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YIELD EVALUATION: DIRECT SEEDED RICE WITH TRANSPLANTED RICE

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ABSTRACT

Background Rice (*Oryza sativa* L.) has prominent place among other food crops in the world, and fulfills the nutritional requirement as a main diet of 50% global population. Direct seeded rice (DSR) has potential in saving water and labor resources and is going to become popular among rice growers of areas where soils are of such type that does not permit true puddling. In DSR, seed is broadcasted or drilled into a well prepared seedbed directly without raising rice nursery and then shifting it in field. To our knowledge limited research was conducted on yield comparison of DSR methods versus transplanting method in Pakistan. A study was planned to compare the paddy yield of two DSR methods (broadcast and drill sowing) with that of conventionally transplanted rice.

Methodology A multi-locational field study was conducted at 6 different villages viz., *Tamboli (Sadhoki), Nangre Bhattian (Sadhoki), Rajpura (Sadhoki) Nithranwala (Kamoki), Chak Pelo (Kamoki), and Chak 37 (Muridke)* during summer season of 2015. The experimental treatments viz., broadcast; conventional and drill were set out in randomized complete block design combined over location with three replications. Super Basmati variety was used as test crop.

Results Experimental results depicted that significantly the taller plant height (135 cm), panicle length (30.4 cm), grains per panicle (112), 1000-grain weight (26.2 g) and paddy yield (5.24 Mg ha^{-1}) were observed in conventional planting method compared to broadcast. However, broadcast and drill planting produced 37% higher number of productive tillers compared to conventional transplanting. Paddy yield showed a positive relationship with number of tillers m^{-2} (R^2 = 0.0912) while week relationship with plant height (R^2 = 0.0179) and 1000-grain weight (R^2 = 0.0332) as shown by regression analysis.

Conclusion In the light of above results it is concluded that direct seeded rice (drill and broadcast) unable to produce significant production than conventional planting method. Therefore, conventional planting method performed better yield and yield attributing parameters.

INTRODUCTION

Rice Globally, rice (*Oryza sativa* L.) is the staple food crop for nearly half the world's population (Prasad et al. 2017) whereas in Pakistan, it is ranked at 2nd position among cereals after wheat crop (Rehman et al. 2015). Rice grains fulfil approximately 60 percent of the population of Pakistan's food needs, and rice is a potential source of food worldwide for animals during the winter (Drake et al. 2002; Nguyen et al. 2008). In Pakistan, rice area and production are about 2.89 million ha and 7.44 million tones, respectively (Economic survey of Pakistan 2017-18). Basmati rice is premium quality rice with typical aromatic odor and flavor and therefore attracts the international market. About 7% of the total global rice market is occupied by Pakistani rice especially the fine grain basmati rice. Compared to other rice producing countries like Australia, USA and Japan, the rice yield in Pakistan

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is still low (Rashid et al. 2001). The main crop management factors responsible for low rice yield in Pakistan are delayed planting and sub-optimal plant population (Mahmood and Walter 1990).

In Pakistan, conventionally the puddled method of seedlings' transplanting is used however this method is cumbersome due acute labor shortage at the time of transplanting. This planting method is being practiced by the farmers and untrained labor does not care of the plant spacing and population per unit area that leads towards low production (Mann and Ashraf 2001). Agricultural crop sub-sector is using 75% of available fresh water resources and conventional method makes the luxurious use of water (Maclean et al. 2002). Growing paddy rice in Pakistan is a serious challenge for food security, while limited water reservoirs and increasing population are other challenges (Briscoe and Qamar 2009). Before that, water scarcity significantly reduced the sustainability of puddled rice cultivation, and may no longer be available for wet cultivation to guarantee better crop production and weed control. We should adopt such water saving methodology which strengthen rice production (Johnson and Mortimer 2005). The main objective behind conventional puddled rice is to cope with weeds. Moreover, conventional method results in subsoil compaction that restricts the growth of next crop (Kukal and Aggarwal 2003).

Recently, many resource conservation technologies have been introduced in the different areas of world to avoid conventional puddling methods. Among these technologies, direct seeded rice (DSR) system is getting popularity among farming community due to its higher water use efficiency (Mann et al. 2004), less labor requirement and cost-effectiveness (Pandey and Velasco 1999). Water requirement in direct-seeded rice is significantly less than conventional puddled method (Choudhary et al. 2007). In conventional method, not only the huge quantity of water but also trained labor for maintaining plant population of transplant rice seedling without root damage is required. Therefor these issues should be solved by direct seeding method (Dawe 2005). Irrigation requirements are fulfilled when there is a need to provide water to fields when soil water drops to less than a critical level. The overall performance of aerobic rice and directly seeded rice can be a more profitable and environmentally maintainable production system. For these reasons, aerobic rice systems could be an attractive alternative technology system in water-scarce environments (Bouman et al. 2007; Bouman et al. 2005).

Due to water and labor shortage, and higher labor charges, Pakistani rice growers are shifting their conventional puddled rice transplanting method into direct seeded rice method and recently, 0.65 million hectares' rice area of Punjab has come under DSR methods (Mann 2006). Direct seeded rice has many advantages in term of resource saving and net return than conventional transplanted rice, therefore direct seeded rice production could not be able to produce significant higher production than conventional transplanted methods. Moreover, there are two main yield reduction constraints which impede the higher production in DSR system i.e. weed infestation and poor crop establishment (Du and Tuong 2002).

One of the reasons for low production under DSR system may be no breeding program in varietal development according to un-puddled environment (Weerakoon et al. 2011; Lafitte et al. 2002). Therefore, successful adaptation of DSR method needs to firstly identify such plant traits that perform better under DSR conditions.

The main object of the study is to investigate the paddy yield of direct seeded rice (broadcast and drill sowing) method with conventional transplanting method under different locations of *kallar* tract of Punjab-Pakistan. This study will help the agronomists and farmers of these areas to select suitable sowing methods.

MATERIALS AND METHODS

Experimental sites

Experiment was conducted at six different locations in rice *Kallar* tract of Punjab-Pakistan viz., Tamboli (Sadhoki), Nangre Bhattian (Sadhoki), Rajpura (Sadhoki), Nithranwala (Kamoki), Chak Pelo (Kamoki) and Chak 37 (Muridke) during summer season 2015 to make yield comparison among different rice planting methods viz., broadcast, drill sowing and conventional transplanting.

Crop husbandry

For broadcast and drill sowing, land was prepared by two-time disc ploughings and cultivations followed by levelling. Rice cultivar *Super Basmati* @ 37 kg ha^{-1} was sown within 1st week of June, 2015. Before sowing, seed was soaked in water for 24 hours then air dried and planted. Drilling was carried out by *Rabi Seed Drill* to 2-3 cm depth keeping row to row distance of 22.5 cm. In broadcast sowing, same quantity of seed was broadcasted manually over well prepared soil and was followed by planking. In case of conventional puddled methods, firstly the nursery of rice crop was sown within the 1st week of June, 2015 and then transplanted in the puddled field one month after nursery sowing. At the time of sowing / transplanting, nutrients N, P and K were applied at the rate of 45, 84 and 31 kg ha^{-1}, respectively in the form of urea, diammonium phosphate and sulfate of potash. Full doses of P and K along with 1/3rd dose of N were applied at the time of sowing / transplanting while the remaining 1/3rd N at active tillering and 1/3rd N at panicle initiation growth stages. For weed control, recommended doses of butachlor 50% EC @ 1250 g a.i. ha^{-1} and bispyribac-sodium 10% SC @ 30 g a.i. ha^{-1} herbicides were applied as their pre- and post-emergence sprays just after nursery transplanting in conventional puddled method and 21 days after sowing in direct seeding methods. Later on, three hand weeding was done as and when needed to control the weeds latterly emerged. In direct seeded rice, field was irrigated approximately one week after sowing when all rice seedlings emerged out from the soil while continuous standing water condition was maintained in conventional transplanted rice. All other agro-management practices were uniformly applied as per their recommendation at all locations.

Observations and measurements

Plants from an area of 1 m^2 randomly selected from three different positions within each plot were harvested at their physiological maturity and paddy yield was recorded by computing the averages of three samples. After threshing and cleaning, the weight of the paddy yield was measured at 10% moisture content and per plot yield was converted into Mg ha^{-1}. Data of plant height, panicle length, productive tillers m^{-2}, grains per panicle, 1000-grain weight, and paddy yield were recorded using their standard procedures.

Experimental design and statistical analysis

The experimental treatments were set out in randomized complete block design combined over location with three replicates having a net plot size of 5 m × 10 m (50 m^2). Data collected were statistically analyzed by using Statistix 8.1 (Analytical Software 2005) computer software and significance among treatment means was judged using Tukey's honestly significant difference test at 5% probability (Steel et al. 1997). Regression analyses were performed on MS Office Excel software.

RESULTS

Data depicted that different sowing methods had significant effect on number of productive tillers, plant height, grains $panicle^{-1}$, panicle length, 1000-grain weight and paddy yield under different locations (Table 2). Significantly higher (329 m^{-2} and 324 m^{-2}) numbers of productive tillers were counted from plots sown with broadcast and drill planting methods followed by conventional transplanting (320 m^{-2}) method. While significantly lower (209 m^{-2}) number of productive tillers was recorded in conventional transplanting method. Significantly the taller plant heights (136.5 cm and 135.2 cm) were recorded in conventional transplanting method whereas the shorter plant height was recorded in drill sowing. Conventional transplanting method produced significantly (30.4 cm) longer panicle length than broadcast and drill sowing. However, the shorter (24.9 cm) panicle length was recorded in drill sowing method. Conventional transplanting method produced significantly the higher (112) number of grains per panicle compared to other planting methods. While lower (73) number of grains per panicle was counted in broadcast and drill planting methods. Significantly the heavier 1000-grain weight (26.2 g) was recorded in conventional transplanting method whereas the lower 1000-grain weight (19.7 g) was recorded in broadcast method. Significantly higher paddy yield (5.24 Mg ha^{-1}) in conventional transplanting method whereas the minimum paddy yield (2.87 Mg ha^{-1}) was observed in drill sowing method. Regression analysis indicated a significant positive relationship of paddy yield with number of productive tillers m^{-2} (R^2 = 0.0912) while weak relationship was noted with plant height (R^2 = 0.0179) and 1000-grain weight (R^2 = 0.0332) (Figure 1). The correlation matrix has been presented in Table 3. The data revealed that significant positive correlation (r = 0.302) exists between paddy yield and number of tillers m^{-2}. While paddy yield showed a non-significant positive correlation with its plant height (r = 0.1337), panicle length (r = 0.1878) and 1000-grain weight (r = 0.1822) under different sowing conditions.

DISCUSSION

Maximum number of productive tillers was recorded in broadcast and drill planting methods (Table 2) may be due to higher seed rates used at seeding time. Our findings conflict with the study of Awan et al. (2005) who recorded higher number of productive tillers in conventional transplanting method. Devic et al. (2012) concluded that productive tillers are the key yield component that has significant impact on grain yield either planting under direct or conventional conditions. Plants height showed the crop health and vigor which indicated the longer root development, uptake and availability of nutrients and water to the plants leaves. Significantly the longer plant height of rice was recorded in conventional planting may be due to minimum number of tillers that reduced the competitions among tillers (Table 2). Our findings supported the result of Awan et al. (2005) and Hussain et al. (2013) who also recorded taller plant in conventional planting methods. Longer panicle length

Table 1 Environmental conditions of district Lahore during the study period 2015

Months	Average temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)	Atmospheric pressure at sea level (h Pa)	Average relative humidity (%)	Total rainfall (mm)	Average wind speed (km h^{-1})	Maximum sustained wind speed (km h^{-1})
June	32.4	37.1	26.9	997.4	48	101.61	4.9	13.3
July	30.4	33.4	27.0	997.5	73.7	1475.49	3.4	10.0
August	30.9	34.2	27.9	998.5	72.7	545.08	2.3	8.2
September	30.0	33.9	26.3	1004.1	61.7	443.76	2.2	8.2
October	25.9	31.2	21.4	1014.1	60.5	38.1	2.3	8.1
November	19.9	25.8	15.1	1012.8	60.4	4.57	1.5	7.9

Table 2 Effect of different planting techniques on rice yield and yield related parameters sown at different sites during 2015

Site	Sowing method	Number of productive tillers (m^{-2})	Plant height (cm)	Panicle length (cm)	Number of grains $panicle^{-1}$	1000-grain weight (g)	Paddy yield (Mg ha^{-1})
Tamboli, Sadhoki	B	329 a	120.9 f	25.8 h	76 j	20.0 e	3.02 j
	C	229 k	135.2 a	26.5 f	87 e	20.3 ed	4.52 b
	D	242 j	123.6 e	26.2 f	78 h	20.7 d	3.17 i
Nangre Bhattian, Sadhoki	B	268 h	117.0 h	26.0 fg	89 d	19.7 e	3.94 g
	C	209 l	136.5 a	29.7 b	112 a	20.6 d	3.68 h
	D	289 e	111.9 k	26.5 f	89 d	20.1 ed	3.94 g
Rajpura, Sadhoki	B	315 bc	121.1 f	27.8 d	75 k	21.0 c	3.91 g
	C	320 ab	134.2 ab	30.4 a	112 a	26.2 a	4.01 f
	D	306 d	119.4 fg	25.8 h	89 d	20.4 d	4.25 cd
Nithranwala, Kamoki	B	275 fg	123.6 e	27.3 de	102 c	19.7 e	4.29 c
	C	261 i	130.1 c	28.3 c	102 c	21.9 b	4.21 e
	D	280 f	124.4 e	27.7 d	104 b	20.0 e	4.12 f
Chak Pelo, Kamoki	B	283 f	120.5 f	26.0 fg	73 l	21.0 c	4.53 b
	C	247 j	127.9 d	26.2 f	77 i	21.5 bc	5.24 a
	D	324 a	123.3 e	26.3 f	73 l	21.8 b	4.22 ed
Chak 37, Muridke	B	305 d	113.1 j	25.5 h	81 g	20.1 ed	3.02 j
	C	256 i	114.5 i	25.8 h	86 f	21.0 c	3.21 i
	D	269 h	115.0 i	24.9 i	75 k	20.3 ed	2.87 k
HSD P≤0.05		5.9	1.3	0.47	0.58	0.63	0.13

Means separated by letters in each column are not significantly different among planting techniques of rice at P≤0.05. B: Broadcast, C: Conventional, D: Drill

Table 3 Correlation matrix among grain yield and yield related traits of rice under different planting methods during 2015

Yield related traits	Number of grains $panicle^{-1}$	Paddy yield (Mg ha^{-1})	Panicle length (cm)	Plant height (cm)	Number of productive tiller (m^{-2})
Paddy yield (Mg ha^{-1})	-0.0070^{NS}	-	-	-	-
Panicle length (cm)	0.7462**	0.1878^{NS}	-	-	-
Plant height (cm)	0.4945**	0.1337^{NS}	0.6347**	-	-
Number of productive tiller (m^{-2})	-0.1825^{NS}	0.3020*	-0.0800^{NS}	-0.2811*	-
1000-grain weight (g)	0.2977*	0.1822^{NS}	0.5964**	0.4216**	0.1448^{NS}

NS=Non-significant, ** = Highly significant, * = Significant

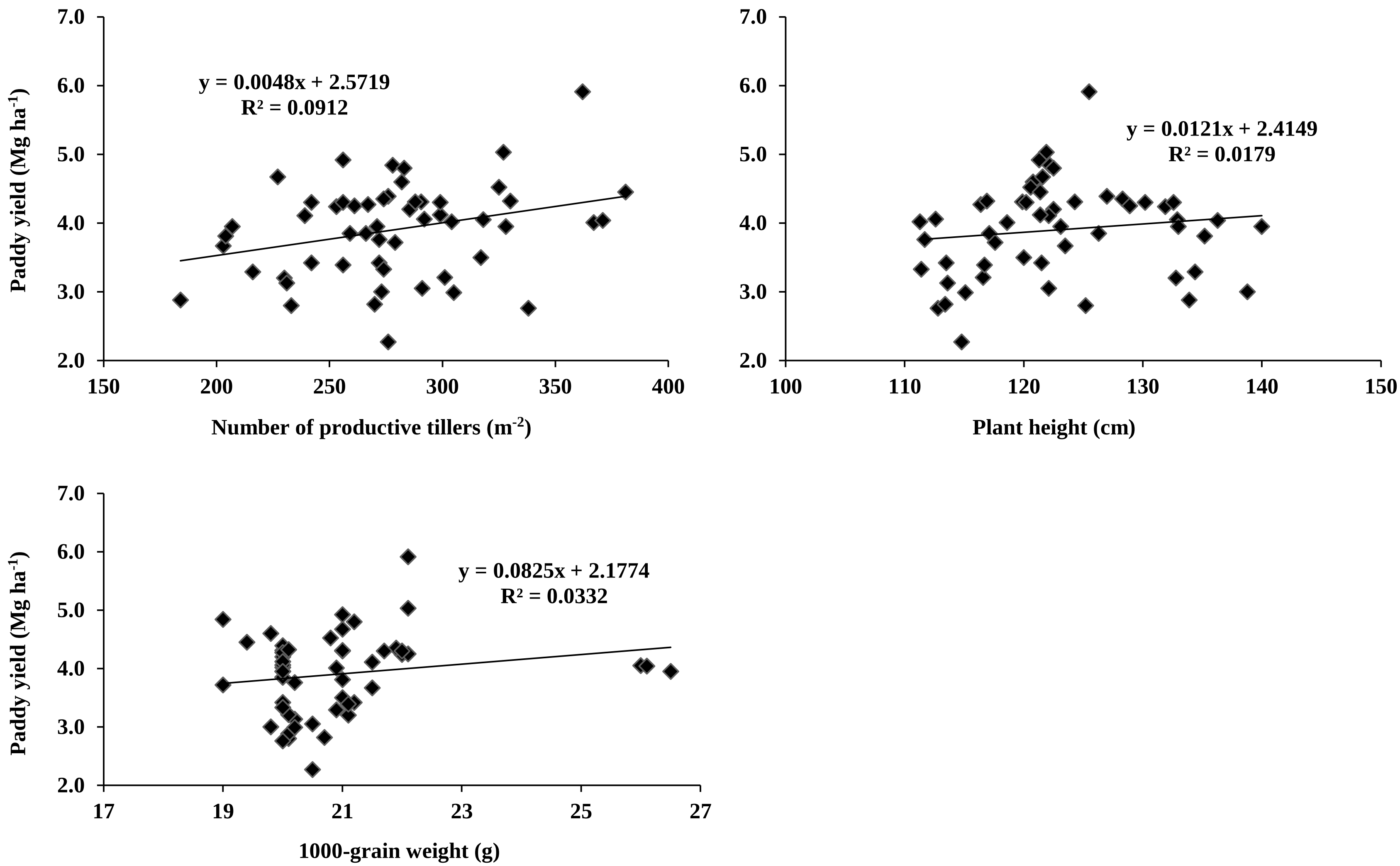

Figure 1 Relationship between paddy yield and yield related traits of rice under different planting methods during 2015

in conventional transplanting method may be due to longer plant height and minimum number of productive tillers (Table 2). Our findings support the study of Awan et al. (2005) and Hussain et al. (2013) who also recorded longer panicle length in conventional transplanting method (Table 2). Grain weight has dominant role in paddy yield and prominent yield reduction will occurred due to reduced grain weight. Our findings supported the result of Awan et al. (2005) who also recorded maximum 1000-grain weight in conventional transplanting method and opposed the findings of Hussain et al. (2013) who concluded that planting methods had non-significant effects on 1000-grain weight. Significantly higher 1000-grain weight in conventional transplanting (Table 2) may be due to minimum number of tillers and longer plant height that reduced the intra-plant competition and improved nutrients and water uptake. Significantly maximum paddy yield in conventional transplanting may be due to higher panicle length, number of grains per panicle and 1000-grain weight (Table 2) that improves the paddy yield. Our findings supported the results of Awan et al. (2005) who also recorded maximum paddy yield in conventional transplanting method. Significantly minimum paddy yield in drill planting method may be due to lower plant height as a result of more number of tillers that leads to poor root development and caused lodging (Mackill et al. 1996). Rice plants sown with drill planting method are more susceptive to lodging as compared to those transplanted in field through conventional puddling method (Farooq et al. 2011).

CONCLUSION

Study results showed that the conventional planting method is superior to the broadcast and drill planting because conventional transplanting method of rice gives higher paddy yield and yield attributing parameters. However, farmers which are facing water shortage, they can produce their paddy production through adopting the broadcast and drill sowing methods being an alternate way of production.

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