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Evaluation of Planting Methods for Rice in Rice-Wheat Zone of Sheikhupura, Pakistan

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ABSTRACT

This study was conducted to evaluate different planting methods for rice crops in the rice wheat zone of Sheikhupura Pakistan for the year 2019-2020. Four planting methods were tested in this study conventional transplanting of rice, 2- Manual transplanting of rice by rope, 3-Mechanical transplanting of rice and 4-Direct seeding of rice. Among all these methods, the mechanical transplanting of rice method proved to perform best in terms of meeting recommended plant population of rice crop, rice crop yield and yield parameters followed by manual transplanting of rice by rope method and direct seeding of rice method. Mechanical transplanting of rice is a mechanized technology for sowing rice crops; solving labor problems and time management. Transplanting of rice by rope method is a laborious method. Direct seeding of rice method also fulfil labour, and plant population issues with proper weeds management, Conventional transplanting of rice method performed poorly in terms of plant population, yield and yield parameters.

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INTRODUCTION

The food demand is increasing worldwide which is expected to increase by 35% to 56% between 2010 and 2050 (Michiel *et al*., 2021). The annual growth rate of crop yields must be 2.4 % to ensure the food demands, this trend can help double food production by 2050 (Ray *et al*., 2013). FAO (2009) have proposed an average annual increase in food production of 44 million metric tons and this should be sustainable for the next 44 years to meet food requirements. Rice is a salient crop for those farmers who plant rice on large acreages and also for those people who earn their income by working in these rice fields (Zeigler and Barclay, 2008). Rice is the second major cereal crop after wheat for almost half of the world's population (Bouman, 2003a). Asia is the largest rice-producing continent and exporter in the world. It is an important Kharif crop in Pakistan. Pakistan showed a 9.323 million tonnes production of rice and a growth of 10.7% over last year's production of 8.420 million tonnes (Economic Survey of Pakistan, 2021-22). Production of rice Rice yield in Pakistan is lower as compared to other rice-producing countries (Aslam, 2016). There are many factors of less rice production in Pakistan such as limited water resources, limited skilled labour, inappropriate plant population, imbalance nutrient management, and poor weeds and pest control management (Baloch *et al*., 2004). There are several reasons for low rice yield in Pakistan such as conventional methods for transplanting rice, shortage of recommended plant population in the field, labour shortage, costly labour, imbalance use of fertilizer and delayed planting. Among these factors, the shortage of recommended plant population is an

important factor (Mahmood and Walter, 1990). In Pakistan rice is normally transplanted by costly labourers who have no skills for providing a standard plant population in the field (Mann *et al*., 2007). The trend is shifting towards resource conservation systems of rice because of limited resources of water, energy and impacts of existing rice production systems (Tilman *et al*., 2001). Manual transplanting is the most adapted rice cultivation practice in India but some problems of labour shortage, high cost and less plant population are associated with it. Manual transplanting requires high labour requirements therefore labour shortage occurs during the peak seasons of rice cultivation and at that time cost of labour is high. Manual rice transplanting is a high labour-consuming process which needs 200-250 man-h/per ha. In the peak season of rice sowing, a labour shortage occurs (Das, 2012). In manual transplanting, labour does not meet the recommended plant population which ultimately affect the crop yield. In manual transplanting, there is less of a non-uniform plant population because labour wants to complete more area per unit of time. Therefore, there is a need for an efficient machine for transplanting of rice (Singh *et al*.,1981). Due to multiple issues in the conventional transplanting of rice, modern rice cultivation practices are need at the time. Mechanization of a crop increase crop yield per area by timely completion of field operations. It minimizes the workload on labour. Mechanized planting ensures the precise placement of inputs such as seeds and fertilizer. Mechanized cropping can reduce farm expenditures by reducing labour requirements (Das, 2012). Worldwide, rice is cultivated in different environments such as irrigated and rain-fed through different methods such as transplanting in Puddled conditions, and direct seeding in a well-prepared wet or dry land. (GRiSP, 2013). In mechanized sowing of rice, direct seeded rice and mechanical transplanting of rice are options. In direct-seeded rice is directly drilled in well-prepared soil which can reduce labour consumption and is a suitable solution for meeting the standard plant population. Direct-seeded rice appeared as a viable rice-sowing method to deal with labour shortage (Liming *et al*., 2015). Three methods of direct seeding are used sowing dry seeds in well-prepared dry soil, wet seeding (pre-germinated seeds are used on wet puddled soil) and water seeding (seed sowing in standing water) (Farooq *et al*., 2011). Direct seeding of rice may have problems of weeds infestation but these weeds can be managed by high-efficacy herbicides. Another modern rice sowing method is the mechanical transplanting of rice by mechanical rice Transplanter. Mechanical transplanting of rice is a mechanized rice planting method, in which rice seedlings are grown in plastic trays and different soil media which known as mat-type nurseries. After gaining some height and maturity of 20 to 25 days, this mat-type nursery is transplanted using transplanters. Mechanical transplanting of rice saves time, saves labour and ensures the standard plant population of rice crops in the field (Manjunatha *et al*., 2009). Advanced cultivation methods such as mechanical transplanting of mat-type nurseries and mechanical direct seeding are gaining popularity and enhanced cultivated areas are under these methods (Jin-long *et al*., 2018). Among different factors planting methods and selection of variety are important factors. System of Rice Intensification either through mechanical transplanting or mechanical direct seeding may be a better way to maximize crop yields.

MATERIAL AND METHODS

Study Area

This study was conducted at Adaptive Research Farm Sheikhupura in 2019 and 2020. Adaptive Research Farm is located in the main city area. The climate of the district is subject to extreme variations. The average rainfall in the district is 635 mm. Rice, wheat, sugarcane and Guava are major crops in the district. The average plot size of the study for both years was 80 feet × 101.75 feet. In this study, four planting methods of rice were evaluated.

1. Conventional transplanting
2. Manual transplanting by rope
3. Mechanical transplanting by rice transplanter
4. Direct seeding of rice

In 1st method, traditional cultivation of rice was done by manpower. In 2nd method, rice was transplanted by using a marked rope. In 3rd method, transplanting of rice was done by Korean made 4 rows of Walk After Rice Transplanter (Asia Rice Transplanter), specifications given in table 1.

In 4th method, direct sowing of rice was done by Direct Seeded Rice Drill in well-prepared soil conditions followed by immediate irrigation and repeated irrigation after 3 days to enhance germination. For all transplanting methods, firstly field was ploughed by a rotavator then puddling was done in standing water by a cultivator and Planker.

In transplanting methods, the rice nursery was

transplanted after 48 hrs sedimentation time of soil. The performance of the rice transplanter was checked. For all these methods super basmati variety was used as a test variety Direct sowing of rice was done in 1st fortnight of June.

Asia Rice Transplanter

Asia Rice Transplanter (ARP-4UUM) is a 2-wheel driven 4 rows Walk After Rice transplanter. It has an engine capacity of 3hp. This transplanter consists of a special floating system which helps the transplanter to float on puddled soil with a thin layer of water. It has 4 planting arm systems. The distance between the two planting arms is 30 cm. It has the option to maintain the planting geometry by adjusting the P×P distance having a range of 11cm – 20 cm. Planting density control and depth control are also located on it.

Table 1. Specifications of Asia Rice Transplanter ARP 4UM.

Dimension	Overall length (mm)	2350
	Overall width (mm)	1480
	Overall Height (mm)	800
	Weight (kg)	175
Engine	Type	Air-cooled 4 cycle gasoline
	Bore × Stroke (mm)	60×50
	Displacement (cc)	141
	Continuous output	2.5 hp
	Maximum output	3.0 hp
	Starting System	Recoil Starting Type
Transmission	Type	2 wheel 3 Floats type
	Transmission	Forward:2, Reverse: 1
	Travelling Speed (m/sec)	0.5-1.4
Working Efficiency	Planting speed (m/sec)	0.3-0.7
	Planting Efficiency	1.4 (ha/8 hours)
Planting Parts	Planting Row	4
	Type	Compelled Planting Type
	Planting Line Intervals (cm)	30
	Planting quantity per pick (pcs)	3-5
	Planting distance adjusting (cm)	11-20

Direct Seeding of Rice Drill (DSR)

In 4th method, the sowing of rice was done by direct seeded rice drill having 9 planting tines. Direct seeded rice drill is used for planting seeds of rice Direct in soil without any preparation in a wet field. It saves a lot of time and manpower. Direct seeding of rice can be done by drilling the seed into a fine seed bed at a depth of 2-3 cm. Before sowing DSR drill was calibrated by following steps.

W= Working width

C = circumference of the ground wheel

D = Distance covered = 20 rev × C

Area = Distance covered × working width

The seed was collected under each tiny during calibration and was measured. An 8 kg seed rate was used for both years.

Nursery Raising for Mechanical Transplanting.

For both years, the nursery for mechanical transplanting was raised in a plastic tray having a dimension of 1 × 2 feet. These trays were filled manually. A finely crushed soil was prepared which was free of foreign material. 100-gram seed was broadcasted in each tray uniformly. In the initial days, irrigation to trays was done by using a water shower. As the nursery matured after a week, then irrigation was done by flooding in a thin layer of water.

Data Recording

Germination data in the direct sowing of rice method was recorded 10 days after germination and in transplanting methods, no plants were recorded after a week of transplanting. No productive tillers were recorded at crop maturity using a meter square of 1m × 1m at three different locations in respective methods

and were averaged to calculate the no of tillers per meter square. 1000 grain weight was recorded by counting 1000 grains of all samples using electronic weight balance and was averaged to calculate the average 1000 grain weight. Similarly, grain yield of the same samples per m ^{2} was recorded. Data analysis was made using statistics software.

RESULTS AND DISCUSSION

No Plants/ m^2

Table 2 shows the number of plants/m^2 and no of planted hills/m^2 for each planting method of rice crop for both years 2019 and 2020. There is a significant difference in number of plants/m^2 among these planting methods.

In the conventional method average, no of plants for rice was recorded as 13 and 12.33 for the years 2019 and 2020 respectively. In the manual transplanting of rice on the rope, the average no of plants was recorded as 19 for both the years 2019 and 2020. In mechanically transplanted rice average no of planted hills/m^2 was recorded as 19 and 20 for the years 2019 and 2020 respectively. The average no of plants in mechanically transplanted rice was recorded as 46.33 and 51.33 for the years 2019 and 2020 respectively. In the direct seeding of rice method average, no of plants/m^2 were recorded as 85.66 and 77 for the years 2019 and 2020 respectively. A maximum no of plants was observed in direct sowing of rice methods as compared to transplanting methods for both years. (Luzes, 1991 & Ali *et al.,* 2012).

Table 2. Number of planted hills and number of plants/m^2 data with respect to the planting methods.

Methods	2019			2020		
	No of planted hills/m^2	Missing Hills/m^2	No of Plants/m^2	No of planted hills/m^2	Missing hills/m^2	No of plants/m^2
Conventional Transplanting	13	-	13^c	12	-	12.33^d
Manual Transplanting by rope	19	-	19^c	19	-	19.00^c
Mechanical Transplanting	19	2	46.33^b	20	1	51.33^b
Direct Seeding of rice	-	-	85.667^a	-	-	77.00^a
Lsd @5%			6.63			5.21

Table 3. Number of Tillers/m^2, Number of grains/panicle, 1000 grain weight and yield (kg/ha) data with respect to all planting methods.

	No of Tillers/m^2		No of grains/panicle		1000 grain weight		Yield (kg/ha)	
	2019	2020	2019	2020	2019	2020	2019	2020
Conventional Transplanting	304.33^c	309.33^c	102.33^c	110.33^c	21.267^b	21.47^b	3340^c	3796.7^d
Manual Transplanting by rope	325.33^b	330.33^b	122.33^b	131.33^b	21.600^{ab}	21.83^{ab}	3720^b	4193.3^b
Mechanical Transplanting	344.67^a	352.33^a	130.33^a	148.67^a	21.900^a	22.39^a	3970^a	4430.0^a
Direct Seeding of Rice	323.00^b	336.00^b	114.67^b	137.00^b	21.767^{ab}	21.91^{ab}	3830^b	4106.7^c
LSD @ 5%	10.93	7.23	7.72	7.59	0.577	0.65	132.80	669.180

No of Tillers/ m^2

Table 3 shows the no of tillers/m^2 data. Maximum no of tillers was observed in the mechanical transplanting of rice method as 344.67 and 352.33 for the years 2019 and 2020 respectively. Tillers of mechanically transplanted rice were found significant from all other methods for both the years 2019 and 2020. Tillers of direct seeding of rice method were found statistically at par with the transplanting of rice by rope method for both years. Minimum tillers were observed in conventionally transplanted rice as 304.3 and 309.3 for the years 2019 and 2020 respectively. In mechanically transplanted rice no of tillers is maximum because rice transplanter transplant 2-3 plants per hill as these produced more primary tillers which ultimately increased the grain yield. The results are in agreement with Thakur *et al*., (2004), Ehsanullah *et al*., (2007), and Rashid *et al*., (2009).

No of Grains / Panicle

Table 3 shows the average no of grains/panicle data.

The maximum no. of grains per panicle was observed in mechanically transplanted rice as 130.33 and 148.67 for the years 2019 and 2020. In the mechanically transplanted rice method, no grains were found significant as compared to all other planting methods for both years 2019 and 2020. In the direct sowing of rice method, the of grains per panicle was recorded as 114.67 and 137.00 for the years 2019 and 2020 respectively. In the transplanting of rice by rope method, no of grains per panicle was recorded as 122.33 and 131.33 for the years 2019 and 2020 respectively. These results show that no of grains per panicle for the direct seeding of rice method and transplanting of rice by rope method is statistically at par with each other. The minimum no of grains per panicle was observed in conventionally transplanted rice as 102.33 and 110.33 for the years 2019 and 2020 respectively. These results are in agreement with Song *et al*., (2009).

1000 Grain Weight (gram)

Table 3 shows the 1000-grain weight data. Maximum 1000 grain weight was observed in the mechanically transplanting method as 21.90 grams and 22.39 grams for the years 2019 and 2020 respectively. Minimum 1000 grain weight data were recorded in conventionally transplanted rice as 21.26 grams and 21.47 grams for the years 2019 and 2020 respectively. 1000 grain weight of direct seeded rice method was recorded as 21.76 grams and 21.91 grams for the years 2019 and 2020 respectively. 1000 grain weight of transplanting of rice by rope method was recorded as 21.60 grams and 21.83 grams for the years 2019 and 2020 respectively. These results show that 1000 grain weight is statistically at par among all these rice planting methods. These results conform with Farooq *et al*., (2011).

Paddy Yield (kg/ha)

Table 3 shows the paddy yield results. Maximum paddy yield was observed in mechanically transplanted rice as 3970 kg/ha and 4430 kg/ha for the years 2019 and 2020 respectively. In 2019, paddy yield of transplanting of rice by rope method and direct seeding of rice method was found statistically at par as 3720 kg/ha and 3830 kg/ha respectively. Minimum paddy yield was observed in conventionally transplanted rice as 3340 kg/ha and 3796.7 kg/ha for the years 2019 and 2020 respectively. In the 2020 year, the paddy yield of all planting methods was found significant from each other. The low yield in the conventional transplanting of rice method is because of less no of plants per meter square as compared to the rope method, mechanical transplanting and direct sowing of rice method. Mechanical transplanting of rice has maximum yield as rice transplanter transplants 2-3 plants per hill as compared to all other methods which produce more tillers and ultimately produce more yield. Mechanized transplanting resulted in 18.8 % and 16.7 % increase in paddy yield over conventionally transplanted rice.

CONCLUSION

In this study, different rice planting methods were tested for the years 2019, and 2020. According to results and discussion, the mechanical transplanting of rice method has an advantage in full filling the desired no of plants/acre and higher yields (kg/ ha). Maximum no of tillers, no of grains, 1000 grain weight and yield were observed in the mechanical transplanting of rice method. Direct sowing of rice has also promised results after mechanical transplanting in sense of no plants, no of tillers and grain yield. Transplanting of rice by marked rope method has also the capability to fulfil the desired no of plants/ acre in the field, but this method is time-consuming and laborious. The minimum no of plants, tillers, and yield was observed in the farmer practice method. In the conventional method, less no of plants/ m^2 causes less no of tillers/ m^2 which ultimately reduces the yield. On the other hand, as the mechanical transplanter transplant 2-3 plants/hill and produce the desire no of planted hills / m^2 it increases the no of tillers which ultimately increased the yield. Direct seeding of rice has some disadvantages for weeds, if these weeds are coped with at an early stage using an efficient herbicide, this technology can lead to similar yield trends as in mechanical transplanting of rice. Furthermore, direct seeding of rice should also be optimized in land preparation and land compaction degree to hold the irrigational water in the field for proper growth of rice crops, as a hard pan is made by puddling to hold water in transplanting methods. But this puddling consumes a large amount of water and energy inputs. Studies should be conducted about land compaction under DSR methods for better management of irrigational water for rice crops. Walk

after rice transplanter has field capacity in the range of 0.3 - 0.5 acre/hour. Walk after rice transplanter has a fuel consumption of 1 litr/h. Hence mechanical transplanting is a cost-effective and time-saving technology. As per the results, mechanical transplanting of rice should be adopted to meet the desired no of plants and higher yields. DSR method is also a promising technology to meet the No of plant and higher yield with careful weeds management and land compaction management for judicious use of water for rice crops.

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