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Performance of Rice Crop under Direct Seeded And Transplanted Method in Central Punjab

Atin Majumder and L.K. Dhaliwal*

Department of Climate change and Agricultural Meteorology
Punjab Agricultural University, Ludhiana-141 004, India
**E-mail: dhaliwal1969@pau.edu*

Abstract: Field experiments were conducted at Punjab Agricultural University Ludhiana, Punjab to study the effect of planting methods on yield and yield contributing characteristics of rice crop during *kharif* 2021 and 2022. The experiments comprise of two dates of sowing (20th May and 30th May), two rice varieties (PR 126 and PR 128) and two planting methods, puddled transplanted rice (PTR) and direct seeded rice (DSR). The highest LAI and tiller number was in PTR method compared to DSR method. The variety PR 128 attained highest LAI and tiller numbers compared to variety PR 126 in both the seasons. Significant difference in grain yield was observed with delay in sowing between 20th May and 30th May. Significantly higher grain yield (8.1 t/ha) was recorded in variety PR 128 as compared to variety PR 126 (6.8 t/ha). The yield contributing characteristics were also significantly higher in 30th May sown crop (variety PR 128), under PTR as compared to DSR. The crop sown in PTR method gave significantly higher grain yield (8.0 t/ha) as compared to DSR method (6.9 t/ha).

Keywords: Puddled transplanted rice, Direct seeded rice, Sowing method, Sowing time

Rice stands as one of the primary cereal crop in northwestern India, particularly in Punjab. The rice cultivation has been increased significantly in Punjab, owing to the accessibility of high-yielding varieties, improved irrigation infrastructure, and government-backed support prices. Rice occupied approximately 31.45 lakh hectares with a total production of about 203.71 lakh tons (PAU Package and Practice 2023). An average of over 4000 liters of water is utilized to yield one kilogram of rice (IRRI 2008). But in Punjab, due to decline in ground water table in most of the places, the cost of pumping the groundwater was increased and water quality also deteriorate over the years (Singh et al., 2022). Along with increasing labour challenges it is very hard to maintain the sustainability of the rice ecosystem. Transplantation into puddled fields was a conventional agricultural technique that often leads to the formation of hard pan, consequently ruin the soil structure. Moreover, the consistently inundation of water, enhances the deep percolation and sometime excessive irrigation, surpassing the actual water demands of the crop. Hence, other practices for rice growing need to be explored to solve this problem such as direct-seeded rice, which need less water in comparison to conventional transplanting method (Kamboj et al., 2022). Direct-seeded rice offers several advantages over transplanted rice, including systematic water utilization, mechanization compatibility, enhanced profitability, increased the quality and early maturity. Additionally, it facilitates an optimal sowing window for subsequent wheat crops, thereby contributing to the sustainability of the rice-wheat cropping system (Ishfaq et al., 2018, Anjum et al., 2019). Given the pressing necessity to enhance the water productivity of rice cultivation in Punjab to mitigate economic losses and ecological deterioration, field experiments were undertaken to investigate the impact of different planting methods on rice yield and yield contributing characteristics.

MATERIAL AND METHODS

The field experiment was carried out at Punjab Agricultural University, Ludhiana, during the 2021 and 2022 *kharif* season. It is situated at 30°54'N latitude and 75°48'E longitude and is 245 m above mean sea level. Two rice varieties, PR 126 (V_1) and PR 128 (V_2) were transplanted (M_1) and directly seeded (M_2) on two different dates 20th May and 30th May for direct seeded rice and 20th June and 30th June for transplanted rice. The experiment was laid out in the split-split plot design with four replication. In the context of direct-seeded rice (DSR) method, urea was given at a rate of 321 kg per ha, distributed evenly across three applications occurring at four, six, and nine weeks after sowing. Conversely, for puddled transplanted rice (PTR) method, urea was applied at a rate of 222.3 kg per hectare, while phosphorus was applied as diammonium phosphate (DAP) at 66.7 kg per hectare, and potash was provided as muriate of potash (MOP) at 49.4 kg per hectare (PAU Package and Practice 2023). Biometric parameters *viz*. leaf area index (LAI) and tiller numbers were recorded at 15 days interval. Yield and yield contributing

characteristics viz. number of grains per plant, number of effective tillers per plant, 1000-grain weight, biological yield, grain yield and straw yield were recorded at harvesting. The meteorological data was recorded at the Agro meteorological Observatory located 150m away from the experimental site.

Statistical analysis: The data collected on different yield and yield contributing characteristics was statistically analyzed by using split-split plot design by using SPSS software and OPStat software.

RESULTS AND DISCUSSION

Weather during *kharif* 2021 and 2022: Throughout the *kharif* of 2021, the maximum temperature ranged between 26.0 and 38.0°C, whereas in the corresponding period of 2022, it varied from 25.6 to 43.7°C (Fig. 1, 2). Similarly, the minimum temperature during the *kharif* 2021 ranged between 8.5 to 28.5°C, while in *kharif* 2022, it spanned from 28.7 to 8.7°C. During the crop growing season of *kharif* 2021, the morning relative humidity ranged between 49.5 to 93.0 per cent and the evening relative humidity ranged between 23.1 to 75.0 per cent. But in *kharif* 2022 the morning relative humidity ranged between 39.4 to 95 per cent and the evening relative humidity ranged between 16.0 to 71.5 per cent. The total sunshine hours ranged between 3.4 to 10.8 hours during

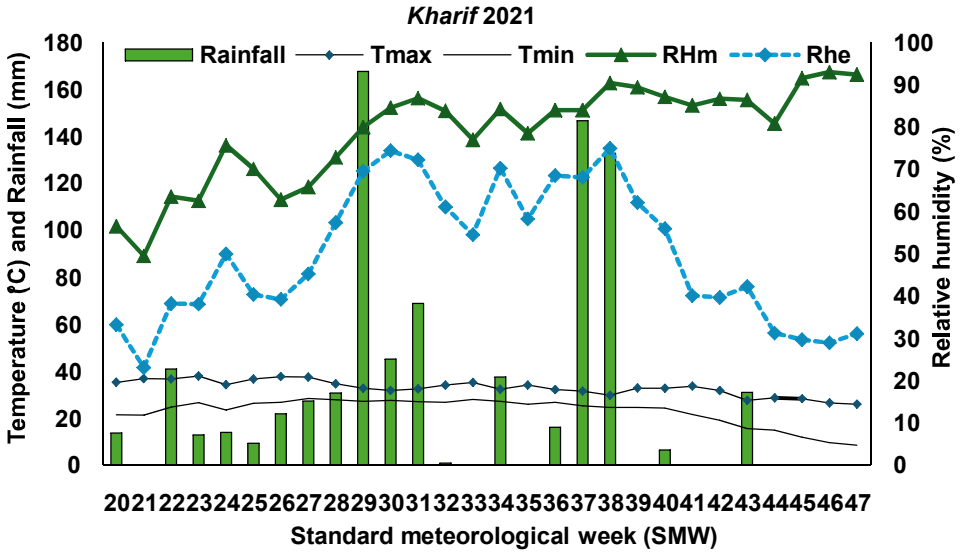

Fig. 1. Variation of meteorological parameters during *kharif* 2021

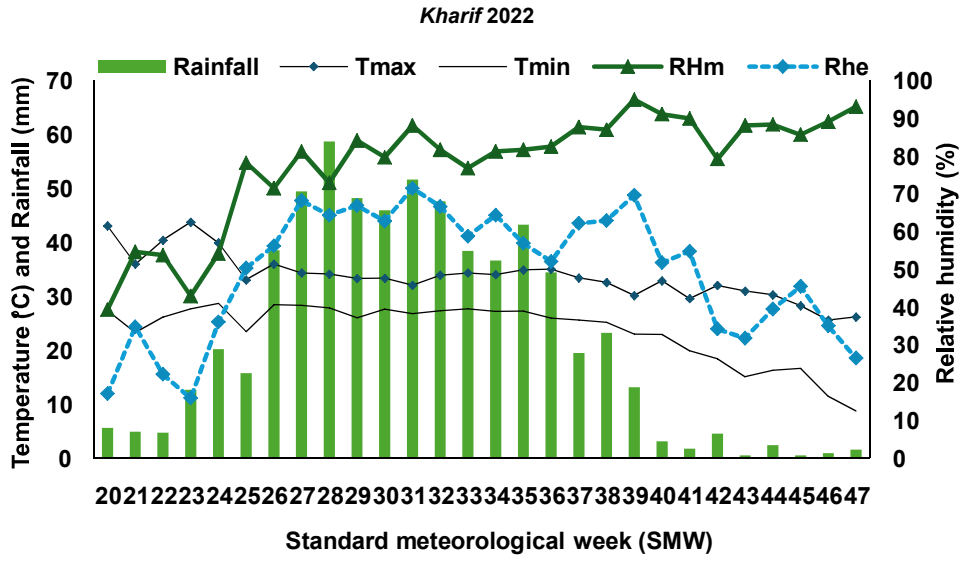

Fig. 2. Variation of meteorological parameters during *kharif* 2022

the crop growing season of *kharif* 2021. But in *kharif* 2022 the total sunshine hours ranged between 1.6 to 10.3 hours. The total rainfall was 759.4 mm during the *kharif* 2021 and 643.7 mm in *kharif* 2022.

Biometric Parameters

Leaf area index - Leaf area index (LAI) was increased up to 90 days after sowing and later decreased up to physiological maturity in both the years (Table 1). The LAI was higher during 30th June transplanting / 30th May sown crop as compared to 20th June transplanting / 20th May sown crop. For 20th June transplanting / 20th May sowing the highest LAI was recorded during 90 days after sowing (DAS), which was 3.62, and for 30th June transplanting / 30th May sowing it was 3.65. Significant difference in LAI were found at all physiological stages (except 45 DAS) between two dates of sowing. There was significant difference between two varieties at every physiological stages. In variety PR 126, the highest LAI was at 90 DAS (3.43), however in variety PR 128, the highest LAI was at 90 DAS which was 3.84. Inherent variances in leaf arrangement, morphology, developmental behaviour and genetic diversity play an important role in varietal expression of biophysical characters in rice. Temperature, the availability of water, and the concentration of nutrients all have an impact on leaf development and overall plant growth, which in turn affects LAI (Hour et al., 2020). In case of method of sowing, LAI was at higher side in PTR compared to DSR. But there was significant difference in LAI at all physiological stages (except 45 DAS). The enhanced growth observed in rice cultivated using the PTR method can be attributed to increased accessibility to photosynthetically active radiation (PAR) and an improved supply of light conducive to photosynthesis. These favorable conditions likely facilitated improved physiological processes, including enhanced carbohydrate metabolism and respiration, thereby promoting the overall development and growth of rice plants in PTR method. Similar results were observed by Gill et al. (2011).

Periodic number of tillers: The highest number of tillers per square meter for both the varieties (PR 126 and PR 128) was at 105 days after sowing (DAS), which was highest in 30th June transplanted/30th May direct sown crop and lowest in 20th June transplanted/20th May direct sown crop. The number of tillers per meter square showed significant response to different transplanting dates (Akbar et al., 2010). This was due to the low temperature during the pollen development stage, which may have led to fewer tillers (Gill et al., 2006). Overall variety PR 128 produced more number of tillers compared to variety PR 126 in both PTR and DSR method. However, at 105 DAS, 30th June transplanted variety PR 128 had highest number of tillers (338 tillersper square meter), followed by 20th June transplanted variety PR 128 (331 tillers per square meter), 30th June transplanted variety PR 126 (297 tillers per square meter), 20th June transplanted variety PR 126 (290 tillers per square meter). Similarly, at 105 DAS, 30th May direct sown variety PR 128 had highest number of tillers followed by 20th May direct sown variety PR 128. The number of tillers in PTR was more as compared to DSR. The competition for nutrients and space between plants was more in DSR due to improper thinning, which was absent in PTR (Choudhary et al., 2016 , Luo 2022). the number of tillers in rice plants decreases significantly under high plant populations, whereas it can be significantly increased with sufficient nutrient supply with proper plant population. This highlights the importance of plant population in regulating tiller development (Chen et al., 2020).

Table 1. Effect of different treatments on leaf area index of rice (Pooled data of 2 years)

Treatments	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
Date of sowing (D)						
20th May	0.33	0.99	2.09	3.62	2.92	2.22
30th May	0.34	0.90	2.14	3.65	2.97	2.27
CD (p=0.05)	NS	0.04	0.03	0.01	0.02	0.03
Variety (V)						
PR 126	0.32	0.97	2.07	3.43	2.84	2.12
PR 128	0.35	0.92	2.16	3.84	3.05	2.37
CD (p=0.05)	0.02	0.04	0.06	0.15	0.14	0.11
Method of sowing (M)						
PTR	0.33	0.96	2.14	3.65	2.97	2.27
DSR	0.33	0.94	2.10	3.62	2.93	2.22
CD (p=0.05)	NS	0.01	0.03	0.02	0.03	0.02

PTR – Puddled transplanted rice; DSR - Direct seeded rice

Yield and Yield Contributing Characters

Effective tillers: The time of sowing influenced the number of effective tillers per plant (at harvest) in both the varieties and significant differences were observed in varieties under different dates of sowing during both the crop seasons (Table 2). The number of effective tillers per plant was higher in 30th June transplanting/30th May direct sowing (9.6) compared to 20th June transplanting/20th May direct sowing (9.3) and are significantly different from each other (Table 2). There may be an influence of sowing timing on tiller development in rice crop. The rice crop enters the initial phase of development slowly when sown early and contrarily, passes quickly when sown late (Urazmetov et al 2023). The variety PR 128 produced more number of tillers per plant (9.7) compared to

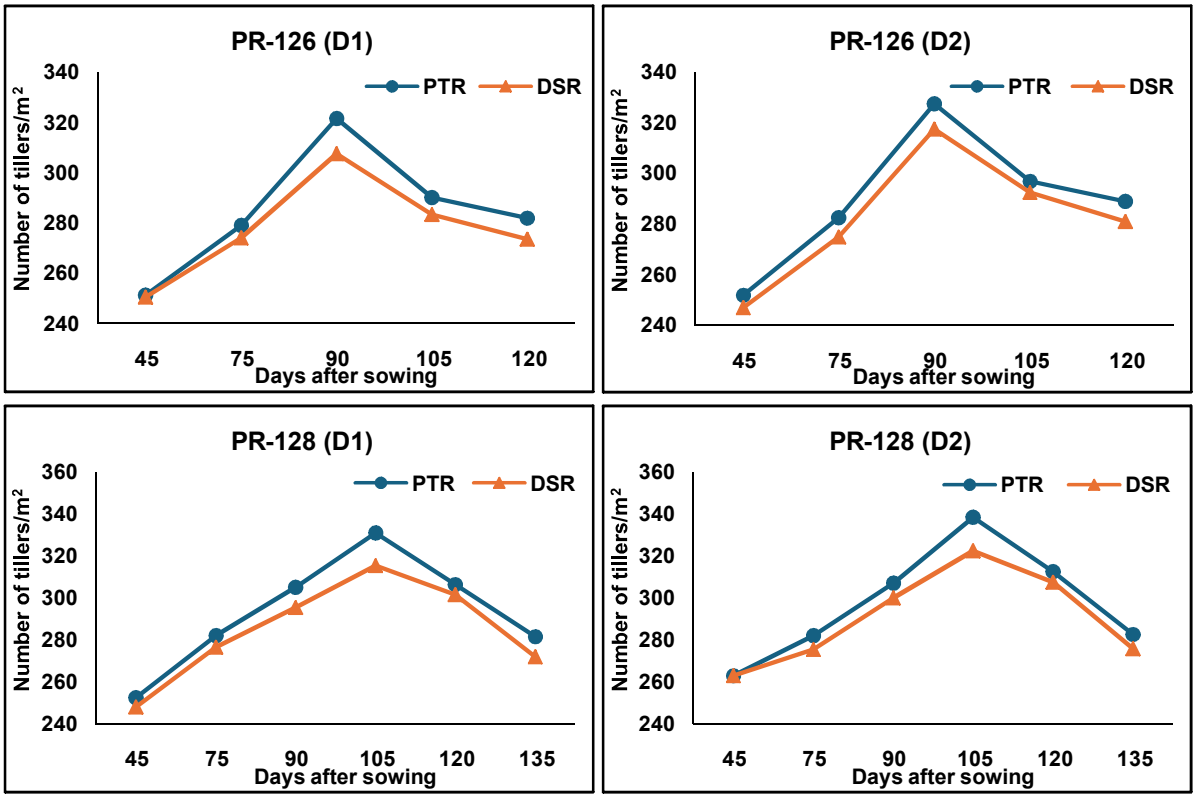

Fig. 3. Periodic number of tillers under different methods of sowing (Pooled data of 2021 and 2022)

Table 2. Effect of different treatments on yield and yield attributes of rice (Pooled data of 2 years)

Treatments	No of effective tillers/plant	No of grains per panicle	1000 grain weight (g)	Biological yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)
Date of sowing (D)						
20th May	9.3	123.4	25.2	21.5	7.5	14.0
30th May	9.6	146.0	25.8	24.5	7.4	17.1
CD (p=0.05)	0.2	9.3	NS	1.5	NS	1.3
Variety (V)						
PR 126	9.1	130.8	25.6	21.6	6.8	14.8
PR 128	9.7	138.6	25.7	22.4	8.1	14.3
CD (p=0.05)	0.3	NS	NS	NS	0.8	NS
Method of sowing (M)						
PTR	9.7	147.6	25.9	21.8	8.0	13.8
DSR	9.2	123.3	25.2	22.3	6.9	15.4
CD (p=0.05)	0.4	13.9	NS	NS	0.7	NS

variety PR 126 (9.1). They are significantly different from each other. PTR method produced more number of effective tillers (9.7) compared to DSR method and are significantly different from each other. The PTR method involving transplanting seedlings into puddled and flooded fields, creates conducive conditions for tiller initiation and development. Chaudhary et al (2023) also highlighted the more tiller production in transplanted rice systems due to enhanced nutrient availability and controlled seedling establishment in puddled fields. The PTR method may promote faster planting and maturing, which can contribute to better tiller production.

Number of grains per panicle: The number of grains per panicle were more (146.0) in 30th June transplanting/30th May direct sowing compared to 20th June transplanting/20th May direct sowing (123.4) and there are significant difference in both date of sowing (Table 2). For variety PR 128 the number of grains per panicle (138.6) was more compare to variety PR 126 (130.8) but they were statistically at per. But there was a significant differences in number of grains per panicle between transplanting method and direct seeded method. Transplanting method produced more number of grains (147.6) compared to directly sown crop (123.3). This aligns with the research conducted by Gavric and Omerbegovic (2021), emphasized the potential for increased grain yield in transplanted rice systems due to enhanced tillering and panicle formation. The observed higher grain count in the transplanting method reflects its efficiency in creating favourable conditions for rice crop growth, thereby contributing to increase in overall grain yield compared to the direct seeding approach.

1000-grain weight: The 1000-grain weight was higher in 30th June transplanting/30th May direct sowing (25.8 g) compared to 20th June transplanting/20th May direct sowing (25.2 g), with no significant difference between them (Table 2). The increase in 1000-grain weight highlighted the sensitivity of this key yield-contributing factor to variations in environmental conditions associated with different sowing dates. The 30th May sowing date likely provided more favourable conditions for grain filling and maturation, resulting in larger and heavier grains (Soleymani and Shahrajabian 2011). There was no significant difference in 1000-grain weight for two varieties and two method of sowing.

Grain yield: Grain yield was higher in variety PR 128 (8.1 t/ha) compared to PR 126 (6.8 t/ha) with significant difference between them (Table 2). But there was no significant difference in grain yield between two dates of sowing. However, the highest grain yield was observed in PTR method (8.0 t/ha), but grain yield obtained in DSR method was 6.9 t/ha and they are significantly different from each other. The higher grain yield in the PTR method can be attributed to factors such as enhanced tiller development, controlled seedling establishment and favorable conditions provided by puddling and transplanting. Khush (2013) also demonstrated the potential for increased grain yield in transplanted rice systems. Additionally, a meta-analysis by Xu et al (2019) also reported that the yield of transplanted rice was higher than that of directly seeded rice.

Biological and straw yield: The other yield contributing characters viz. biological yield and straw yield are significantly different during both date of sowing. The biological yield was higher in 30th June transplanting/30th May direct sowing (24.5 t/ha) compared to 20th June transplanting/20th May direct sowing (21.5 t/ha) and they are significantly different (Table 2). Similarly, 30th June transplanting/30th May direct sowing produced more straw yield (17.1 t/ha) compared to 20th June transplanting/20th May direct sowing (14.0 t/ha) and there was a significant difference between them (Table 2). This may be due to availability of favourable temperature during panicle and grain development period in 30th June (D_2) transplanted crop. These findings were supported by Urazmetov et al (2023) and Chaudhary et al (2023). Similarly, varieties sown directly produced higher biological yield compared to puddle transplanted rice varieties with no significant differences. However, in DSR method, straw production was higher (15.4 t/ha) compared to PTR method (13.8 t/ha). This may be due to the fact that,in direct seeded rice method, seeds are sown directly into the field rather than being transplanted from a nursery, plants typically experience less disturbance to their root systems. This reduced disturbance allows for more extensive root development, which in turn promotes greater nutrient uptake and biomass production, including the production of straw (Tian et al 2022).

CONCLUSION

The biometric parameters in rice as well as yield and yield contributing characters were markedly influenced by varying dates of sowing, varieties and methods of sowing. In general the yield and yield contributing characteristics were comparatively higher in 30th June transplanted/30th May direct sown crop compared to 20th June transplanted/20th May direct sown crop. Similarly, yield and yield contributing characters were higher in variety PR 128 compared to variety PR 126. Overall PTR method provide better grain yield compared to DSR method in both the crop growing seasons. Therefore, adjustments in sowing dates and sowing methods represent a cost-effective strategy for improvingthe rice yield.

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