Effect of crop establishment methods and nitrogen levels on phenology, quality, nutrient content and uptake of coarse rice

Abstract

A field experiment was conducted during the kharif season of 2020 at the farm of College of Agriculture, Kaul (Kaithal) of CCS Haryana Agricultural University, Hisar. The objective of the experiment was to study the response of a short-duration non-scented rice variety called HKR-48 to nitrogen fertilization under two different methods of crop establishment. The experiment followed a randomized block design (RBD) factorial design with the two establishment methods (direct seeding and transplanting) as main plot treatments and six levels of nitrogen (0, 30, 60, 90, 120, and 150 kg/ha) as sub-plot treatments, with three replications.The results of the experiment showed that the transplanted crop took longer to initiate tillering, anthesis (flowering), and reached maturity slightly earlier compared to the direct-seeded crop. However, both establishment methods showed similar timing for panicle emergence. The methods of crop establishment did not have a significant effect on kernel length, kernel breadth, NPK content, and protein content of the grains. However, the transplanted crop had improved hulling, milling, and head rice recovery compared to the direct-seeded crop.With increasing nitrogen levels, there was a delay in the days taken to attain tillering, panicle emergence, anthesis, and physiological maturity, following a graded response. The kernel length and breadth were not influenced by the graded doses of nitrogen. However, the quality parameters such as hulling, milling, head rice recovery, and protein content of the grains improved significantly with increasing nitrogen levels. The phosphorus (P) and potassium (K) content in the grain and straw remained unaffected by the different nitrogen doses, except for nitrogen content. The uptake of NPK by the crop (grain and straw) showed an increasing trend with higher nitrogen application.

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Keywords: **Rice, Nitrogen, DSR, TPR, Quality, Content, Uptake, Phenology**

Introduction

Rice is a vital staple crop that is extensively cultivated in several countries, particularly in Asia. India holds the largest area dedicated to rice farming, with 43.8 million hectares, and ranked as the second-largest producer after China, with 121.4 million metric tons(Anonymous2020). In recent years, basmati rice gained popularity among farmers due to its economic advantages, but the availability of a minimum support price for coarse rice has shifted

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farmers' preference back to non-scented dwarf rice. Coarse rice is now favored by farmers due to its assured output and market demand.However, the traditional method of transplanting rice has led to excessive water usage, causing adverse environmental and soil effects such as declining water table, increased methane emissions, compacted soil layers, reduced permeability, and decreased productivity of subsequent crops (Sharma ,2003). As a result, direct seeding of rice (DSR) has emerged as a more sustainable and efficient approach. DSR conserves water, reduces methane emissions, requires less labor, lowers input costs, and prevents the formation of compacted soil layers, promoting better growth of subsequent crops. Consequently, DSR has gained popularity among rice growers in recent years.

Nitrogen plays a crucial role in rice growth and yield, affecting various factors including tillering, panicle formation, grain development, and overall grain yield. It is essential to apply the appropriate amount of nitrogen fertilizer to achieve optimal crop yield, quality, environmental sustainability, and economic considerations, especially in intensive rice cultivation area. Coarse rice, in particular, requires higher nitrogen levels compared to aromatic rice. Thus it is important to evaluate the response of nitrogen application undercrop establishment methods like direct seeding. Nutrient dynamics in DSR may differ from traditional transplanting methods due to alternating wetting and drying conditions. Considering these factors, the current experiment was done to investigate the effect of different crop establishment methods and nitrogen levels on the phenology, quality, nutrient content, and nutrient uptake in 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 had a sandy clay loam texture and moderate organic carbon content (0.52%). The available nitrogen was low (182 kg/ha), phosphorus was medium (32 kg/ha), and potash was high (385 kg/ha). The soil pH was slightly alkaline (8.1), and the electrical conductivity (EC) was 2.8 dS/m. The rice variety used in the experiment was HKR-48. The experimental design followed a randomized block design (RBD) factorial design, with two establishment methods (direct seeding and transplanting) as main plots and six nitrogen levels (0, 30, 60, 90, 120, and 150 kg/ha) as subplots. The experiment was replicated three times.

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Phenological studies were undertaken to evaluate different growth stages of the rice crop under each treatment. The number of days taken to reach tillering, panicle emergence, anthesis (initiation of flowering), and physiological maturity were recorded for both the transplanting (TPR) and direct seeding (DSR) methods.Quality parameters of the rice grains were also assessed. The kernel length was measured by randomly selecting ten grains from each plot and taking the average length in millimeters (mm). The length-to-breadth ratio (L:B) was calculated by measuring the breadth of the same ten grains and determining the ratio. Hulling percentage, which indicates the efficiency of hull removal, was calculated by dividing the weight of hulled rice by the weight of paddy and multiplying by 100. Similarly, milling percentage, which indicates the efficiency of bran and aleuronic layer removal, was calculated by dividing the weight of milled rice by the weight of paddy and multiplying by 100. Head rice recovery, representing the percentage of whole grains after milling, was determined by dividing the weight of head rice by the weight of paddy and multiplying by 100. The protein content in the grains was calculated by multiplying the nitrogen concentration in the grains with a factor of 6.25.

Nutrient studies focused on the nitrogen (N), phosphorus (P), and potassium (K) content in the grains and straw. Samples of both grain and straw were dried, ground, and digested with specific acid mixtures to estimate the nitrogen content using the Nessler's Reagent Method, while phosphorus and potassium were estimated using the Vanadomolybdophosphoric Yellow Color Method and Flame Photometer Method, respectively. Additionally, the uptake of N, P, and K by the grain and straw was calculated in kilograms per hectare (kg/ha).

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$$\text{Nutrient uptake by grain (kg/ha)} = \frac{\text{Nutrient content in grain (\%) X Grain yield (kg /ha)}}{100}$$

$$\text{Nutrient uptake by straw (kg/ha)} = \frac{\text{Nutrient content in straw (\%)X Straw yield (kg /ha)}}{100}$$

Results and discussion

The phenological studies revealed that transplanted rice took more days to reach the tillering stage compared to direct-seeded rice. However, there was no significant difference between the two establishment methods in terms of days taken for panicle emergence. The days taken for anthesis were higher in transplanted rice. Transplanted crop also matured slightly earlier than direct-seeded crops, by about 3-4 days.

The number of days taken for all phenological stages increased with higher nitrogen levels. This could be attributed to the fact that increased nitrogen levels prolonged the plant's photosynthetic activity, resulting in an extended vegetative period and slower development of phenological stages and senescence. These findings align with a previous study by Singh et al. (2017).

Regarding quality parameters, the length, breadth, and length-to-breadth ratio (L:B) of rice kernels did not differ significantly between the two establishment methods or nitrogen levels. However, the protein content of grains increased with higher nitrogen rates, with the highest protein content observed under 150 kg N/ha. These results are consistent with the findings of Gautam et al. (2008) and Maqsood et al. (2013).

Hulling percentage, milling percentage, and head rice recovery showed significant differences based on the establishment methods and nitrogen levels. The highest values were observed under transplanted conditions and with the application of 150 kg N/ha. This could be attributed to better nutrient availability, reduced percolation losses, and sufficient spacing in rows. These findings are in line with the results of Gautam et al. (2008).

In terms of nutrient studies, the N, P, and K content in grains and straw did not show significant differences between the two establishment methods. However, increasing nitrogen levels led to a significant increase in nitrogen concentration in grains and straw, with the highest concentration observed under 150 kg N/ha. This might be attributed to increased uptake and availability of nitrogen to the plants. These results support the findings of Kabat and Satapathy (2011).

The uptake of N, P, and K by grain and straw showed significant differences between the two establishment methods and the application of increasing nitrogen doses. Transplanted rice had higher nutrient uptake compared to direct-seeded rice, and the uptake was highest under the application of 150 kg N/ha due to higher grain and straw yield. These results are consistent with the findings of Nandan et al. (2020).

Table 1: Days taken to different phenological stages in coarse rice as affected bymethodsof establishment and nitrogen levels

Treatments	**Phenological stages**			
Methods of establishment	**Days taken to Tillering**	**Daystakento panicle emergence**	**Days taken to anthesis**	**Days taken to physiological maturity**
DSR	27.9	56.4	84.3	117.8

TPR	35.0	56.2	85.3	114.3
SE(m) ±	0.2	0.2	0.2	0.3
CD (P=0.05)	0.5	NA	0.6	0.8
Nitrogen levels (kg ha^{-1})				
N_1:0	30.0	54.2	82.2	112.8
N_2:30	31.2	55.8	84.2	114.0
N_3:60	31.3	56.3	85.2	115.2
N_4:90	32.0	56.8	85.3	116.5
N_5:120	32.0	57.3	86.2	118.2
N_6:150	32.2	57.3	85.8	119.5
SE(m) ±	0.3	0.4	0.3	0.5
CD (P=0.05)	0.9	1.2	0.9	1.4

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Table 2: Grain quality parameters of coarse rice as affected by methods of establishment and nitrogen levels

Treatments	**Quality parameters**		
Methods of establishment	**Kernel length (mm)**	**Kernel breadth (mm)**	**Length : Breadth**
DSR	6.93	1.94	3.56
TPR	7.08	1.95	3.63
SE(m) ±	0.08	0.01	0.05
CD (P=0.05)	NS	NS	NS
Nitrogen levels (kg ha^{-1})			
N_1:0	6.77	1.91	3.54
N_2:30	6.87	1.92	3.57
N_3:60	6.97	1.95	3.58
N_4:90	7.10	1.95	3.63
N_5:120	7.13	1.98	3.60
N_6:150	7.18	1.96	3.66
SE(m) ±	0.15	0.20	0.09
CD (P=0.05)	NS	NS	NS

Table 3: Grain quality parameters of coarse rice as affected by methods of establishment and nitrogen levels

Treatments	**Quality parameters**			
Methods of establishment	**Hulling percentage**	**Milling percentage**	**Head rice recovery (%)**	**Protein content in grains (%)**
DSR	74.7	67.7	50.6	7.5
TPR	75.6	68.3	51.9	7.4

SE(m) ±	0.2	0.1	0.2	0.04
CD (P=0.05)	0.5	0.4	0.5	NS
Nitrogen levels (kg ha^{-1})				
N_1:0	74.0	65.3	48.7	5.8
N_2:30	74.3	66.7	50.1	6.5
N_3:60	74.8	68.5	51.6	7.2
N_4:90	75.2	69.0	52.1	7.8
N_5:120	76.0	69.3	52.5	8.4
N_6:150	76.9	69.6	52.5	8.9
SE(m) ±	0.3	0.2	0.3	0.07
CD (P=0.05)	0.8	0.7	0.8	0.2

Table 4: Nutrient (N, P and K) content in coarse rice grain and straw as affected by methods of establishment and nitrogen levels

Treatments	**N, P and K content in grain (%)**			**N, P and K content in straw (%)**		
Methods of establishment	**N**	**P**	**K**	**N**	**P**	**K**
DSR	1.2	0.23	0.21	0.61	0.14	1.45
TPR	1.2	0.23	0.20	0.62	0.14	1.45
SE(m) ±	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen levels (kg ha^{-1})						
N_1:0	0.92	0.22	0.20	0.47	0.13	1.20
N_2:30	1.04	0.23	0.20	0.52	0.13	1.36
N_3:60	1.15	0.24	0.20	0.59	0.14	1.44
N_4:90	1.24	0.23	0.20	0.66	0.14	1.55
N_5:120	1.35	0.24	0.21	0.71	0.15	1.57
N_6:150	1.42	0.25	0.21	0.75	0.15	1.58
SE(m) ±	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.03	NS	NS	0.03	NS	0.03

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Conclusion:

The experiment showed that direct-seeded rice (DSR) had slightly earlier tiller emergence compared to transplanted rice (TPR), with no significant difference in panicle emergence. However, TPR reached the anthesis stage slightly later but matured earlier than DSR. The number of days taken for different growth stages increased with higher nitrogen levels. Grain quality parameters such as protein content, length, breadth, and length-to-breadth ratio (L:B) did not differ significantly between the establishment methods or nitrogen levels. However, transplanted rice exhibited higher hulling percentage, milling percentage, and head rice recovery. Among the nitrogen treatments, these quality parameters varied significantly. The nitrogen, phosphorus, and potassium content in grains and straw did not differ significantly between DSR and TPR. However, the uptake of these nutrients was higher in transplanted rice due to its higher yield. The nitrogen concentration in grains and straw increased significantly with higher nitrogen doses, with the highest values observed under the treatment receiving 150 kg N/ha. These findings indicated that the establishment methods did not significantly affect grain quality parameters and nutrient content, transplanted rice showed advantages in terms of hulling, milling, head rice recovery, and nutrient uptake.

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