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Effect of method of establishment and date of planting on growth and yield of rice (*Oryza Sativa* L.) in the Southern Transitional Zone of Karnataka

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ABSTRACT

A field experiment was conducted during Kharif 2025 at the Agricultural and Horticultural Research Station, Kathalagere, Davanagere, to study the effect of method of establishment and date of planting on growth and yield of rice (*Oryza sativa* L.) variety RNR-15048 under the Southern Transitional Zone of Karnataka. The experiment was laid out in a Factorial Randomized Complete Block Design with nine treatment combinations of three methods of establishment (conventional, mechanical transplanting and SRI) and three dates of planting (second fortnight of July, first fortnight of August and second fortnight of August), replicated thrice. At 60 days after transplanting (DAT), the SRI method recorded the highest number of tillers hill⁻¹ (23.27), dry matter accumulation (29.42 g hill⁻¹), root length (31.10 cm) and root volume (31.10 mL hill⁻¹), although plant height (74.46 cm) and leaf area index (4.52) were greatest under conventional transplanting. Planting in the second fortnight of July produced superior growth and root traits over later dates. SRI recorded significantly higher productive tillers hill⁻¹ (23.04), grains panicle⁻¹ (244.43), grain yield (5964 kg ha⁻¹) and straw yield (7376 kg ha⁻¹) than mechanical and conventional transplanting. Among the interactions, SRI planted in the second fortnight of July (M_{3D1}) recorded the highest grain yield (6353 kg ha⁻¹) and straw yield (7786 kg ha⁻¹), while conventional transplanting in the second fortnight of August (M_{1D3}) recorded the lowest values.

Keywords: Rice, SRI, Mechanical transplanting, Date of planting, RNR-15048, Growth, Yield

Introduction

Rice (*Oryza sativa* L.), a member of the family Poaceae, is one of the most widely cultivated and economically important cereal crops in the world and the primary staple for more than half of the global population. It contributes approximately 20 per cent of the total caloric intake of the world's population and nearly 31 per cent of the calorie requirement of the Indian population. The Asia-Pacific region accounts for more than 90 per cent of global rice production and consumption. Globally, rice is cultivated over about 168.4 million hectares with a production of 541.6 million tonnes. In India, it occupies around 51 million hectares with a production of 151 million tonnes and a productivity of 4.44 t ha⁻¹, while Karnataka grows rice on 1.3 million hectares with a productivity of 3,223 kg ha⁻¹ (Anon., 2025) [1].

Food production must increase by nearly 70 per cent by 2050 to meet the needs of a growing population (FAO, 2009) [2], while land, water and labour resources are shrinking (Foley et al., 2011) [3]. Conventional puddled transplanting requires about 3000-5000 litres of water to produce one kilogram of grain (Tuong et al., 2003) [4]. The System of Rice Intensification (SRI), which involves transplanting of young single seedlings at wider spacing with alternate wetting and drying, has gained attention as a resource-efficient alternative, while mechanical transplanting addresses labour scarcity and timely establishment (Alam et al., 2020) [5].

Rice productivity is also strongly influenced by sowing time, since different planting dates expose the crop to different temperature, rainfall and sunshine regimes from emergence to maturity (Sastri, 2010) [6]. Appropriate selection of planting date and establishment method therefore helps in maximizing growth, resource-use efficiency and yield. Hence, the present study was undertaken to evaluate the growth, root traits and yield of rice under different methods of establishment and dates of planting in the Southern Transitional Zone of Karnataka.

Materials and Methods

The field experiment was conducted during Kharif 2025 at the Agricultural and Horticultural Research Station (AHRS), Kathalagere, Davanagere (14° 16' 11" N, 75° 49' 31" E; 602 m above mean sea level), located in the Southern Transitional Zone (Zone VII) of Karnataka. The soil was sandy loam and slightly acidic (pH 6.30), with normal electrical conductivity (0.16 dS m⁻¹), medium organic carbon (0.69 %), 282.32 kg ha⁻¹ available N and 248.53 kg ha⁻¹ available K₂O, determined by standard procedures (Jackson,

1973; Piper, 1966; Walkley *et al.*, 1934; Subbaiah *et al.*, 1956) [7, 8, 9, 10]. The crop received 312.60 mm of rainfall in 43 rainy days from July to December 2025 against a normal of 615.80 mm in 47 days, with markedly lower rainfall than normal in September, November and December.

The experiment was laid out in a factorial randomized complete block design (RCBD) with nine treatments replicated thrice (27 plots; gross plot size 5 m × 4 m). The treatments were three methods of establishment, *viz.*, conventional transplanting (M_1), mechanical transplanting (M_2) and SRI (M_3), combined with three dates of planting, *viz.*, second fortnight of July (D_1 ; 28-07-2025), first fortnight of August (D_2 ; 12-08-2025) and second fortnight of August (D_3 ; 26-08-2025). The medium-duration variety RNR-15048 (Telangana *Sona*) was used. *Twenty-two-day-old seedlings* from wet-bed nurseries were transplanted at 15 cm × 10 cm in M_1 ; 18-day-old tray-raised seedlings were transplanted at 20 cm × 10 cm in M_2 ; and 12-day-old seedlings from raised beds were transplanted singly at 25 cm × 25 cm in M_3 . The recommended fertilizer dose of 100:50:50 kg N, P_2O_5 and K_2O ha^{-1} was applied through urea, di-ammonium phosphate and muriate of potash, with N in splits and full P and K at transplanting. Weeds were controlled with pyrazosulfuron (10 % WP) at 20 g a.i. ha^{-1} followed by hand weeding (and cono-weeding in SRI). A water depth of 2.5-5 cm was maintained in M_1 and M_2 , while SRI plots were irrigated intermittently under moist conditions. Stem borer and sheath rot were managed with chlorpyrifos (2 ml l^{-1}) and carbendazim (250 g ha^{-1}).

Observations were recorded from five randomly selected hills per net plot and a further five hills were uprooted at 60 DAT and at harvest for destructive sampling. Plant height was measured from the base of the plant to the tip of the longest leaf; tillers $hill^{-1}$ were counted and averaged; leaf area was worked out from leaf length and maximum breadth with a correction factor of 0.78 and leaf area index (LAI) was computed as the ratio of leaf area $hill^{-1}$ to land area $hill^{-1}$; and dry matter was recorded after oven drying at 65 °C to constant weight (g $hill^{-1}$). Roots were washed free of soil, root length was measured from the root-shoot junction to the tip of the longest root, root volume (mL $hill^{-1}$) was determined by water displacement. Productive tillers $hill^{-1}$ and grains panicle $^{-1}$ were recorded at harvest, and grain and straw yields were recorded from the net plot after sun drying and expressed in kg ha^{-1} . The data were subjected to Fisher's analysis of variance (Gomez *et al.*, 1984) [11] and critical difference (CD) was computed at 5 per cent probability wherever the *F* test was significant.

Results and Discussion

Growth parameters at 60 DAT and at harvest

Plant height, tillers $hill^{-1}$, leaf area index (LAI) and dry matter accumulation at 60 DAT and at harvest were significantly influenced by method of establishment and date of planting and, except for LAI, by their interaction (Table 1). Conventional transplanting recorded the tallest plants (74.46 cm), followed by mechanical transplanting

(62.57 cm), while SRI recorded the shortest plants (46.64 cm); the same trend continued at harvest (102.34, 90.70 and 75.11 cm, respectively). This might be due to closer spacing and greater competition for light and space, which favours vertical growth, as reported by Barla and Kumar (2011) [12]. Conventional transplanting also recorded the highest LAI (4.52 at 60 DAT and 4.58 at harvest), followed by mechanical transplanting (3.98 and 4.01) and SRI (1.57 and 1.56), probably owing to the higher plant population per unit area under closer spacing, whereas SRI produced greater leaf area per individual hill. In contrast, SRI recorded 23.27 tillers $hill^{-1}$, which was 52.9 per cent higher than conventional transplanting (15.22) at 60 DAT and 25.90 against 17.02 at harvest. The wider spacing under SRI reduces competition and favours tiller initiation and leaf development, as also observed by Hugar *et al.* (2009) [13]. The higher tillering, better leaf development and improved root growth under SRI also resulted in the highest dry matter accumulation (29.42 g $hill^{-1}$), 47.2 per cent more than conventional transplanting (19.98 g $hill^{-1}$), indicating greater accumulation of photosynthates. At harvest, dry matter was 54.59 g $hill^{-1}$ under SRI compared with 46.49 and 41.30 g $hill^{-1}$ under mechanical and conventional transplanting, respectively.

Among the dates of planting, the second fortnight of July (D_1) recorded the highest plant height (65.88 cm), tillers $hill^{-1}$ (21.23) and dry matter (27.28 g $hill^{-1}$), which declined progressively with delay in planting to 56.06 cm, 15.94 and 21.12 g $hill^{-1}$, respectively, under the second fortnight of August (D_3). LAI also declined with delay in planting (3.77, 3.34 and 2.95 at 60 DAT) and all four parameters showed the same trend at harvest (93.68 cm, 23.52, 3.79 and 51.02 g $hill^{-1}$ under D_1 against 84.64 cm, 18.04, 3.00 and 43.82 g $hill^{-1}$ under D_3 for plant height, tillers $hill^{-1}$, LAI and dry matter, respectively). Early planting exposed the crop to a longer, more favourable growing period, whereas delayed planting shortened the vegetative phase and exposed the crop to declining rainfall and lower minimum temperatures (Maity *et al.*, 2008; Khan and Bhagat, 2005) [15, 14]. Among the interactions, M_3D_1 recorded the highest tillers $hill^{-1}$ (27.53) and dry matter (34.40 g $hill^{-1}$), whereas M_1D_3 recorded the lowest values (13.40 and 17.63 g $hill^{-1}$, respectively). Plant height was greatest under M_1D_1 (79.00 cm) and least under M_3D_3 (43.27 cm). A similar trend was observed at harvest, with M_3D_1 recording the highest tillers $hill^{-1}$ (29.88) and dry matter (57.00 g $hill^{-1}$) and M_1D_1 the tallest plants (106.71 cm), while the interaction effect on LAI was non-significant.

Root parameters at 60 DAT and at harvest

Root length and root volume at 60 DAT and at harvest were significantly higher under SRI than under mechanical and conventional transplanting (Table 2). SRI recorded a root length of 31.10 cm at 60 DAT and 26.52 cm at harvest, a root volume of 31.10 and 31.17 mL $hill^{-1}$, respectively. The wider spacing, young single seedlings and reduced root disturbance under SRI favoured greater root proliferation, as reported by Xie *et al.* (2021) [16]. The better root system would have enhanced nutrient and water uptake and thereby supported greater tillering and dry matter accumulation.

Table 1. Plant height (cm), number of tillers $hill^{-1}$, leaf area index and dry matter accumulation (g $hill^{-1}$) of rice at 60 DAT and at harvest as influenced by method of establishment and date of planting

Treatments	Plant height (cm)		Tillers $hill^{-1}$		Leaf area index		Dry matter (g $hill^{-1}$)	
	60 DAT	At harvest	60 DAT	At harvest	60 DAT	At harvest	60 DAT	At harvest
Method of establishment (M)								
M_1 : Conventional method	74.46	102.34	15.22	17.02	4.52	4.58	19.98	41.30
M_2 : Mechanical transplanting	62.57	90.70	17.18	19.49	3.98	4.01	22.67	46.49
M_3 : SRI method of transplanting	46.64	75.11	23.27	25.90	1.57	1.56	29.42	54.59
S.E.m. $\pm$	0.61	0.67	0.32	0.31	0.04	0.10	0.41	0.42
C.D. @ 5 %	1.83	2.01	0.98	0.93	0.13	0.30	1.25	1.26

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Treatments	Plant height (cm)		Tillers hill ⁻¹		Leaf area index		Dry matter (g hill ⁻¹)	
	60 DAT	At harvest	60 DAT	At harvest	60 DAT	At harvest	60 DAT	At harvest
Date of planting (D)								
D ₁ : Second fortnight of July	65.88	93.68	21.23	23.52	3.77	3.79	27.28	51.02
D ₂ : First fortnight of August	61.73	89.83	18.50	20.85	3.34	3.36	23.67	47.55
D ₃ : Second fortnight of August	56.06	84.64	15.94	18.04	2.95	3.00	21.12	43.82
S.E.m. ±	0.61	0.67	0.32	0.31	0.04	0.10	0.41	0.42
C.D. @ 5 %	1.83	2.01	1.00	0.98	0.13	0.30	1.28	1.30
Interaction (M × D)								
M ₁ D ₁	79.00	106.71	17.10	19.00	5.26	5.31	22.46	44.88
M ₁ D ₂	74.46	102.00	15.16	17.00	4.40	4.48	19.86	41.00
M ₁ D ₃	69.92	98.31	13.40	15.06	3.88	3.97	17.63	38.02
M ₂ D ₁	68.72	96.72	19.06	21.67	4.40	4.44	25.00	51.18
M ₂ D ₂	64.00	92.00	17.26	19.74	4.03	4.03	22.76	47.03
M ₂ D ₃	55.00	83.39	15.24	17.07	3.50	3.55	20.26	41.27
M ₃ D ₁	49.93	77.60	27.53	29.88	1.65	1.63	34.40	57.00
M ₃ D ₂	46.73	75.50	23.10	25.80	1.57	1.56	28.40	54.61
M ₃ D ₃	43.27	72.23	19.19	22.00	1.48	1.47	25.46	52.17
S.E.m. ±	1.05	1.16	0.56	0.54	0.07	0.17	0.72	0.73
C.D. @ 5 %	3.17	3.48	1.69	1.62	NS	NS	2.17	2.18

DAT: Days after transplanting. M₁D₁: Conventional method at 2nd fortnight of July; M₁D₂: at 1st fortnight of August; M₁D₃: at 2nd fortnight of August; M₂ (Mechanical transplanting) and M₃ (SRI method) follow the same date order. NS: Non significant.

Planting in the second fortnight of July (D₁) recorded the highest root length (29.38 and 24.83 cm) and root volume (29.38 and 29.51 mL hill⁻¹) at 60 DAT and at harvest, respectively, significantly superior to D₂ and D₃. Among the interactions, M₃D₁ recorded the highest root length (33.00 and 32.00 cm) and root volume (33.00 and 35.00 mL hill⁻¹), whereas M₁D₃ recorded the lowest root length (18.93 and 16.35 cm) and root volume (18.93 and 20.77 mL hill⁻¹) at 60 DAT and at harvest, respectively.

Yield parameters and yield

The number of productive tillers hill⁻¹, grains panicle⁻¹, straw yield and grain yield were significantly influenced by both factors, while the interaction effect was significant for all except grains panicle⁻¹

(Table 3). SRI recorded significantly higher productive tillers hill⁻¹ (23.04) than mechanical (18.56) and conventional transplanting (15.58), an increase of 47.9 per cent over conventional. The wider spacing, reduced competition and better root development under SRI favoured tiller initiation and survival up to maturity, and since productive tillers contribute directly to panicle number, they contributed to higher yield (Hugar *et al.*, 2009) [13]. Similarly, SRI recorded the highest grains panicle⁻¹ (244.43), which was 19.2 per cent higher than conventional transplanting (205.11), probably owing to greater assimilate availability from the larger leaf area, dry matter and root system during the reproductive stage.

Table 2. Root length (cm) and root volume (mL hill⁻¹) of rice at 60 DAT and at harvest as influenced by method of establishment and date of planting

Treatments	Root length (cm)		Root volume (mL hill ⁻¹)	
	60 DAT	At harvest	60 DAT	At harvest
Method of establishment (M)				
M ₁ : Conventional method	22.30	18.06	22.30	24.09
M ₂ : Mechanical transplanting	26.09	20.43	26.09	26.97
M ₃ : SRI method of transplanting	31.10	26.52	31.10	31.17
S.E.m. ±	0.35	0.33	0.35	0.54
C.D. @ 5 %	1.05	1.01	1.05	1.63
Date of planting (D)				
D ₁ : Second fortnight of July	29.38	24.83	29.38	29.51
D ₂ : First fortnight of August	26.48	21.11	26.48	27.42
D ₃ : Second fortnight of August	23.62	19.07	23.62	25.30
S.E.m. ±	0.35	0.33	0.35	0.54
C.D. @ 5 %	1.05	1.01	1.05	1.63
Interaction (M × D)				
M ₁ D ₁	26.30	19.98	26.30	26.45
M ₁ D ₂	21.66	17.99	21.66	23.61
M ₁ D ₃	18.93	16.35	18.93	20.77
M ₂ D ₁	28.86	22.50	28.86	29.29

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Treatments	Root length (cm)		Root volume (mL hill ⁻¹)	
	60 DAT	At harvest	60 DAT	At harvest
M ₂ D ₂	26.70	20.66	26.70	26.45
M ₂ D ₃	22.71	18.11	22.71	23.61
M ₃ D ₁	33.00	32.00	33.00	35.00
M ₃ D ₂	31.08	24.66	31.08	32.13
M ₃ D ₃	29.23	22.88	29.23	29.29
S.Em. ±	0.60	0.58	0.60	0.95
C.D. @ 5 %	1.82	1.75	1.82	2.78

DAT: Days after transplanting. NS: Non significant. Treatment symbols as in Table 1.

The improved yield attributes under SRI were reflected in grain yield. SRI recorded a significantly higher grain yield (5964 kg ha⁻¹) than mechanical (5150 kg ha⁻¹) and conventional transplanting (4580 kg ha⁻¹), corresponding to increases of 15.8 and 30.2 per cent, respectively. Straw yield followed a similar trend (7376, 6566 and 5957 kg ha⁻¹ under SRI, mechanical and conventional methods, respectively), which could be due to greater tiller production, dry matter and root growth. Similar superiority of SRI in yield attributes and yield has been reported by Hugar *et al.* (2009) [13] and Mohanty *et al.* (2014) [17].

Among the dates of planting, the second fortnight of July (D₁) recorded the highest grain yield (5674 kg ha⁻¹), followed by D₂ (5282 kg ha⁻¹) and D₃ (4737 kg ha⁻¹); D₁ out-yielded D₃ by 19.8 per cent. D₁ also recorded significantly more productive tillers (21.17), grains panicle⁻¹ (234.74) and straw yield (7084 kg ha⁻¹). The 2025 *Kharif* season received only 312.6 mm of rainfall against a normal of 615.8 mm, with rainfall and relative humidity declining and temperature conditions becoming less favourable towards the reproductive and grain-filling stages of the delayed plantings. High temperature during these sensitive stages adversely affects fertilization and grain filling (Wahid *et al.*, 2007; Welch *et al.*, 2010) [18, 19], and the impor-

tance of stage-wise rainfall, sunshine and temperature for rice yield has been highlighted by Khan *et al.* (2005) [14], Sattar *et al.* (2017) [20] and Godbole (2019) [14, 20, 21]. Better synchronization of timely planting with radiation interception and grain yield was likewise reported by Gautam *et al.* (2019) [22]. Weather-based regression in the present study indicated that accumulated growing degree days and photothermal units explained a very large share of the variation in grain yield, in agreement with Maity *et al.* (2008) [15].

The interaction was significant for grain yield, where SRI planted in the second fortnight of July (M₃D₁) recorded the highest yield (6353 kg ha⁻¹), significantly superior to all other combinations including M₃D₂ (5941 kg ha⁻¹) and M₃D₃ (5598 kg ha⁻¹). It out-yielded the conventional method planted on the same date (M₁D₁; 5127 kg ha⁻¹) by 23.9 per cent. M₃D₁ also recorded the highest productive tillers (24.55 hill⁻¹), grains panicle⁻¹ (262.22) and straw yield (7786 kg ha⁻¹), whereas conventional transplanting in the second fortnight of August (M₁D₃) recorded the lowest grain yield (3836 kg ha⁻¹), grains panicle⁻¹ (192.33) and straw yield (5169 kg ha⁻¹). Thus M₃D₁ yielded 65.6 per cent more grain than M₁D₃, which shows that timely planting and a resource-efficient establishment method act together to improve yield.

Table 3. Grain yield (kg ha⁻¹), straw yield (kg ha⁻¹), number of productive tillers hill⁻¹ and number of grains panicle⁻¹ of rice as influenced by method of establishment and date of planting

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Productive tillers hill ⁻¹	Grains panicle ⁻¹
Method of establishment (M)				
M ₁ : Conventional method	4580	5957	15.58	205.11
M ₂ : Mechanical transplanting	5150	6566	18.56	218.00
M ₃ : SRI method of transplanting	5964	7376	23.04	244.43
S.Em. ±	62.49	67.48	0.22	3.11
C.D. @ 5 %	187.36	202.30	0.66	9.34
Date of planting (D)				
D ₁ : Second fortnight of July	5674	7084	21.17	234.74
D ₂ : First fortnight of August	5282	6702	18.99	222.45
D ₃ : Second fortnight of August	4737	6113	17.02	210.34
S.Em. ±	62.49	67.48	0.22	3.11
C.D. @ 5 %	187.36	202.30	0.66	9.40
Interaction (M × D)				
M ₁ D ₁	5127	6526	18.30	216.00
M ₁ D ₂	4776	6176	14.96	207.00
M ₁ D ₃	3836	5169	13.50	192.33
M ₂ D ₁	5542	6941	20.68	226.00
M ₂ D ₂	5131	6580	19.00	219.00
M ₂ D ₃	4777	6176	16.00	209.00
M ₃ D ₁	6353	7786	24.55	262.22
M ₃ D ₂	5941	7349	23.02	241.37
M ₃ D ₃	5598	6995	21.56	229.70
S.Em. ±	108.24	116.88	0.38	5.39

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Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Productive tillers hill ⁻¹	Grains panicle ⁻¹
C.D. @ 5 %	324.52	350.40	1.15	NS

NS: Non significant. Treatment symbols as in Table 1.

Conclusion

The SRI method of establishment produced the best crop growth with more tillers hill⁻¹, dry matter and a stronger root system and recorded the highest grain yield (5964 kg ha⁻¹), 30.2 and 15.8 per cent higher than conventional and mechanical transplanting, respectively. Planting in the second fortnight of July gave better growth and yield (5674 kg ha⁻¹) than planting in August, as delayed planting met less favourable weather during the critical growth stages. SRI planted in the second fortnight of July (M₃D₁) recorded the highest grain yield (6353 kg ha⁻¹), followed by SRI planted in the first fortnight of August (5941 kg ha⁻¹) and is the most promising combination for the Southern Transitional Zone of *Karnataka*. Multi-location and multi-season trials are suggested to validate these findings.

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