR	33.3	272.3	264.0	260.7
SE(m) ±	0.9	2.6	1.8	1.2
CD (P=0.05)	2.7	7.7	5.4	NS
Nitrogen levels (kg ha^{-1})				
N_1:0	36.6	202.8	192.3	189.3
N_2:30	37.7	250.2	238.5	234.3
N_3:60	41.1	287.2	274.8	271.2
N_4:90	41.1	306.5	292.3	287.5
N_5:120	42.2	312.0	300.0	294.0
N_6:150	42.2	316.0	303.7	297.7
SE(m) ±	1.6	4.6	3.2	2.0
CD (P=0.05)	NS	13.5	9.5	6.1

Table 3: Dry matter accumulation of coarse rice at different growth stages as affected by methods of establishment and nitrogen levels

Treatments	**Dry matter accumulation (g/m^2)**			
Methods of establishment	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
DSR	13.2	306.0	552.1	591.2
TPR	7.9	292.7	548.6	592.1
SE(m) ±	0.2	1.2	1.9	2.1
CD (P=0.05)	0.7	3.5	NS	NS
Nitrogen levels (kg ha^{-1})				
N_1:0	9.5	207.8	371.2	396.6
N_2:30	9.9	267.3	483.3	516.6
N_3:60	10.9	311.1	571.7	612.1
N_4:90	10.9	331.7	612.9	662.8
N_5:120	11.2	337.9	627.9	676.9
N_6:150	11.2	340.6	635.0	684.8
SE(m) ±	0.2	2.0	3.3	3.7

CD (P=0.05)	0.7	6.0	9.8	11.0

Table 4: Yield and yield attributes of coarse rice as affected by methods of establishment andnitrogen levels

Treatments	Yield attributes			Grain yield (kg/ha)
Methods of establishment	**Number of effective tillers m^{-2}**	**Number of grains panicle^{-1}**	**Test weight (g)**	
DSR	258.7	92.5	24.2	4754
TPR	255.7	107.7	24.5	5319
SE(m) ±	1.2	1.3	0.1	28
CD (P=0.05)	NS	3.9	NS	84
Nitrogen levels (kgha^{-1})				
N_1:0	184.3	69.2	22.9	4111
N_2:30	229.3	84.3	23.8	4658
N_3:60	266.8	100.5	24.2	5048
N_4:90	282.2	110.7	24.6	5294
N_5:120	288.3	117.0	25.2	5488
N_6:150	292.2	119.0	25.1	5620
SE(m) ±	2.0	2.3	0.2	49
CD (P=0.05)	6.0	6.9	0.6	145

Conclusion:

The rice variety HKR-48 demonstrated superior performance when transplanted rather than directly seeded. There were no notable variations in effective tillers between direct seeding (DSR) and transplanting (TPR). Transplanting conditions produced approximately 16% more grains per panicle and yielded about 12% more grains overall. In terms of growth and yield parameters, the test variety showed a significant response to varying levels of nitrogen. The maximum grain yield was achieved with 150 kg N/ha, which was comparable to the yield obtained with 120 kg N/ha.

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