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Effect of Different Transplanting Dates on Yield of Basmati Rice (*Oryza sativa* L.) under Mid-Hill Conditions of Himachal Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Aim: The present study optimizes, Effect of different transplanting dates on yield of basmati rice (*Oryza sativa* L.) under mid-hill conditions of Himachal Pradesh.
Place and Duration of Study: A field experiment on the Effect of different transplanting dates on yield of basmati rice (*Oryza sativa* L.) under mid-hill conditions of Himachal Pradesh was carried out in *kharif season of 2024* in the Experimental Farm of the Department of Agronomy, CSK HPKV, Palampur.

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Methodology: The study was performed using a Randomized Block Design (RBD) that included 9 treatments and was replicated three times. The treatments involved three distinct transplanting dates (June 5th, June 15th, and June 25th) along with three varieties (Basmati-370, Kasturi Basmati, and Pusa Basmati 1121). The experimental site's soil had a silty clay loam texture, was acidic in reaction, and contained medium levels of available nitrogen, phosphorus, and potassium

Results: Transplanting on 5th June resulted in significantly higher yield attributes and yields compared to later transplanting dates while the lowest values for all parameters were recorded under 25th June transplanting. Among the varieties, Basmati-370 produced significantly higher number of effective tillers/m^2, weight of panicle, weight of grains/panicle, 1000-grain weight, grain yield, straw yield and harvest index compared to Kasturi Basmati and Pusa Basmati 1121. Pusa Basmati 1121 recorded the lowest performance across all parameters.

Conclusion: Early transplanting on 5th June combined with Basmati-370 was found to be the most suitable treatment combination for enhancing the productivity of basmati rice. This study finds the effective transplanting date and suitable variety for maximizing the yield of basmati rice on mid-hill conditions of Himachal Pradesh.

Keywords: Basmati rice; growth attributes; transplanting dates; yield.

1. Introduction

"Rice (*Oryza sativa* L.) is one of the most important staple food crops feeding nearly half of the global population. It contributes significantly to food and livelihood security in most Asian countries, where more than 90 % of the world's rice is produced and consumed" (Rai & Kushwaha, 2005). India stands first in area with 51.5 m ha and second in production with 151 million tonnes with a productivity of 4.40 kg/ha, reflecting its vital role in the agricultural economy (Anonymous, 2025). In Himachal Pradesh, rice is the second major cereal after maize is predominantly grown under mid-hill humid conditions with an area of 88.16 hectares with production of 199.00 metric ton and productivity 2257.26 Kgs/hectare, where climatic factors such as rainfall distribution, temperature fluctuations and relative humidity strongly govern its growth and productivity (Anonymous, 2023-24).

The growth of rice mainly depends on choosing the right time for transplanting because it decides how the crop will face the weather during different growth stages (Deshmukh & Patel, 2013). Rice is a warm-loving crop and grows best when the climate is hot and humid. If the temperature or rainfall is not suitable, it can negatively affect plant height, seedling establishment, tiller formation and biomass build-up (Ji *et al*., 2007). Extreme high and low temperatures affect plant growth, panicle initiation and flowering, leading to significant reductions in rice yield (Ahmed *et al.,* 2020). When the crop is transplanted early, it gets more time under favourable temperatures and longer days, which supports better vegetative growth (Medhi *et al.,* 2019). However, late transplanting exposes the crop to less sunlight and lower temperatures, which slows down growth and reduces overall plant development (Saseendran *et al*., 2000).

Previous studies have reported wide variation in varietal response to transplanting time due to differences in growth behavior and genetic adaptability (Mann & Dhillon, 2023). Basmati rice varieties, in particular, are sensitive to environmental variation during early growth stages due to their longer growth duration and aromatic grain quality attributes. Under mid-hill conditions of Himachal Pradesh, where rainfall patterns are erratic and temperatures gradually decline after July, optimum transplanting time becomes crucial for achieving desirable vegetative growth and biomass accumulation. Although considerable research exists on the influence of transplanting dates under plains and lowlands, limited scientific evidence is available for the mid-hill ecology where crop phenology is closely linked with microclimatic variation. "Agricultural production and productivity of any region are regulated by the prevailing climate through temperature, rainfall, light intensity, radiation and sunshine duration" (Goswami et al. 2006).

Keeping this in view, the present investigation entitled *"Effect of different transplanting times on yield of basmati rice (Oryza sativa L.) under mid-hill conditions of Himachal Pradesh"* was carried out with the objective to see the response of different transplanting dates on yield of basmati rice varieties.

2. Materials and Method

A field experiment was conducted during *kharif* 2024 at the Experimental Farm, Department of Agronomy, CSK HPKV, Palampur. The location of the experiment was 1290 meters above mean sea level at 32°6'N latitude and 76°3' E longitude. During the crop growth season, the weekly maximum and minimum temperatures varied from between 35.3 °C and 7.8 °C, respectively. The total rainfall received during the crop season was 2512 mm; however, it was unevenly distributed during the early growth stages of crop. The bright sunshine hours ranged from 0.9 hours to 11.1 hours, and the mean relative humidity ranged between 26.1 to 91.8 % during the cropping season.

The soil at the site was silty clay loam, acidic in nature, with medium levels of available nitrogen, phosphorus, and potassium.

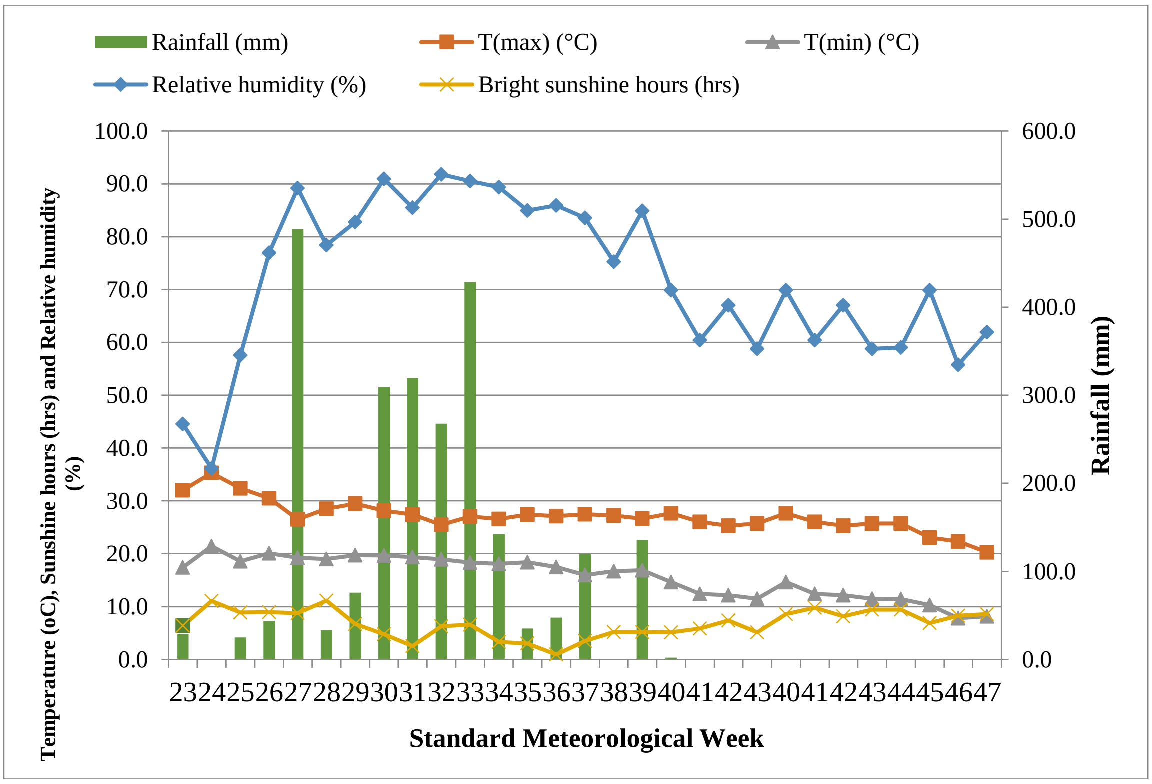

Fig. 1. Mean weekly meteorological data of *kharif* 2024 at Palampur

Table 1. Physio-chemical properties of the soil

Soil property	Value	Method
Sand (%)	21.5	International pipette method (Piper, 1966)
Silt (%)	44.3	
Clay (%)	34.2	
Textural class	Silty clay loam	
pH	5.45	1: 2.5 Soil: water suspension (Jackson, 1967)
Organic carbon (%)	0.74	Rapid titration method (Walkley & Black, 1934)
Available Nitrogen (kg/ha)	288.2	Alkaline permanganate method (Subbiah & Asija, 1956)
Available Phosphorus (kg/ha)	23.9	0.5 $NaHCO_3$ extraction (Olsen, 1954)
Available Potassium (kg/ha)	240.5	Neutral normal ammonium acetate extraction method (AOAC, 1970)

The study was laid out in a Randomized Block Design (RBD) including three transplanting dates (5th June, 15th June and 25th June) and three rice varieties (Basmati-370, Kasturi Basmati and Pusa Basmati 1121), with three replications for each treatment combination. Thirty-day-old seedlings were transplanted at a spacing of 20 × 20 cm, with one seedling per hill.

The crop received 90 kg N, 40 kg P_2O_5, and 40 kg K_2O per hectare. Nitrogen was applied in three equal doses: one-third at transplanting, one-third at maximum tillering, and the final one-third at the panicle initiation stage. Phosphorus was applied as single superphosphate at the time of transplanting, while potassium was supplied through muriate of potash at the time of transplanting.

3. Results and Discussion

3.1 Yield Attributes and Yield

The number of effective panicle/m^2 is directly related to yield components and play crucial role in determining overall productivity. As regards with transplanting dates significantly higher values for number of effective tillers/m^2 were reported on first day of transplanting (5th June) which was statistically at par with the 15th June of transplanting, in contrast, the crop transplanted on 25th June recorded lower values for the number of effective tillers/m^2. Late transplanting (25th June) exposed the crop to relatively adverse environmental conditions during the tillering stage, such as suboptimal temperature, lower light intensity, or increased pest pressure, additionally, low temperatures during the reproductive phase may have further restricted panicle initiation and grain filling, resulting in fewer effective tillers compared to the 5th June transplanting. Among the varieties, Basmati-370 recorded higher values for number of effective tillers/m^2 followed by Kasturi Basmati. While the lower values were recorded for Pusa Basmati 1121. These findings are consistent with earlier reports by Vishwakarma et al. (2016), Singh et al. (2019), Paschapur et al. (2021) and Mann and Dhillon (2023), who also reported that timely transplanting significantly improves tiller development, panicle density and overall productivity of crop.

An analogous outcome was observed for the length of panicle, further reinforcing the positive influence of the treatment on reproductive yield attributes, early transplanting of the crop led to the significantly higher value for panicle length which was followed by 15th June transplanting. This can be attributed that early transplanting ensured the panicle initiation and differentiation phases coincided with optimum temperature (around 28–30 °C), which favour elongation of the rachis and branching. Conversely, late transplanting exposed the crop to relatively lower temperatures during reproductive growth, restricting cell elongation and panicle extension. All the varieties also showed significant difference in panicle length under observation. Basmati-370 showed higher panicle length, which was statistically at par with Kasturi Basmati. Significantly lower values were recorded for Pusa Basmati 1121. This results align with the findings of Mehta et al. (2019) and Mann and Dhillon (2023) who reported that the thermal environment strongly regulates panicle development in rice.

The data on Table 2 indicated that the weight of panicle and weight of grains/panicles. It follows the same trend as number of effective tillers/m^2 the 5th June transplanted crop recorded significantly higher value, which was statistically at par with 15th June. This may be due to the enhanced assimilates availability during the grain-filling stage. Early transplanted crops benefited from longer sunshine hours, improved photosynthetic activity, and reduced competition for assimilates between vegetative and reproductive sinks. In contrast, late transplanting shortened the effective grain-filling duration resulting in incomplete translocation of stored carbohydrates into developing grains. Such source limitation under shortened crop duration has been well documented. Among the cultivars, Basmati-370 recorded higher value, which was at par with Kasturi Basmati. Mann and Dhillon (2023) similarly reported that early transplanting produces maximum weight of panicle and grain weight/panicle.

The effect of transplanting dates and varieties on 1000-grain weight was found to be non-significant. While the higher value was recorded for 5th June, transplanting and lower value was recorded on 25th June. The 1000-grain weight exhibited relatively smaller differences among transplanting dates, indicating that its trait is largely under genetic control compared to panicle length and weight. Nevertheless, a slight reduction was recorded under late transplanting (25th June), which can be attributed to incomplete starch deposition in the endosperm resulting from a shortened grain-filling phase and low exposure to night temperatures. Among the varieties, Basmati-370 recorded higher value and lower values were obtained on Pusa Basmati 1121. Similar findings were reported by Shabana et al. (2016), Mehta et al. (2019) and Singh et al. (2021).

The yield of the basmati rice was interpreted in Table 4. The crop transplanted on 5th June consistently outperformed in terms of yield and harvest index. The superiority of early transplanting may be attributed to a longer vegetative growth period, which resulted in greater tiller production, higher panicle density/unit area and enhanced spikelet formation. Moreover, panicle initiation and flowering under early transplanted crops coincided with favourable temperature regimes and optimum solar radiation, thereby supporting better reproductive development the extended grain-filling duration under early transplanting further facilitated complete starch deposition, the test weight and grain weight/panicle. In contrast, late transplanting exposed the crop to sub-optimal weather conditions, reduced sunshine hours and higher pest and disease pressure during reproductive stage, ultimately leading to reduced yields. Basmati-370 produced noticeably higher grain yield among all the cultivars. These results reaffirms that timely transplanting is essential for achieving the higher grain yield, also reported by Wani et al. (2016), Priyadarshi et al. (2018), Tiwari et al. (2018), Saha et al. (2019), Mehta et al. (2019) and Mann and Dhillon (2023). However the interaction effect of both the factors are found to be significant.

The interaction effect of transplanting dates and varieties on the grain yield was found to be significant and has been presented in Table 3. A date-wise comparison of varieties revealed that Basmati-370 produced significantly higher grain yield at all dates of transplanting which was at par with Kasturi Basmati at 5th date of transplanting. A comparison of varieties at different dates showed that Basmati-370, Kasturi Basmati and Pusa Basmati 1121 recorded significantly higher grain yield at the first date of transplanting (5th June) followed by 15th June and 25th June.

Table 2. Effect of treatments on yield attributes

Treatments	Number of effective tillers/m^2 (No.)	Length of panicle (cm)	Weight of panicle (g)	Weight of grains/panicle (g)	1000-grain weight (g)
Date of transplanting					
5th June	238.0	22.54	3.79	3.39	28.1
15th June	224.3	21.58	3.53	3.27	27.9
25th June	205.4	20.42	3.33	3.13	27.7
SEm ±	3.6	0.31	0.05	0.04	0.3
CD (*P=0.05*)	10.8	0.94	0.16	0.12	NS
Variety					
Basmati-370	245.4	22.44	3.73	3.40	28.6
Kasturi Basmati	220.1	21.52	3.53	3.24	27.9
Pusa Basmati 1121	202.2	20.73	3.38	3.15	27.4
SEm ±	3.6	0.31	0.05	0.04	0.3
CD (*P=0.05*)	10.8	0.94	0.16	0.12	NS

Table 3. Interaction effect of transplanting dates and varieties on grain yield

	5th June	15th June	25th June
Basmati-370	2698	2581	2397
Kasturi Basmati	2514	2335	2096
Pusa Basmati 1121	2085	1356	600
CD (*P=0.05*)			
For comparison of varieties at different date			208

Table 4. Effect of treatments on yield

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Date of transplanting			
5th June	2432	3461	40.9
15th June	2091	3292	39.3
25th June	1698	3110	35.3
SEm ±	40	55	1.8
CD (*P=0.05*)	120	165	NS
Variety			
Basmati-370	2559	3567	41.5
Kasturi Basmati	2315	3388	40.6
Pusa Basmati 1121	1347	2916	33.5
SEm ±	40	55	1.8
CD (*P=0.05*)	120	165	NS

The data on effect of different transplanting dates and basmati rice on straw yield (Table 4) revealed that crop transplanted on 5th June produced significantly highest straw yield followed by 15th June and 25th June. The higher straw yield under early transplanting is attributed to a longer vegetative period, greater tiller production and higher leaf area index. In contrast, late-planted crops experienced shortened thermal time, reduced sunshine hours and greater environmental stress which restricted the vegetative growth and biomass production. Significant varietal differences were also observed, with Basmati-370 recorded highest straw yield, followed by Kasturi Basmati and Pusa Basmati 1121. Similar results are reported by Singh et al. (2019) and Sharma et al. (2022).

The data on the harvest index (Table 4) indicated that numerically higher harvest index was found on 5th June transplanting compared to 15th and 25th June. Harvest index which indicates the efficiency of partitioning assimilates into the grain, was highest under early and mid-June transplanting and declined with late planting. This trend suggests that timely transplanting not only enhanced total biomass but also improved assimilate allocation toward grain. Among the *basmati* rice varieties, *Basmati*-370 recorded a numerically higher harvest index than *Kasturi Basmati* and *Pusa Basmati* 1121. However, the interaction between different transplanting dates and varieties on harvest index was found to be non-significant. Same trend retained as were reported by Singh et al. (2019) and Mann and Dhillon (2023).

4. Conclusion

The present investigation revealed that transplanting time had a marked influence on the reproductive growth of basmati rice under mid-hill conditions. Early transplanting on 5th June enabled the crop to utilize favourable temperature and longer photoperiod during the growth stages, which resulted in higher yield attributes and yield as compared to 15th and 25th June transplanting. Among the tested varieties, Basmati-370 consistently recorded superior performance, followed by Kasturi Basmati, whereas Pusa Basmati 1121 remained inferior. The findings suggest that transplanting basmati rice around the first week of June, particularly with Basmati-370, is an effective agronomic approach for improving the productivity of basmati rice under the mid-hill conditions of Himachal Pradesh.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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Competing Interests

Authors have declared that no competing interests exist.

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