AATCC Review

14 July 2025: Received
04 September 2025: Revised
11 September 2025: Accepted
10 October 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Effect of weed management methods and nitrogen levels on nitrogen use efficiency of drum seeded rice

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ABSTRACT

Drum seeded rice faces major challenges in achieving uniform crop establishment due to severe weed competition and inefficient nutrient utilization. Managing synchronized nitrogen supply and effective weed control remains critical for sustaining yield and profitability in this system. Keeping these points in view, a field experiment was conducted at the College Farm, PJTAU, Rajendranagar, during the rabi season of 2020–21 and 2021–22 to evaluate the impact of nitrogen levels and weed management practices on the performance of drum-seeded rice. The experiment was laid out in a factorial randomized block design with three replications, comprising four weed management practices (W_1: Unweeded control, W_2: Pretilachlor + pyrazosulfuron-ethyl as PE followed by penoxsulam + cyhalofop-butyl as POE, W_3: Pyrazosulfuron-ethyl as PE followed by penoxsulam + cyhalofop-butyl as POE, and W_4: Pretilachlor + pyrazosulfuron-ethyl as PE followed by mechanical weeding at 25 and 50 DAS) and four nitrogen levels (N_1: 0 kg ha^{-1}, N_2: 75% RDN-112.5 kg ha^{-1}, N_3: 100% RDN-150 kg ha^{-1}, and N_4: 125% RDN-187.5 kg ha^{-1}). Results revealed that 100% RDN recorded the highest agronomic efficiency and apparent nitrogen recovery, which declined at higher nitrogen levels. Conversely, 75% RDN resulted in greater physiological efficiency and partial factor productivity, suggesting improved nitrogen use efficiency at reduced application rates. Among weed management practices, integrated chemical and mechanical methods (W_2, W_3, W_4) were more effective than the unweeded control.

Keywords: *Agronomic efficiency, Apparent recovery, Grain yield, Nitrogen use efficiency (NUE), Post emergence (POE), Pre emergence (PE).*

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than half of the global population, and its productivity is critical to food security, especially in Asia. Among various rice cultivation methods, drum seeding has gained popularity due to its efficiency, reduced labor requirement, and potential for timely crop establishment [1]. However, drum-seeded rice faces challenges such as suboptimal nutrient management and weed competition, which can significantly impact yield and crop quality. Nitrogen (N) is a vital macronutrient that directly influences rice growth, yield, and grain quality. Proper nitrogen management in drum-seeded rice is essential to optimize nitrogen use efficiency (NUE), reduce environmental impacts such as nitrogen leaching and greenhouse gas emissions, and enhance overall productivity [2]. Excessive or improper nitrogen application can lead to nutrient losses and increased weed growth, complicating weed control efforts [3]. Weed infestation remains one of the significant biotic constraints in rice cultivation, causing yield reductions by competing for nutrients, light, and space [4]. Drum-seeded rice, being less competitive in early growth stages due to direct seeding without transplanting, is particularly vulnerable to weed pressure [5]. Effective weed management through integrated approaches, including herbicide application, cultural practices, and optimal nitrogen management, is crucial to maintain the crop's productivity [6]. Therefore, understanding the interaction between nitrogen management and weed dynamics in drum-seeded rice systems is vital for developing sustainable cultivation practices that enhance yield, resource use efficiency, and environmental safety. Minimal research has been conducted on the combined effects of weed and nitrogen management in direct-seeded rice established using a drum seeder. Most previous studies have focused either on chemical fertilizers or weed management practices alone, primarily during the *kharif* season. However, information on the integrated impact of these two management strategies during the *rabi* season remains scarce. In view of this knowledge gap, the present study was conducted to assess the combined effects of weed and nitrogen management practices on crop yield and cost-effectiveness in drum-seeded rice.

MATERIAL AND METHODS

A field experiment was conducted during the rabi seasons of 2020-21 and 2021-22 at the College Farm, College of Agriculture, Rajendranagar, PJTAU to study the effect of weed management practices and nitrogen levels on rice. The soil texture of the experimental site was loamy sand with a pH of 8.17, low organic carbon (0.37%) and available nitrogen (236 kg ha^{-1}), medium phosphorus (31.3 kg ha^{-1}), and high potassium (419.6 kg ha^{-1}). The experiment was laid out in a factorial randomized block design with 16 treatment combinations and three replications, consisting of four weed management

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DOI: https://doi.org/10.21276/AATCCReview.2025.13.04.739

practices (unweeded control; pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR @ 615 g ha^{-1} as pre-emergence followed by penoxsulam 1.02% + cyhalofop-butyl 5.1% OD @ 120 g ha^{-1} as post-emergence; pyrazosulfuron-ethyl 70% WDG @ 21 g ha^{-1} as pre-emergence followed by penoxsulam 1.02% + cyhalofop-butyl 5.1% OD @ 120 g ha^{-1} as post-emergence; and pretilachlor 6% + pyrazosulfuron-ethyl 0.15% GR @ 615 g ha^{-1} as pre-emergence followed by mechanical weeding at 25 and 50 DAS) and four nitrogen levels (control, 75% RDN- 112.5 kg N ha^{-1}, 100% RDN-150 kg N ha^{-1}, and 125% RDN-187.5 kg N ha^{-1}). The rice variety JGL 24423 was sown with a drum seeder at 20 cm spacing. A basal dose of 60 kg P_2O_5 ha^{-1} in the form of single superphosphate and 40 kg K_2O ha^{-1} in two equal splits (basal and panicle initiation) as muriate of potash was applied uniformly to all plots, while nitrogen was supplied through urea as per treatments in three equal splits at basal, tillering, and panicle initiation stages. Pre-emergence herbicides were applied at 3 DAS by mixing with sand, post-emergence herbicide was sprayed at the 2-3 leaf stage of weeds, and mechanical weedings were carried out at 25 and 50 DAS using a conoweeder. Grain yield was estimated from the net plot, excluding border plants. The nutrient content of grain was analyzed and then multiplied by the respective grain yields to present the nutrient uptake at harvest, expressed in kg ha^{-1}. Grain yield and total nitrogen uptake were presented in Table 1. Fertilizer use efficiency indices were computed to assess the response of crops to applied nitrogen. Four standard efficiency parameters were estimated using established methods. The data were analyzed statistically, applying the analysis of variance technique for the FRBD design. The significance was tested by the 'F' test [7].

Agronomic efficiency (kg kg^{-1})

The agronomic efficiency is the response in yield per unit input as indicated by kg of grain per kg of N. It was computed by using the formula suggested by [8].

$$\text{AE (kg grain kg}^{-1}\text{ N)} = \frac{\textbf{Grain yield in fertilized plot (kg/ha)} - \textbf{Grain yield in unfertilized plot(kg/ ha)}}{\textbf{Quantity of fertilizer N applied (kg /ha)}}$$

Apparent recovery (%)

Apparent recovery, also known as recovery fraction, was computed by the method suggested by [9].

$$\text{Apparent recovery of N (\%)} = \frac{Ui-Uo}{Ni} \times 100$$

Where, U_i – uptake of N in particular treatment (kg ha^{-1})
U_o – uptake of N in unfertilized plot (kg ha^{-1})
N_i – quantity of N applied for the treatment (kg ha^{-1})

Physiological efficiency (kg yield kg^{-1} nutrient uptake)

Physiological efficiency, also known as efficiency of utilization, as indicated by kg of grain per kg of absorbed N. It was calculated by the following formula suggested by [8].

$$\text{PE (kg grain/kg N absorbed)} = \frac{\text{Grain yin fertilized plot (kg/ ha)} - \text{Grain yield in unfertilized plot (kg /ha)}}{\text{N uptake in fertilized plot (kg /ha)} - \text{N uptake in fertilized plot (kg/ ha)}}$$

Partial factor productivity (kg grain kg^{-1}N)

The partial factor productivity (Pfp) from applied nutrient was a useful measure of nutrient use efficiency because it provides integrative index that quantifies total economic output related to utilization of all nutrient resource in the system [10]. It is the ratio of grain yield to the applied nutrient and was computed as follows. Pfp was expressed in kg grain kg^{-1} N.

$$\text{Partial factor productivity} = \frac{\text{Grain yield (kg/ ha)}}{\text{Total amount of nutrient applied (kg /ha)}}$$

RESULTS AND DISCUSSIION

The nitrogen use efficiency of drum-seeded rice in the study was assessed in terms of agronomic efficiency (kg grain kg^{-1} N applied), apparent nitrogen recovery (%), physiological efficiency (kg grain kg^{-1} N uptake) and partial factor productivity (kg grain kg^{-1} N). These results are presented in Table 2. Graded levels of nitrogen altered various parameters of nitrogen use efficiency.

Agronomic efficiency (AE) indicates the quantity of grain produced per unit of nitrogen applied and is the product of efficiency of absorption as well as utilization. Increased levels of nitrogen tend to lower the AE. Higher AE (23.65, 23.88 and 23.76 kg grain kg^{-1} N) was associated with the N level of 100 % RDN during 2020, 2021, and in the pooled mean, and it tends to decrease with additional levels of N *i.e.,* 125 % RDN (21.01, 21.24 and 21.12 kg grain kg^{-1}N).

Apparent recovery indicates the efficiency of absorption of applied N and it decreased at higher levels of fertilizer N application. The apparent recovery was higher (38.84, 41.10 and 39.97 %) with 100 % RDN in both years and in pooled means and lowest with 125 % RDN (35.26, 37.19 and 36.22 %). This clearly shows that when a limited quantity of N was applied, the crop efficiently absorbed the available N in the soil with minimal loss. Beyond 100 % RDN, apparent recovery tends to decrease. This indicates the rice plant inability to utilize the majority of the nitrogen applied at higher doses, due to several losses of applied nitrogen.

Physiological efficiency (PE) indicates the efficiency of utilization of absorbed N and is expressed as the quantity of grain produced per unit quantity of N absorbed by the crop. The highest PE (62.56, 59.46 and 60.90 kg grain kg^{-1}N) in *rabi* 2020, 2021 and in pooled means was recorded with 75 % RDN. Beyond this level, the rate of efficiency decreased with increased levels of N, with the lowest observed in 125 % RDN (59.59, 57.10 and 58.31 kg grain kg^{-1}N).

Maximum partial factor productivity of nitrogen was recorded with the lowest N level i*.e.,* 75 % RDN (41.55, 43.03 and 42.29 kg grains kg^{-1} N in 2020, 2021 and pooled means respectively). It was decreased significantly with successive increases in N levels, while lowest was found with 125 % RDN (32.35, 33.37 and 32.86 kg grains kg^{-1} N). This was because using higher input resulted in lower grain yield.

The NUE was higher at lower N levels and decreased with increasing nitrogen levels due to higher amounts of nitrogen loss through leaching, volatilization, uptake by weed plants and other losses with higher N levels. This also led to lower utilization of applied nitrogen, thereby decreasing nitrogen use efficiency. A declining trend with increasing doses of nitrogen has been reported by [11] and [12].

Table 1. Grain of drum seeded rabi rice influenced by weed management practices and nitrogen levels

Treatments	Grain yield			Total Nitrogen uptake (Grain+Straw)		
	2020-21	**2021-22**	**Pooled mean**	**2020-21**	**2021-22**	**Pooled mean**
Weed management practices						
W_1	2178	2326	2252	42.85	50.18	46.51
W_2	5606	5773	5690	98.57	105.81	102.19
W_3	4924	5105	5014	86.38	94.84	90.61
W_4	5830	6024	5927	102.5	110.78	106.64
SEm±	140	142	140	3.64	3.72	3.69
CD(P=0.05)	404	410	405	10.51	10.76	10.65
Nitrogen levels						
N_1	2125	2275	2200	41.29	46.75	44.02
N_2	4675	4841	4758	82.05	89.99	86.02
N_3	5672	5857	5765	99.55	108.4	103.97
N_4	6065	6256	6161	107.4	116.47	111.94
SEm±	140	142	140	3.64	3.72	3.69
CD(P=0.05)	404	410	405	10.51	10.76	10.65
Interaction						
SEm±	280	284	281	7.28	7.45	7.37
CD(P=0.05)	808	820	811	NS	NS	NS

Weed management practices (F_1)	Nitrogen levels (F_2)
W_1 : Unweeded	**N_1 :** No nitrogen
W_2 : Pretilachlor 6 % + Pyrazosulfuron-ethyl 0.15 % GR 615 g ha^{-1} PE *fb* Penoxsulam 1.02 % + Cyhalofop butyl 5.1 % OD 120 g ha^{-1} POE	**N_2 :** 75 % RDN (112.5 kg N ha^{-1})
W_3 : Pyrazosulfuron – ethyl 70 % WDG 21 g ha^{-1} PE *fb* Penoxsulam 1.02 % + Cyhalofop butyl 5.1 % OD 120 g ha^{-1} POE	**N_3 :** 100 % RDN (150 kg N ha^{-1})
W_4 : Pretilachlor 6 % + Pyrazosulfuron-ethyl 0.15 % GR 615 g ha^{-1} PE *fb* mechanical weeding 25 and 50 DAS	**N_4 :** 125 % RDN (187.5 kg N ha^{-1})

Table 2. Fertilizer use efficiency of drum seeded rabi rice as influenced by weed management practices and nitrogen levels

Treatments	Agronomic efficiency (kg grain kg^{-1} N)			Apparent recovery (%)			Physiological efficiency (kg grain kg^{-1} N uptake)			Partial factor productivity (kg grain kg^{-1} N)		
	2020-21	**2021-22**	**Pooled mean**	**2020-21**	**2021-22**	**Pooled mean**	**2020-21**	**2021-22**	**Pooled mean**	**020-21**	**2021-22**	**Pooled mean**
Weed management practices												
W_1	-	-	-	-	-	-	-	-	-	-	-	-
W_2	-	-	-	-	-	-	-	-	-	-	-	-
W_3	-	-	-	-	-	-	-	-	-	-	-	-
W_4	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogen levels												
N_1	-	-	-	-	-	-	-	-	-	-	-	-
N_2	22.66	22.81	22.74	36.23	38.44	37.33	62.56	59.46	60.90	41.55	43.03	42.29
N_3	23.65	23.88	23.76	38.84	41.10	39.97	60.88	58.11	59.45	37.81	39.05	38.43
N_4	21.01	21.24	21.12	35.26	37.19	36.22	59.59	57.10	58.31	32.35	33.37	32.86

*Data was not statistically analyzed

Weed management practices (F_1)	Nitrogen levels (F_2)
W_1 : Unweeded	**N_1 :** No nitrogen
W_2 : Pretilachlor 6 % + Pyrazosulfuron-ethyl 0.15 % GR 615 g ha^{-1} PE *fb* Penoxsulam 1.02 % + Cyhalofop butyl 5.1 % OD 120 g ha^{-1} POE	**N_2 :** 75 % RDN (112.5 kg N ha^{-1})
W_3 : Pyrazosulfuron – ethyl 70 % WDG 21 g ha^{-1} PE *fb* Penoxsulam 1.02 % + Cyhalofop butyl 5.1 % OD 120 g ha^{-1} POE	**N_3 :** 100 % RDN (150 kg N ha^{-1})
W_4 : Pretilachlor 6 % + Pyrazosulfuron-ethyl 0.15 % GR 615 g ha^{-1} PE *fb* mechanical weeding 25 and 50 DAS	**N_4 :** 125 % RDN (187.5 kg N ha^{-1})

CONCLUSION

The results suggest that adopting 100 % RDN (150 kg N ha^{-1}) is the optimal rate for achieving efficient nitrogen utilization in drum-seeded rice systems under the given conditions.

Future Scope

The research work done on nitrogen levels, further can be studied on split application of nitrogen in drum seeded rice to reduce weed growth. Integrated nutrient management by intercropping with green manures and IWM practices can be studied in drum seeder rice.

Acknowledgement

I am grateful to my advisor Dr. K. P. Vani for her unwavering support and guidance. I owe thanks to all my committee members and the professors, Department of Agronomy, PJTSAU. I must also thank my parents and friends for the immense support and assistance throughout my research work to complete the research successfully.

Conflict of Interest

I declare that there is no conflict of interest.

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