

Original Research Article

Productivity and profitability of *kharif* rice (*Oryza sativa* L.) under seedling age and nitrogen management

ABSTRACT

Aim: The aim of the experiment is to know the effect of seedling age and nitrogen management on growth, yield attributes, yield and economics of *kharif* rice.

Study design: The experiment was laid out in split-plot design.

Place and Duration of Study: Research Farm of Agricultural Research Station, Brinjhagiri, Chhatabar of Faculty of Agricultural Sciences, Siksha 'O'Anusandhan (Deemed to be University), Bhubaneswar (Odisha), during *kharif* season of 2023.

Methodology: Three seedling ages viz. S₁: 3 weeks (21 days), S₂: 4 weeks (28 days) and S₃: 5 weeks (35 days) as main plot treatment and four nitrogen management strategies i.e. N₁: 100% N through urea, N₂: 50% N through urea + 50% N through neem cake, N₃: 50% N through urea + 50% N through FYM and N₄: 50% N through FYM + 50% N through neem cake as sub-plot treatments replicated thrice. The net plot size was 4m x 3m.

Results: S₂ resulted highest grain yield (4.74t ha⁻¹) and straw yield (7.18t ha⁻¹). N₁ produced highest grain yield (4.54t ha⁻¹) and straw yield (6.96t ha⁻¹). Maximum net return (₹60367) and return per rupee investment (1.98) received from 4 weeks old seedling with 100% N through urea application.

Conclusion: Transplantation of 4 weeks old seedling (28 days) and 50% N through urea + 50% N through neem cake can be recommended to achieve higher yield. Maximum net return (₹60367), gross return (₹121687) and return per rupee investment (1.98) received from 4 weeks old seedling with 100% N through urea application.

Keywords: *Kharif* rice, seedling age, nitrogen management, yield and economics.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food for over half of the world's population, particularly in Asia, where about 90% of the total rice is produced and consumed. India is the second largest producer and consumer of rice in the world. In India, rice occupies an area of 43.86 M ha with an annual production of 117.94 Mt (DAC & FW, 2019-20). It serves as a primary source of food grain for billions of people, highlighting its significance in global food security. Rice production in India has shown significant progress over the years, but it has faced unprecedented challenges due to environmental degradation and climate change in recent years (Wassmann *et al.*, 2009) [22]. Nitrogen is identified as the most essential nutrient for rice production, crucial for achieving high yields. It promotes plant growth, enhances grain yield and quality, and is involved in various physiological processes such as tillering and protein synthesis. Despite the benefits of nitrogen fertilizers, their excessive use can lead to environmental issues and soil degradation. Farmers often apply large amounts of nitrogen through chemical fertilizer to maximize yields, but only a fraction (20-50%) is effectively utilized by the crop. Nitrogen, a key element for crop growth, has a significant impact on agricultural output. A sufficient nitrogen supply increases the synthesis of chlorophyll, the green pigment responsible for photosynthesis. Chlorophyll absorbs and converts sunlight into energy, enabling plants to produce carbohydrates and drive vegetative growth. The introduction highlights the necessity for integrated nitrogen management practices that combine chemical fertilizers with organic sources towards sustainability. This approach aims to improve nutrient uptake efficiency, enhance soil health, and reduce the negative impacts of chemical fertilizers on the environment. A split application of nitrogen fertilizer improved yields by 23-30% when combined with younger seedlings (Kyalo *et al.*, 2020) [6].

The age of seedlings used for growing rice can have a significant impact on the overall crop yield and quality. The effect of seedling age on rice crop is a critical factor that farmers need to consider when planning their cultivation practices. One of the primary reasons why seedling age is essential in rice cultivation is its impact on the maturity and growth rate of the crop. Younger seedlings have higher tillering potential which drastically decreases with age. Younger seedlings produce more yield in comparison to older seedlings (Virik *et al.*, 2020) [21]. Transplanting 20 days old seedlings has been commonly reported to generate an increase in grain yield as a result of higher tiller production (Pasuquinet *al.*, 2008) [15]. On the above background, the experiment was conducted with the objective to know the effect of seedling ages and nitrogen management on growth, yield attributes, yield and economics of *kharif* rice.

2. MATERIALS AND METHODS

A field experiment was carried out at the Agricultural Research Station in Brinjhagiri, Chatabar of the Faculty of Agricultural Sciences at Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha during the *kharif* season of 2023. The location situated in the South east coastal plain Zone of India. The field where the experiments was conducted is located at Latitude is 20.46° N and Longitude 85.67° E. The soil of the experimental field was sandy loam soil, slightly acidic with pH 5.78, EC 7.33 ds m⁻¹, soil organic carbon 0.41% and with 258.6 kg ha⁻¹, 20.29 kg ha⁻¹, 138.4 kg ha⁻¹ available

NPK(Table 1). The experimental rice variety, CR Dhan 205 an aerobic rice variety released by NRRI, Cuttack. It is a medium duration variety matures in 105-110 days with semi-dwarf plant type was used for the experiment. The experiment followed a split-plot design with three replications. The net plot size was 4m × 3m. The main plot treatment involved three seedling ages viz. S₁: 3 weeks (21 days), S₂: 4 weeks (28 days) and S₃: 5 weeks (35 days) and the subplot treatment involved four nitrogen management strategies i.e. N₁: 100% N through urea, N₂: 50% N through urea + 50% N through neem cake, N₃: 50% N through urea + 50% N through FYM and N₄: 50% N through FYM + 50% N through neem cake. The seed bed was prepared and rice was sown on June 27th, 2023. A recommended nutrient dose of 60:30:30 kg/ha N, P₂O₅, K₂O was applied. Half of N along with full dose of P and K were applied as basal and mixed with the soil of the individual plots. Different fertilizer and manure doses were applied depending on the treatment allocated. Seedlings of varying ages were transplanted on the following dates: July 18th (S₁: 21 days old seedling), July 25th (S₂: 28 days old seedling), and October 1st (S₃: 35 days old seedling), with a row spacing of 20 cm and a plant spacing of 10 cm. The biometric data like plant height (cm) and number of tillers per plant and yield related data like, number of effective tillers per till, number of grains per panicle, panicle weight, test weight (g), grain yield (kg ha⁻¹) and straw yield (kg ha⁻¹) was taken during maturity period. The harvest index and economics of cultivation were calculated.

Table 1: Physico-chemical properties of the experimental soil.

Properties	Value	Method used
Mechanical composition		
Sand (%)	70.2	International pipette method (Jackson, 1973)
Silt (%)	21.3	
Clay (%)	8.5	
Soil texture	Sandy loam soil	USDA system (Brady, 1974)
pH	5.78	(Jackson, 1973)
Electrical conductivity (ds m ⁻¹)	7.33	(Jackson, 1973)
Organic carbon (%)	0.41	Walkley and Black method (Jackson, 1973)
Available nitrogen (kg/ha)	258.60	Alkaline permanganate method (Jackson, 1973)
Available phosphorus (kg/ha)	20.29	Olsen's method (Olsen <i>et al.</i> , 1954)
Available potassium (kg/ha)	138.40	Flame photometric method (Jackson, 1973)

3. RESULT AND DISCUSSION

3.1. Biometric Parameters

The study analyzed plants that S₂: 4 weeks old seedling (28 days) produced the tallest plant (102.0cm) and highest number of tillers per hill (13.91) whereas the shortest plant (94.5cm) and lowest number of tillers per hill (12.05) was produced by S₃: 5 weeks aged seedling (35 days) (Table 2). Older seedlings usually recover more slowly (Rajendran *et al.*, 2004) [17]. Result from the study; clearly proved that 4 weeks aged seedling produced a greater number of tillers in comparison with

older seedlings (Mahato *et al.*, 2024) [8]. Seedling age also significantly influenced plant height, younger seedlings produced significantly taller plants than old seedlings (Hussain *et al.*, 2012) [5]. In case of nitrogen management, 100% N through urea (N₁) attained the tallest plant (104.4cm) followed by 50% N through urea + 50% N through neem cake (N₂) (101.4cm) and the maximum number of tillers per hill (14.32) with N₁ treatment, followed by 50% N through urea + 50% N through neem cake (N₂) (13.02). Whereas, at maturity, 50% N through FYM + 50% N through neem cake (N₄) produced the smallest plant (91.9cm) and the lowest number of tillers per hill (11.99) (Table 2). The highest plant height was observed with chemical fertilizers. It may be due to the fast release of nutrients by chemical fertilizer and plant unable to uptake it readily (Meena *et al.*, 2003) [10]. Also, in nitrogen application from inorganic sources increases plant height faster than inorganic and organic combinations because of the faster availability (Malik *et al.*, 2003) [9]. The higher number of tillers recorded with chemical + Organic fertilizer was statistically at par with 100% chemical fertilizer application (Tomar *et al.*, 2018) [20].

3.2 Yield and yield attributes

The highest number of effective tillers per hill (8.57), number of grains per panicle (111.92), panicle weight (2.50g) and test weight (22.29g) was observed in S₂: 4 weeks old seedling (28 days). The lowest effective tillers per hill (7.78) in S₃, number of grains per panicle (106.42) in S₃, panicle weight (2.30g) in S₁ and test weight (21.31g) in S₁. Dhungana *et al.*, (2021) [4] revealed that there was greater effective tiller per hill in the plant of younger seedlings than older ones. The significant reduction in total tillers production with delay in planting (Nayak *et al.*, 2003) [12]. The highest test weight was observed in 28 days old seedlings. This increase in test weight among younger seedlings may be due to a higher number of filled grains per panicle and longer panicles (Pramanik and Bera 2013, Chaudhari *et al.* 2015 and Singh and Singh 2009) [16, 2,19].

In terms of nitrogen management, it was observed that applying 100% nitrogen through urea (N₁) resulted in the highest number of effective tillers per hill (8.74), highest test weight (22.23 g) was recorded for N₁. The lowest number of effective tillers per hill (7.44) and test weight (21.28g) were recorded for 50% N through urea and 50% N through FYM (N₃). When inorganic nitrogenous fertilizers were combined with organic sources like FYM, there was a significant increase in the number of effective tillers per hill, especially with 100% RDF combined with FYM (Behera *et al.*, 2022) [1]. The combination of organic and inorganic nitrogen sources can improve growth parameters such as the number of leaves, tillers, and panicles, as well as increase test weight (Noraida & Hisyamuddin, 2021) [13]. 50% N through FYM + 50% N through neem cake (N₄) resulted in the highest number of grains per panicle (113.33) and highest panicle weight (2.5g) was recorded in the 100% N through urea (N₁) treatment, while the treatment with 50% N through urea + 50% N through FYM (N₃) had the lowest number of grains per panicle (101.78) and the lowest panicle weight (2.17g). A positive impact of applying 100% N from organic sources on the growth and yield attributes of rice (Pandey and Chitale 2015) [14]. S₂: 4 weeks old seedling (28 days) showed the significantly highest grain yield (4.74t ha⁻¹) straw yield (7.18 t ha⁻¹) and harvest index (0.40) while S₃: 5 weeks old seedling (35 days) had the lowest grain yield (4.03t ha⁻¹), straw yield (6.18t ha⁻¹) and harvest index (0.39). Young seedlings showed superior yield attributes and overall performance in rice cultivation, emphasizing

the significance of seedling age in maximizing crop yield and quality over aged seedling (Singh *et al.*, 2023) [18]. In the context of nitrogen management, the highest grain yield (4.54t ha^{-1}) and straw yield (6.96t ha^{-1}) were found when using 100% N through urea (N_1) application. The highest harvest index (0.40) was achieved with 50% N through urea + 50% N through neem cake (N_2). The lowest grain yield (4.17t ha^{-1}), straw yield (6.35t ha^{-1}) and harvest index (0.39) were obtained from 50% N through FYM + 50% N through neem cake (N_4) treatment (Table 3). Yield increment in full chemical application as well as integration with chemical + organic was observed (Chaudhary and Thakur, 2007 and Mehdi *et al.* 2011) [3,11]. Reshma *et al.*, (2024) [7] reported that treatments with 50% organic and 50% inorganic fertilizers yielded higher as compared to results of 100% inorganic applications, indicating effective nutrient management.

Table.2: Effect of seedling age and nitrogen management on plant height (cm), no. of tillers/hill, no. of effective tillers/hill, panicle weight (g) and test weight (g) on *kharif* rice.

Treatment	Plant height (cm)	No. of tillers/hill	No. of effective tillers/hill	No of grains/panicle	Panicle weight	Test weight
S ₁ : 3 weeks (21 days)	98.68	13.04	8.28	107.83	2.30	21.31
S ₂ : 4 weeks (28 days)	101.98	13.91	8.57	111.91	2.50	22.29
S ₃ : 5 weeks (35 days)	94.54	12.04	7.78	106.41	2.33	21.90
SEm (±)	0.58	0.24	0.08	3.00	0.10	0.73
CD (p = 0.05)	2.30	0.96	0.31	11.79	0.40	2.86
N ₁ : 100% N through urea	104.36	14.32	8.74	112.55	2.50	22.23
N ₂ : 50% N through urea + 50% N through neem cake	101.42	13.03	8.14	107.22	2.34	21.80
N ₃ : 50% N through urea + 50% N through FYM	95.96	12.66	7.40	101.78	2.17	21.28
N ₄ : 50% N through FYM + 50% N through neem cake	91.88	11.99	8.50	113.33	2.50	22.02
SEm (±)	0.71	0.43	0.10	2.22	0.08	0.39
CD (p = 0.05)	2.77	1.70	0.38	8.73	0.32	1.54

Table.3: Effect of seedling age and nitrogen management on grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index on *kharif* rice.

Treatment	Grain yield (t/ha)	Straw yield(t/ha)	Biological yield (t/ha)	Harvest Index
S ₁ : 3 weeks (21 days)	4.32	6.63	10.96	0.39
S ₂ : 4 weeks (28 days)	4.74	7.18	11.92	0.40
S ₃ : 5 weeks (35 days)	4.03	6.17	10.20	0.39
SEm (±)	0.40	0.24	0.61	0.01
CD (p = 0.05)	1.55	0.96	2.40	0.06
N ₁ : 100% N through urea	4.54	6.96	11.50	0.39
N ₂ : 50% N through urea + 50% N through neem cake	4.44	6.74	11.19	0.40
N ₃ : 50% N through urea + 50% N through FYM	4.30	6.60	10.90	0.39

N ₄ : 50% N through FYM + 50% N through neem cake	4.17	6.35	10.52	0.39
SEm (±)	0.14	0.20	0.25	0.01
CD (p = 0.05)	0.54	0.79	0.96	0.04

3.3 Cost of cultivation

The cost of cultivation, gross return, net return and return per rupees invested will vary depending on the age of the seedlings and nitrogen management practices (Table 4.19). The cost of cultivation is highest for the treatment S₂N₄ (₹ 79490.40) and the lowest cost of cultivation is calculated in S₁N₁(₹60370). Gross return received highest for S₂N₁(₹ 121687) and lowest for S₃N₄(₹ 94272). Net return and return per rupee investment were calculated highest for S₂N₁ (₹ 60367 and 1.98 respectively) and lowest for S₃N₄(₹ 13832 and 1.17 respectively).

Table 4: Effect of seedling age and nitrogen management on economics of *kharif* rice.

Treatments	Cost of Cultivation (₹)	Gross Return (₹)	Net Return (₹)	Return per rupee investment
S ₁ N ₁ : 3 weeks old seedling with 100% N through urea	60370.00	109763	49393	1.82
S ₁ N ₂ : 3 weeks old seedling with 50% N through urea + 50% N through neem cake	74705.20	107220	32515	1.44
S ₁ N ₃ : 3 weeks old seedling with 50% N through urea + 50% N through FYM	64205.20	105300	41095	1.64
S ₁ N ₄ : 3 weeks old seedling with 50% N through FYM + 50% N through neem cake	78540.40	101620	23080	1.29
S ₂ N ₁ : 4 weeks old seedling with 100% N through urea	61320.00	121687	60367	1.98
S ₂ N ₂ : 4 weeks old seedling with 50% N through urea + 50% N through neem cake	75655.20	118800	43145	1.57
S ₂ N ₃ : 4 weeks old seedling with 50% N through urea + 50% N through FYM	65155.20	113510	48355	1.74
S ₂ N ₄ : 4 weeks old seedling with 50% N through FYM + 50% N through neem cake	79490.40	110657	31166	1.39
S ₃ N ₁ : 5 weeks old seedling with 100% N through urea	62270.00	102530	40260	1.65
S ₃ N ₂ : 5 weeks old seedling with 50% N through urea + 50% N through neem cake	76605.20	100570	23965	1.31
S ₃ N ₃ : 5 weeks old seedling with 50% N through urea + 50% N through FYM	66105.20	97700	31595	1.48
S ₃ N ₄ : 5 weeks old seedling with 50% N through FYM + 50% N through neem cake	80440.40	94272	13832	1.17
SEm (±)		86	39	
CD (p = 0.05)		345	157	

4. CONCLUSION

Transplantation of 4 weeks old seedling (28 days) produced highest yield and 50% N through urea + 50% N through neem cake can be recommended to achieve higher yield. Maximum net return (₹60367), gross return (₹ 121687) and return per rupee investment (1.98) received from 4 weeks old seedling with 100% N through urea application.

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