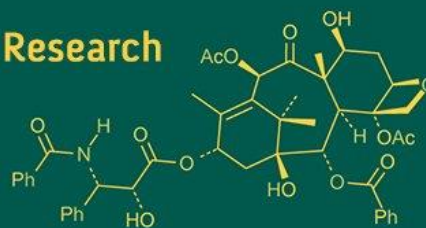
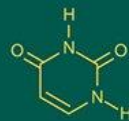
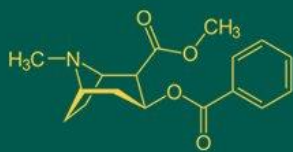


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Effect of establishment methods on growth and yield of Kalanamak Rice (*Oryza sativa* L.) cultivars

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Abstract

A field experiment was conducted during the *kharif* season of 2025 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, to evaluate the "Effect of Establishment Methods on Growth and Yield of Kalanamak Rice (*Oryza sativa* L.) Cultivars". The experiment was laid out in a Randomized Block Design (RBD) with eight treatment combinations, replicated three. The treatments comprised four dwarf Kalanamak cultivars (Pusa Narendra Kalanamak 1652, Bauna Kalanamak 101, Kalanamak Kiran, and Bauna Kalanamak 102) evaluated under two crop establishment methods: Conventional Transplanting and the System of Rice Intensification (SRI). The experimental soil was sandy loam in texture, neutral in pH (7.2), and low in organic carbon (0.42%). Recommended Dose of Fertilizers (RDF) was applied uniformly at 120:60:60 kg/ha of N:P:K. The experimental results revealed that the System of Rice Intensification (SRI) significantly outperformed conventional transplanting across all evaluated cultivars in terms of growth attributes and yield parameter response. Among the various treatment combinations, Treatment 8 (T₈: SRI + Bauna Kalanamak 102) recorded the maximum plant height (88.92 cm), highest number of tillers per plant (16.20), and maximum number of effective tillers per plant (14.13). Furthermore, the highest grain yield (4.3 t/ha) were also significantly registered under Treatment 8, followed closely by SRI with Pusa Narendra Kalanamak 1652 (T₅: 4.1 t/ha). Additionally, Bauna Kalanamak 101 proved to be a highly promising variety, exhibiting robust early vegetative growth and early maturity (90-100 days). The study concludes that the System of Rice Intensification (SRI) coupled with the Bauna Kalanamak 102 cultivar is a highly efficient, resource-saving, and profitable cultivation strategy for aromatic Kalanamak rice production in the agro-climatic zone of Prayagraj, Uttar Pradesh

Keywords: Kalanamak Rice, Sri, conventional transplanting, economics, grain yield

Introduction

Rice (*Oryza sativa* L.) is one of the important cereals crop mainly grown in *kharif* season and play very significant role in Indian food security Singh *et al.* (2017) [5]. About 90% of rice grown in the world is produced and consumed in the Asia region, with China leading in production Kalanamak rice is one of the finest quality aromatic rices of India, primarily grown in Eastern Uttar Pradesh. However, traditional cultivation methods often result in lower yields. Cultivation of Kalanamak rice is recorded since the Buddhist period (900 BC). The grains-were found from excavation of Kapilvastu (now Aligarhwa) now in district (Siddharth Nagar, Uttar Pradesh, India). This site is located close to Nepal border. The site of Kapilvastu was the Kingdom of King Shuddhodhan (meaning pure rice), father of Lord Buddha. During the excavation carbonized rice grains resembling to Kalanamak Rice were recovered from one of the rooms, which was supposed to be the kitchen store of King Shuddhodhan. Fa-Hien, the Chinese traveller wrote that when Prince Siddhartha. Choudhary (2012) [4].

Aromatic types were sown in nursery beds using the concept of the penicle-to-row method seedlings from one panicle were transplanted in a single row. Observations on initial and 50% flowering tillering ability, maturity, Initial flowering ranged between 100 to 108 days and 50% flowering ranged between 104 to 114 days. Maturity duration ranged between the ranges 134 days Superior performing and Kalanamak rice is not only prized for its aromatic qualities but also for its nutritional benefits, Studies have shown that kalanamak rice is rich in micro nutrients such as iron and zinc which are essential human health.

Chaudhary *et al.* (2024) ^[3], This variety is famous for its taste and aroma. It is cooking at marriages is considered auspicious and its smoke is believed to be purifying the atmosphere. It derives its name from its black husk. It is grown widely in Tarai area of Uttar Pradesh adjoining Nepal particularly in the districts of, Siddharthnagar, Santkabirnagar and Basti and in small pockets in districts Gorakhpur, Maharajganj, Balrampur, Gonda, Bahraich, Shravasti, Deoria and Padrauna North Eastern Plain Zone of Eastern UP. Singh *et al.*.

Materials and Methods

A field experiment was conducted during *Kharif* season of 2025. The materials used and the methods adopted in the present investigation with a brief description of the site of the experiment was conducted, design (RBD) Randomized Block Design, and with 8 treatment combinations, replicated 3. The treatments comprised four dwarf Kalanamak cultivars varieties (Pusa Narendra Kalanamak 1652, Bauna Kalanamak 101, Kalanamak Kiran, & Bauna Kalanamak 102) evaluated under two crop establishment methods. Conventional Transplanting and System of Rice Intensification (SRI). The experimental revealed the growth parameters, plant height, no. of tillers all observation during experimental field. Recommended Dose of Fertilizers (RDF) was applied uniformly at 120:60:60 kg/ha of N:P:K.

Results and Discussion

Growth Parameter

Plant height (cm)

The plant height of Kalanamak rice cultivars was significantly affected by different establishment methods and varieties at 100 DAT (Table 1). The plant height under different treatments ranged between 81.94 cm and 88.92 cm. The maximum plant height (88.92 cm) was recorded in Treatment 8 (T₈: SRI + Bauna Kalanamak 102), which was significantly superior to all other treatment. The superior plant height under the System of Rice Intensification (SRI) can be attributed to the transplantation of young, vigorous 12-day-old seedlings and wider spacing, which reduces mutual competition for sunlight, nutrients, and moisture. These findings are in close conformity with Chaudhary *et al.*, who reported that newly developed dwarf (Bauna) lineages of Kalanamak are genetically tailored to achieve an average height of around 95 cm limitation in traditional tall varieties (120 cm). The marginal variation observed in the current study (88.92 cm) is likely due to the specific agro-climatic conditions of the Prayagraj region.

Plant dry weight (g/plant)

The accumulation of dry matter per plant showed significant variation across different treatment combinations at 100 DAT (Table 1). The maximum plant dry weight (91.55 g/plant) was observed in Treatment 2 (Conventional Transplanting + Bauna Kalanamak 101), followed by Treatment 6 (88.46 g/plant) and Treatment 7 (87.97 g/hill). Among the SRI treatments, Treatment 7 (T₇: SRI + Kalanamak Kiran) and Treatment 8 (T₈: SRI + Bauna Kalanamak 102) recorded robust dry matter accumulation of 87.97 g and 85.86 g. Optimized resource utilization and enhanced root architecture under SRI play a vital role in biomass partitioning. These results align with Singh *et al.* (2025) ^[7], who stated that dry matter accumulation in Kalanamak rice is significantly enhanced by optimized crop establishment and precise nutrient management. Furthermore, Chaudhary *et al.* highlighted that the dwarf

plant architecture of the 'Bauna' series allows the plant to allocate significantly more photosynthesized resources toward structural biomass rather than excessive vegetative elongation, eliminating lodging risks.

Crop growth rate (g/m²/day)

Crop Growth Rate (CGR) during the 80 to 100 DAT interval exhibited significant variations among the treatments (Table 1). Interestingly, conventional transplanting methods generally maintained higher CGR values during this specific interval compared to the System of Rice Intensification (SRI). The maximum CGR (24.60 g/m²/day) was recorded in Treatment 1 (Conventional Transplanting + Pusa Narendra Kalanamak 1652), closely followed by Treatment 3 (23.60 g/m²/day). Under SRI conditions, the maximum CGR (16.19 g/m²/day) was achieved in Treatment 7 (SRI + Kalanamak Kiran). These outcomes are in harmony with the findings of Singh *et al.* (2025) ^[7], who noted that enhanced soil aeration and balanced nutrient management provided during early stages significantly boost biomass production speed in Kalanamak cultivars. The higher CGR values in conventional plots at later stages may be due to delayed canopy closure or denser plant populations per unit area.

Relative growth rate (g/g/day)

The Relative Growth Rate (RGR) recorded during the 80 to 100 DAT interval did not show any statistically significant difference (NS) among the various treatment combinations (Table 1). However, numerically, the highest RGR (0.05 g/g/day) was observed in Treatment 8 (T₈: SRI + Bauna Kalanamak 102), followed by Treatment 5 and Treatment 7 (both at 0.04 g/g/day). The higher numerical values of RGR in SRI-managed plots during the early-to-mid growth stages can be credited to the transplantation of young, 12-day-old seedlings. These young seedlings maintain high metabolic activity and superior photosynthetic rates. As noted by Chaudhary *et al.*, the physiological efficiency of the 'Bauna' (dwarf) Kalanamak lineages is superior due to their optimized source-to-sink relationship. The results confirm this trend, as the observed RGR values exceed the growth efficiencies typically documented in traditional tall landraces.

Number of Tillers/plant

The data pertaining to the number of tillers per hill of Rice (Kalanamak varieties) as influenced by different crop management practices at periodic intervals (40, 60, 80, and 100 DAT) At 100 DAT: At the final observation stage, the maximum number of tillers (16.2) was consistently recorded with Treatment 8 (SRI of Bauna Kalanamak 102). However, it was found to be statistically at par with Treatment 2 (15.24), Treatment 7 (14.76), Treatment 4 (15), and Treatment 6 (14.38). Overall, the data indicates that the System of Rice Intensification (SRI) in Bauna Kalanamak 102 variety resulted in a higher number of tillers compared to other treatment combinations as the crop progressed toward maturity. According to Singh *et al.* (2025) ^[7], establishment methods that optimize soil aeration and nutrient availability significantly boost the tillering capacity of Kalanamak rice. My findings are in close conformity with the observations of Chaudhary *et al.*, who reported that dwarf (Bauna) lineages of Kalanamak are specifically bred for high tillering efficiency to maximize the photosynthetic surface area.

Number of effective Tillers/plant

The production of productive or effective tillers per plant evaluated at 120 DAT showed a significant response to cultivation practices and cultivars (Table1). The maximum number of effective tillers per plant (14.13) was registered in Treatment 8 (T₈: SRI + Bauna Kalanamak 102) Statistical analysis showed that it was at par with. Treatment 2 (13.53) under conventional transplanting. Other treatments like Treatment 5 (13.26) and Treatment 6 (13.06) closely followed. The creation of a higher number of effective tillers under SRI is due to the healthy development of roots and greater spacing, which avoids mutual shading. These findings align with Chaudhary *et al.*, who concluded that the genetic architecture of the Bauna Kalanamak 102 variety facilitates superior source-to-sink partitioning, ensuring that a larger percentage of total tillers successfully convert into productive, panicle-bearing effective tillers.

Yield attributes and yield parameter

Grain yield (t/ha)

Grain yield was significantly influenced by the establishment methods and cultivars (Table 2). The maximum grain yield (4.3 t/ha) was produced by Treatment 8 (T₈: SRI + Bauna Kalanamak 102). It was followed by Treatment 5 (4.1 t/ha: SRI + Pusa Narendra Kalanamak 1652). The significantly higher grain yield under the SRI method is a result of the combined effect of higher effective tillers, better root depth, and superior grain filling. As stated by Chaudhary *et al.* (2020) ^[2], the adoption of technical interventions like SRI significantly enhances the vegetative and reproductive efficiency of dwarf Kalanamak cultivars. The superior performance of Bauna Kalanamak 102 under

SRI highlights that dwarf genotypes are highly responsive to an aerated, resource-efficient SRI environment.

Test weight (g)

Test weight, which represents grain boldness and the efficiency of grain filling, was evaluated for different treatments (Table 2). The test weight (13.23 g) was achieved under Treatment 8 (T₈: SRI + Bauna Kalanamak 102), followed by Treatment 2 (12.97 g). The improvement in grain weight under SRI plots can be attributed to the wider geometry, which reduces mutual shading, maintains high relative humidity in the crop canopy, and allows optimal photosynthetic activity. These results are strongly supported by Singh *et al.* (2025) ^[7], who confirmed that optimized crop establishment practices significantly enhance post-anthesis dry matter translocation, leading to thorough grain filling and higher test weight in aromatic rice varieties like Kalanamak.

Harvest Index (%)

The Harvest Index (HI) denotes the efficiency of the plant in converting biological yield into economic grain yield. The harvest index (46.33%) at per value was recorded under Treatment 8 (T₈: SRI + Bauna Kalanamak 102), closely followed by Treatment 2 (45.67%) 'Bauna' series indicates a highly efficient translocation of photosynthates from source to sink (panicle). Traditional Kalanamak varieties generally exhibit lower harvest indices because their tall structure leads to lodging and poor resource routing. In contrast, the dwarf plant architecture in this study ensured that a significantly larger portion of the total biological biomass was converted into actual grain yield, confirming the findings of Singh *et al.* (2025) ^[7].

Table 1: Influence of establishment methods on growth attributes of Kalanamak Rice

	Treatment Combination	Plant height (cm)	Plant dry weight (g)	Number of tiller per plant	Number of effective tiller/plant	C.G.R.	R.G.R.
		100DAT	100DAT	100DAT	120DAT	80To100 DAT	80To100 DAT
1	Conventional Transplanting Pusa Narendra kalanamak 1652	81.98	80.45	14.14	12.46	24.6	0.012
2	Conventional Transplanting Bauna kalanamak 101.	87.07	91.55	15.24	13.53	22.84	0.011
3	Conventional Transplanting Kalanamak kiran.	85.59	79.83	14.87	13	23.6	0.012
4	Conventional Transplanting Bauna kalanamak 102.	81.94	86.86	15	12.63	22.04	0.011
5	System of Rice Intensification Pusa Narendra kalanamak 1652.	83.05	85.14	14.44	13.26	14.94	0.014
6	System of Rice Intensification Bauna kalanamak 101.	84.45	88.46	14.38	13.06	10.93	0.013
7	System of Rice Intensification Kalanamak kiran.	86.32	87.97	14.76	12.46	16.19	0.014
8	System of Rice Intensification Bauna kalanamak 102.	88.92	85.86	16.2	14.13	14.8	0.015
	F test	S	S	S	S	S	-
	S.Em(±)	0.87	1.65	0.96	0.34	1.46	0.04
	CD(p=0.05)	2.63	5.00	0.32	1.03	4.41	-

Table 2: Effect of establishment methods and varieties on. Yield Attributes kalanamak Rice

Treatment Combination		Seed yield (t/ha.)	Test weight (g)	Harvest index (%)
1	Conventional Transplanting Pusa Narendra kalanamak1652.	3.7	11.77	43.14
2	Conventional Transplanting Bauna kalanamak 101.	3.9	12.97	45.67
3	Conventional Transplanting kalanamak Kiran.	3.6	11.03	42.46
4	Conventional Transplanting Bauna kalanamak 102.	3.9	11.63	43.54
5	System of Rice Intensification Pusa Narendra kalanamak1652.	4.1	10.98	42.33
6	System of Rice Intensification Bauna kalanamak 101.	3.8	12.13	45.64
7	System of Rice Intensification kalanamak kiran.	3.7	11.53	43.05
8	System of Rice Intensification Bauna kalanamak 102.	4.3	13.23	46.33
	F test	S	-	-
	S. Em(±)	0.19	0.67	1.17
	CD(p=0.05)	0.58	-	-

Conclusion

From the experimental findings, it is concluded that, to achieve highest yield and maximum profit from Kalanamak Rice, variety Bauna Kalanamak 102 should be sown under System of Rice Intensification (SRI) (treatment 8) under the Prayagraj Conditions (Vindhyan Zone)

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