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Influence of Methods of Establishment and Nitrogen Levels on Yield, Yield Attributes and Nitrogen Uptake of Dry Seeded Rainfed Lowland Rice

SAYAN GHOSH, LALICHETTI SAGAR*, M. DEVENDER REDDY AND RANJEET SINGH BOCHALAYA[1]

Department of Agronomy and Agroforestry, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Gajapati-761 211 (Odisha), India
**(e-mail: lalichetti.sagar@cutm.ac.in; Mobile: 70065 05360)*

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ABSTRACT

Rice (*Oryza sativa* L.) is a staple crop vital to food security, particularly in Asia, yet its productivity remains low, especially in Southern Odisha. The conventional transplanting method is labour-intensive, costly and highly susceptible to climate change. In this context, Dry Seeded Rice (DSR) is gaining attention as a resource-efficient and climate-resilient alternative. However, the absence of standing water in DSR system leads to accelerated nitrogen losses, making nitrogen management critical for improving growth and yield of rice. To address this challenge, the present research was laid out in split plot design comprising four methods of establishment in main plot (broadcasting, line sowing, hill sowing and transplanting without piddling) and four nitrogen levels in sub plot (0, 40, 80 and 120 kg N/ha) which were replicated thrice. The results indicated that grain and straw yield, nitrogen content in grain and straw as well as nitrogen uptake in grain, straw and total were not significantly influenced by methods of establishment. However, nitrogen levels had a significant influence on the above-mentioned parameters with the highest values recorded by 120 kg N/ha which was on par with 80 kg N/ha both in terms of grain and straw yield. Therefore, application of 80 kg N/ha irrespective of methods of establishment could be the most optimum nitrogen level to achieve sustainable productivity in dry-seeded rainfed lowland rice.

Key words: Dry seeding, methods of rice crop establishment, nitrogen levels, rainfed lowland rice

INTRODUCTION

Rice is the most important cereal food crop of the developing world and staple food for more than 3 billion people of the world (Birla *et al*., 2017). In India, rice occupies an area of 46.38 million hectares with an annual production of 130.29 million tonnes and productivity of 2829 kg/ha (GoI, 2023). The state of Odisha is one of the leading states of rice both in area (3.94 million hectares) and production (9.14 million tonnes) with a low productivity (2318 kg/ha; GoO, 2023).

In Odisha, particularly in the southern region, rice cultivation is predominantly carried out through the conventional method of transplanting seedlings into puddled fields. This method necessitates farmer to prepare fields through puddling and then transplant young seedlings, which was highly labour-intensive, time-consuming and costly (Kaur and Singh, 2017). Moreover, in this region, frequent early-season droughts often delay transplanting by 1 to 3 weeks adversely affecting crop establishment and overall productivity (Shahid *et al*., 2021).

In this scenario, dry seeded rice can be an alternative method to conventional transplanted rice as it avoids puddling and transplanting of young seedlings and requires less water, labour, time and cultivation cost.. Therefore, gaining attention as a promising alternative to the conventional puddled transplanted rice system, DSR eliminates the need for puddling and transplanting, thereby reducing water usage, labour requirements and operational costs (Chaudhary *et al*., 2023). Studies have shown that dry seeding not only

[1]Department of Agronomy, Maharishi Markendeshwar (Deemed to be University), Mullana, Ambala-133 203 (Harayana), India.

conserves resources but also offers better adaptability to climate variability, making it a suitable option for sustainable rice production in regions like southern Odisha (Surendran *et al*., 2021). The DSR presents several agronomic challenges such as high weed infestation and greater nitrogen losses that adversely impact crop productivity (Horvath *et al.,* 2023).

The productivity of rice is influenced by nutrient management besides other practices (Ishfaq *et al*., 2021). Nitrogen is a critical input for enhancing the growth and yield of rice, but its efficient use in DSR remains a significant challenge (Mrudhula *et al.,* 2021). The nitrogen fertilizer application is essential to get high yields. The information on nitrogen requirement of dry seeded rice under rainfed conditions for realizing optimum yield for Odisha is meagre. In this backdrop, the present study was conducted.

MATERIALS AND METHODS

The field experiment was conducted at Post Graduate Research Farm, M. S. Swaminathan School of Agriculture, Gajapati district, Odisha 18°80'49" N latitude and 84°17'90" E longitude located at an altitude of 87 m above the mean sea level under typical sub humid and tropical climatic conditions with sandy loam soil. During the experimental period, the maximum and minimum temperatures varied from 31°C to 34°C and 21°C to 27°C, respectively. A total rainfall of 799 mm was recorded during the study period. Sunshine hours ranged from 4 to 9 h/day, while pan evaporation varied between 2.7 to 3.5 mm/day. During the crop growing period, the relative humidity in the morning varied from 84 to 87% and in the afternoon ranged from 65 to 82%.

The soil of the experimental site was characterized as sandy loam in texture with slightly acidic pH. The organic carbon content was low (0.49%), and the available nitrogen was also low (196 kg/ha). The soil had moderate levels of available phosphorus (14 kg/ha) and potassium (125 kg/ha).

The study was carried out using the rice variety RNR 15048, following the recommended fertilizer dose of 80:40:40 kg N:P_2O_5:K_2O/ha. The experimental design was a split plot design comprising four methods of establishment in main plot viz., broadcasting, line sowing, hill sowing and transplanting without puddling and four nitrogen levels in sub-plot viz., 0, 40, 80 and 120 kg N/ha were replicated thrice.

The dry seeding was done on July 2, 2024 in a well-prepared soil as per the treatment methods and on the same day nursery was sown for transplanting which was done on August 1, 2024. The nitrogen fertilizer at 50% of each treatment was applied at the time of sowing or transplanting and remaining 50% of nitrogen was applied in two equal splits at tillering and panicle initiation stages of the crop. The entire quantity of phosphorus (40 kg/ha) and potassium (40 kg/ha) was applied as basal dose before sowing/transplanting. Care was taken to control the weeds by applying pendimethalin @ 1 kg a.i per ha at 3 DAS/DAT. One hand weeding was done at 30 days after sowing in dry seeded crop and 20 days after transplanting in transplanted crop. The crop was purely grown with the rainfall received and no irrigation was given. The observations on growth, yield attributes and yield were collected as per standard methods. The weights of the grain and straw from each plot were measured after appropriate sun drying and the grain yield was reported at 14% moisture level. The N content and uptake by grain and straw was estimated by following the Modified micro-Kjeldahl method.

The collected data on growth, yield attributes, yield and nitrogen uptake were subjected to Analysis of Variance (ANOVA) to determine treatment effects. The statistical analysis was performed using the 'agricolae' package in R version 4.4.2 (R Core Team, 2024). To interpret the differences among treatments, Standard Error of Means (S. Em±) and Critical Difference (C. D.) at 5% significance level (P=0.05) were computed as per the standard procedure.

RESULTS AND DISCUSSION

The yield attributes such as effective tillers per square metre, number of spikelets per panicle, number of filled spikelets per panicle and percentage of filled spikelets of dry seeded rainfed lowland rice were significantly influenced by methods of establishment and nitrogen levels (Table 1). However, grain and straw yield was significantly influenced only by nitrogen levels.

Among the methods of establishment, the maximum numbers of effective tillers per

Table 1. Influence of different methods of establishment and nitrogen levels on yield and yield attributes of dry seeded rainfed lowland rice during, 2024

Treatments	Effective tillers/m^2	No. of spikelets/ panicle	No. of filled spikelets/ panicle	Percentage of filled spikelets	1000-grain weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Methods of establishment (M)							
Broadcasting	239	125	102	81.01	12.69	3804	4603
Line sowing	244	127	107	83.97	13.35	3826	4814
Hill sowing	251	131	113	86.00	14.33	3917	4910
Transplanting without puddling	210	143	129	89.97	13.55	4074	5159
S. Em.±	6.26	2.61	2.85	0.51	0.42	97.00	178.70
C. D. (5%)	21.66	9.05	9.87	1.77	NS	NS	NS
Nitrogen levels (N), kg/ha							
0	207	118	95	80.61	13.13	2683	3460
40	223	129	106	82.47	13.08	3011	4516
80	241	138	121	88.06	13.35	4850	5642
120	273	142	127	89.81	14.36	5078	5868
S. Em.±	6.61	2.17	2.12	0.37	0.42	96.03	107.34
C. D. (5%)	19.29	6.34	6.18	1.08	NS	280.31	313.32
Interaction (M × N)							
S. Em.±	13.22	4.34	4.23	0.74	0.83	192.07	214.69
C. D. (5%)	NS	12.35	NS	2.11	NS	546.44	610.79

NS–Not Significant.

square metre were noted by hill sowing method and it was comparable with line sowing method and broadcasting (Table 1). All the former DSR treatments were significantly superior over transplanting without puddling which might be attributed to better plant spacing, reduced competition, improved aeration and lower transplant shock compared to transplanting. However, the transplanting without puddling recorded the significantly higher number of spikelets per panicle, number of filled spikelets per panicle and percentage of filled spikelets compared to DSR methods of establishment likely due to better root establishment, synchronized crop development and improved nutrient uptake during the reproductive phase. Moreover, hill sowing recorded significantly higher number of filled spikelets per panicle and percentage of filled spikelets compared to broadcasting due to more uniform plant stand and reduced intra-plant competition. The 1000-grain weight might be genetically governed character making it relatively stable across different methods of establishment. These were in close conformity with the findings of Rahman *et al.* (2019). However, due to compensatory mechanism of effective tillers per square metre and filled spikelets per panicle the grain and straw yield showed a comparable response among different methods of establishment.

Among nitrogen levels, the effective tillers were significantly higher at 120 kg N/ha over 80, 40 and 0 kg N/ha. The effective tillers observed at 80 and 40 kg N/ha were comparable with each other and significantly superior over 0 kg N/ha. Nitrogen being the key component of amino acids, proteins, chlorophyll and nucleic acids significantly contributed towards more tillers which further contributed to higher photosynthetic efficiency, allowing the plant to assimilate more carbohydrates and energy, which are then translocated to support the formation and maintenance of effective tillers. The number of spikelets per panicle, filled spikelets per panicle and percentage of filled spikelets were all significantly higher at 80 and 120 kg N/ha, with no statistical difference between them, but both were superior to 40 and 0 kg N/ha. This could be due to saturation of nitrogen use efficiency with the increase in nitrogen beyond 80 kg N/ha. However, the 1000-grain weight remained unaffected by nitrogen levels indicating its strong genetic control and stability. This was in close conformity with the findings of Ramulu *et al.* (2020). Further, the yield attributes as influenced by different nitrogen levels attributed to achieve the highest grain yield with 120 kg N/ha which was on par with 80 kg N/ha and significantly superior over 40 kg N/ha and 0 kg N/ha. Similar trend was observed by straw yield of dry seeded rainfed lowland rice. Similar findings were observed by Sagar *et al.* (2024).

The interaction effect between methods of crop

Table 2. Interaction effect between methods of establishment and nitrogen levels on number of spikelets per panicle, percentage of filled spikelets, grain and straw yield of dry-seeded rainfed lowland rice during, 2024

Treatment combinations	No. of spikelets/ panicle	Percentage of filled spikelets	Grain yield (kg/ha)	Straw yield (kg/ha)
M_1N_1	106	73.65	2272	2928
M_1N_2	122	78.65	3249	4500
M_1N_3	128	84.31	4733	5442
M_1N_4	143	87.45	4962	5540
M_2N_1	121	78.99	2778	3125
M_2N_2	122	81.19	2555	4593
M_2N_3	137	87.56	4720	5573
M_2N_4	127	88.16	5253	5967
M_3N_1	120	80.63	2971	3335
M_3N_2	127	83.46	2631	4496
M_3N_3	141	89.36	4992	5815
M_3N_4	138	90.55	5074	5992
M_4N_1	125	89.17	2710	4450
M_4N_2	143	86.60	3608	4477
M_4N_3	145	91.02	4957	5736
M_4N_4	159	93.08	5023	5973
S. Em.±	4.34	0.74	192.07	214.69
C. D. (5%)	12.35	2.11	546.44	610.79

establishment and nitrogen levels had a significant influence on the number of spikelets per panicle, percentage of filled spikelets, grain and straw yield (Table 2). Among the treatment combinations, transplanting without puddling combined with 120 kg N/ha recorded the highest number of spikelets per panicle and the highest percentage of filled spikelets, which were significantly superior to all other treatment combinations. However, grain and straw yields were comparable between 80 and 120 kg N/ ha, regardless of the method of establishment.

The nitrogen content in grain and straw did not vary significantly among different methods of crop establishment, which may be attributed to the absence of significant differences in grain and straw yields (Table 3). Since nitrogen uptake in grain, straw and total (grain + straw) is a function of both nitrogen content and yield, the lack of variation in these two parameters led to no significant differences in nitrogen uptake as well. Thus, when both yield components and nitrogen content remain unaffected by the establishment method, the total nitrogen uptake also remained consistent.

Table 3. Influence of different methods of establishment and nitrogen levels on N content and uptake of dry-seeded rainfed lowland rice, 2024

Treatments	N content (%)		N uptake (kg/ha)		
	Grain	Straw	Grain	Straw	Total
Methods of establishment (M)					
Broadcasting	1.50	0.66	58.29	30.82	89.11
Line sowing	1.54	0.68	60.03	33.15	93.18
Hill sowing	1.51	0.66	60.32	33.14	93.45
Transplanting without puddling	1.53	0.67	63.24	35.02	98.26
S. Em±	0.021	0.007	2.21	0.92	2.71
C. D. (5%)	NS	NS	NS	NS	NS
Nitrogen levels (N) (kg/ha)					
0	1.37	0.59	36.64	20.47	57.11
40	1.46	0.63	43.82	28.68	72.50
80	1.60	0.71	77.69	40.00	117.69
120	1.65	0.73	83.72	42.99	126.71
S. Em±	0.023	0.005	1.79	0.79	1.87
C. D. (5%)	0.067	0.01	5.21	2.31	5.46
Interaction (M × N)					
S. Em±	0.046	0.010	3.57	1.58	3.74
C. D. (5%)	NS	NS	NS	NS	NS

NS–Not Significant.

Among the nitrogen levels, the nitrogen content and uptake increased significantly with increase in nitrogen levels from 0 to 40, 80 and 120 kg N/ha. The highest values of nitrogen content were recorded by 120 kg N/ha which was at par with 80 kg N/ha in grain, while they differed significantly with respect to N content in straw. Similarly, the highest nitrogen uptake in grain, straw and total was noted by 120 kg N/ha which was significantly superior over other nitrogen levels under comparison. This discussion corroborates with the findings of Rajesh *et al.* (2017) and Kumar *et al.* (2018). The interaction effect between methods of crop establishment and nitrogen levels could not influence nitrogen content in grain and straw, as well as nitrogen uptake in grain, straw and total (grain+straw).

CONCLUSION

In the light of above, it can be concluded that application of 80 kg N/ha irrespective of methods of establishment could be the most optimum nitrogen level to achieve sustainable productivity in dry-seeded rainfed lowland rice.

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