PERFORMANCE EVALUATION AND COMPARISON OF RIDE-ON AND WALK-AFTER RICE TRANSPLANTERS

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ABSTRACT: Rice (Oryza sativa) is an important cereal grain used as a staple food to fulfill daily calories requirement. Conventionally, rice seeds are sown in a nurseries and then transplanted manually into the paddy fields with the help of skilled labor, but this method is time-consuming, costly, and as well as labor-intensive. This conventional method may result in irregular plant patterns, decreased plant population, and ultimately reduction of farm yield and profit. To avoid this problem nowadays, rice transplanters (ride-on and walk-after) are selectively used while their feasibility in local field condition is to be evaluated. To assess the efficacy of these machines key performance indicators i.e. effective field capacity, field efficiency and seedling losses were selected. The data collected were investigated at a 5% level of probability and the trials were conducted with the experimental design following Randomized Complete Block Design (RCBD) with three replications. The ride-on rice transplanter (SPV-8C) had maximum mean effective field capacity (0.67ha/h) and field efficiency (73.6%) at speed of 5 km/h while the seedling losses were minimum (1.23%) for walk-after rice transplanter (SPW-48C) at speed of 2 km/h. The experimental results shown that effective field capacity and field efficiency was found better for ride-on rice transplanter (SPV-8C) as compared to ride-on rice transplanter (SPV-6CMD) and walk-after rice-transplanter (SPW-48C).

Keywords: Rice transplanter, Effective field capacity, Field efficiency, Seedling loss,

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INTRODUCTION

Rice is an essential cereal food for almost half of the global population. It is grown in more than 100 countries. Asia produces 90% of the total world production. There are around 110,000 varieties of rice that are different in nutritional content and quality [1]. Rice is the second largest produced commodity in the world and gives farmers financial security and generates billions of rupees as revenue. Basmati rice is extremely well-liked with high demand in the international market due to its superior quality, subtle aroma, soft and prolonged kernel, and outstanding grain elongation while cooking [2].

In 2020, the total rice cultivation in the world was on an area of more than 165 million hectares and production was about 756.7 million metric tons, led by China and India with a combined 52% of this total. In the year 2019, Pakistan's farmers cultivated rice on an area of almost 3 million hectares with 7 and a half million tons of yield and ranked 10th among the largest rice-producing countries [3].

Pakistan is the world's tenth-largest rice producer. Pakistani rice exports account for more than 8% of the rice trade of the world [4]. It is a key crop in the agricultural economy of Pakistan. Rice is an important Kharif crop. Pakistan ranked tenth among the top rice producers in the world in 2019 with 7.5 Mt of rice produced. In 2016–17, Pakistan produced 6.7 Mt, of which about 4 Mt were exported to countries in the region, the Middle East, and Africa. Rice cultivation is practiced in several regions of Sindh, Punjab, and Baluchistan and also is a great source of income for the farming community [5].

Rice is commonly cultivated in the Sindh and Punjab provinces of Pakistan. Sialkot, Gujranwala, Jhang, Hafiz Abad, Okara, and Sheikhupura in Punjab, and Dadu, Jacobabad, Shikarpur, Badin, Thatta, and Larkana in Sindh province are among the most fertile locations for rice cultivation in Pakistan. Sindh is known for its long white rice types IRRI-6 and IRRI-9, whereas Punjab is known for its international Basmati rice variants IRRI-9 and others. Punjab is at the top in rice production with 58% of total output, while Sindh, NWFP, and Baluchistan have 29%, 10%, and 3% production respectively. Kernel Basmati, Basmati 385, Super Basmati, DR-82, IRRI-9, KS-282, IRRI-6, and DR-83 are the most popular varieties cultivated in Pakistan [6].

The rice-wheat cropping system (RWCS) demands a lot of farm labor, water, capital, and energy and with time it might become less cost-effective. The deteriorating soil structure, declining subterranean water levels, and decreased land and water productivity, all are potential risks of this system. Numerous resource-conserving technologies (RCTs) were suggested by scientists for this technique, including direct drilling, bed planting, and transplanting. One of the most famous cropping systems is of rice-wheat, especially in Punjab province of Pakistan. Currently, harvesting is performed by the help of manual labor or by using obsolete combine harvesters having enormous losses for grain quality and quantity [7][17].

The two most popular techniques for cultivating rice are direct sowing and transplanting. The transplanting approach as compared to direct sowing had a better yield and less weed growth. In India and Pakistan, paddy planting greatly depends on manual labor. About 306 man-hours per hectare (man-h/ha) are required for manual rice transplantation. The self-propelled rice transplanter's (eight rows) performance was evaluated based on percentages of lost, floating, and buried hills and was observed at 9.5%, 3.0%, and 2.0%, respectively. The effective Field Capacity (EFC) and Efficiency of the machine were 0.23 ha/h and 75.1 percent, respectively. The use of mechanization in nursery raising, out-planting, interculture, irrigation, plant protection, pruning, harvesting, and processing has a great impact on the whole production cycle [8][16]. Commercialization of such machinery is the need of the hour to enhance productivity and maintain quality, resulting in increasing exports and contributing to a better economy [19].

In Pakistan, different types of rice machinery is available in the local market for transplanting rice in well prepared field. However, the feasibility of the machine with respect to effective field capacity, field efficiency, machine losses, ease of operation and cost/benefit ratio has not been calculated in local field conditions. The current experiment was planned with three objectives, including (i) to evaluate the performance of ride-on and walk-after rice transplanters, (ii) to compare the performance of both types of rice transplanters, and (iii) to prepare a cost analysis for these machines.

MATERIALS AND METHODS

To conclude the suitable rice transplanting method, both types of rice transplanters (ride-on and walk-after) were selected during this research. An experiment was conducted for field testing of both machines at village Basir Pur, tehsil Depal Pur, district Okara of Punjab province in rice-growing season of 2022.

The data of machine losses (paddy loss during rice transplanting), theoretical field capacity, effective field capacity, and field efficiency for these machines i.e. ride-on rice transplanters (SPV-8C and SPV-6CMD) and walk-after rice transplanters (SPW-48C) was recorded. Data collected were statistically analyzed by using "Statistix 8.1" software at a 5 % level of probability [18]. The trials were conducted with the experimental design following randomized complete block design (RCBD) with three replications.

Growing of rice nursery:

To decrease overall expenses on land preparation and other inputs like seeds, fertilizer and water rice seeds were grown in nursery (sowing trays). The seedlings were prepared for transplantation when they were 12 to 15 days old.

Measuring variables: The machine ride-on rice transplanters was tested at three different forward speeds (3, 4, and 5 km/h) while the walk-after rice transplanter was tested at speeds (2, 2.16 and 2.2 km/h) for recording the following parameters.

Theoretical field capacity: The speed at which a machine would operate in an ideal world with no interruptions is known as the theoretical field capacity (TFC). In current experiment, TFC was calculated in unit hectares per hour.

The TFC of the machine was tested by using a formula [9].

$$\text{TFC} = \frac{[\text{Working width (m)}] \times [\text{Forward speed (km/h)}]}{10}$$

Effective field capacity: By dividing the area completed by the actual field time, it is simple to determine a machine's effective field capacity (EFC).

The EFC of the machine was computed by formula [9].

$$EFC = \frac{\text{Total area transplanted (ha)}}{\text{Time taken in transplanting (h)}}$$

Field efficiency: Field efficiency means finishing a certain field operation while wasting a minimum amount of time, fuel, and other farm resources.

The field capacity of the machine was obtained by formula [3].

$$FE(\%) = \frac{EFC}{TFC} \times 100$$

Seedling losses: The seedling losses mean seedlings lost during the transplanting operation. They were measured at different $1m^2$ areas in the field and then averaged and multiplied by the total m^2 in those areas [10].

Seedling Losses (Pods/ha) = [Pods lost in $1m^2$ area] × [Total m^2 in whole area]

RESULTS AND DISCUSSION

Data recorded for various parameters were analyzed statistically by using *Statistix 8.1* software. Performance of ride-on and walk-after rice transplanters were expressed in terms of theoretical field capacity, effective field capacity, field efficiency, and seedling losses. Their results were statistically analyzed on a 5% level of probability.

Ride-on rice transplanter SPV-6CMD: The performance of Ride on rice transplanter was evaluated and the following results were obtained.

Effective field capacity (ha/h): The effect of different forward speeds (S_1=3 km/h, S_2=4 km/h, S_3 =5 km/h) on the effective field capacity (EFC) of ride-on rice transplanter SPV-6CMD was observed. The mean EFC at speeds S_1, S_2, and S_3 were 0.42, 0.50, and 0.57 ha/h respectively. Statistical investigation revealed that the maximum mean EFC (0.57 ha/h) was achieved at S_3 (5km/h) whereas the lowest mean EFC (0.42ha/h) was achieved at S_1 (3km/h) as shown in Table 1. The results of different speeds were suggestively dissimilar as compared to each other at a 5% level of probability. The outcomes were compared with the previous research. The outcomes of this study are parallel to the findings of scientists who reported that EFC of 6-rows Self Propelled Rice Transplanter is 0.54 ha/h [11].

Table 1: Effective Field Capacity of 6 rows Ride on Rice Transplanter (SPV-6CMD).

Speed		EFC		Mean
S_1	0.41 c	0.43 c	0.42 c	0.42 c
S_2	0.50 b	0.51 b	0.50 b	0.50 b
S_3	0.55 a	0.57 a	0.56 a	0.57 a

Field efficiency (%): The effect of different forward speeds (S_1=3 km/h, S_2=4 km/h, S_3=5 km/h) on the Field Efficiency (FE) of ride-on rice transplanter SPV-6CMD was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. Mean FE at three speeds were 46.2, 53.5, and 64.7% respectively. Statistical analysis has shown that maximum mean FE (83.0%) was achieved at S_3 (5km/h) whereas the lowest mean FE (46.2%) was observed at S_1 (3 km/h). The results of different speeds were substantially unalike as compared to each other at a 5% level of probability. After comparing the outcomes with previous outcomes, they were found to be parallel with the results proposed by [11] who found that FE of 6-rows Self Propelled Rice Transplanter is 62.96%.

Seedling losses (%): The effect of different forward speeds (S1 = 3 km/h, S2 = 4 km/h, S3 = 5 km/h) on Seedling Losses (SL) of Ride-On Rice Transplanter SPV-6CMD was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. Mean SL at three speeds S1, S2, and S3 were 5.3%, 2.73%, and 6.03% respectively. Statistical analysis has shown that minimum SL (2.73%) was found at S2 (4 km/h). The results of different speeds were suggestively different with respect to each other at a 5% level of probability. Similar outcomes were acquired in the research of [12] who concluded that percentage of SL were 2.5% for 6 rows riding type rice transplanter.

Table 2. Field Efficiency of 6 rows Ride-On Rice Transplanter (SPV-6CMD).

Speed		FE		Mean
S_1	53.5 a	52.8 a	51.1 a	52.4 a
S_2	56.9 b	58.4 b	56.9 b	57.4 b
S_3	64.3 c	63.1 c	61.9 c	63.1 c

Table 3. Seedling Losses of 6 rows Ride-On Rice Transplanter (SPV-6CMD).

Speed		Seedling Losses		Mean
S_1	5.1 a	6.5 a	4.5 a	5.3 a
S_2	2.5 b	2.4 b	2.3 b	2.73 b
S_3	5.7 c	6.3 c	6.1 c	6.03 c

Performance evaluation of Ride-On rice transplanter SPV-8C: The performance of Ride-On rice transplanter was evaluated and the following results were obtained.

Effective field capacity: The effect of different speeds (S1 = 3 km/h, S2 = 4 km/h, S3 = 5 km/h) on the Effective Field Capacity (EFC) of Ride-On Rice Transplanter SPV-8C was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. The mean EFC at three speeds were 0.54, 0.62, and 0.67 ha/h respectively. Statistical analysis has revealed that best mean EFC (0.67) was found at S3 (5 km/h) whereas the lowest mean EFC (0.54) was achieved at S1 (3 km/h). The results of different speeds were significantly different with respect to each other at a 5% level of probability. The discoveries of this research are in line with the outcomes of [13] who concluded that EFC of 8 rows rice transplanter is 0.65 ha/h.

Field efficiency: The effect of different forward speeds (S1 = 3 km/h, S2 = 4 km/h, S3 = 5 km/h) on the Field Efficiency (FE) of ride-on rice transplanter SPV-8C was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. The mean FE at three speeds S1, S2, and S3 were 66.6, 72.0, and 73.6% respectively. Statistical analysis has shown that maximum mean FE (73.6%) was achieved at S3 (5 km/h) whereas the lowest mean FE (66.6%) was observed at S1 (3 km/h). The results of different speeds were meaningly dissimilar as compared to each other at a 5% level of probability. The given fallouts are parallel with the outcomes of [13] who reported that 8 rows rice transplanter have FE of 74.8%.

Table 4. Effective Field Capacity of 8 rows Ride on Rice Transplanter (SPV-8C).

Speed	EFC			Mean
S_1	0.53 b	0.55 b	0.54 b	0.54 b
S_2	0.61 c	0.63 c	0.64 c	0.62 c
S_3	0.68 a	0.66 a	0.67 a	0.67 a

Table 5. Field Efficiency of Ride-On Rice Transplanter (SPV-8C).

Speed	FE			Mean
S_1	65.4 a	67.9 a	66.6 a	66.6 a
S_2	70.1 b	72.4 b	73.5 b	72.0 b
S_3	74.7 c	72.5 c	73.6 c	73.6 c

Seedling losses: Effect of different forward speeds (S1 = 3 km/h, S2 = 4 km/h, S3 = 5 km/h) on Seedling Losses (SL) of Ride-On rice Transplanter SPV-6CMD was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. Mean SL at three speeds S1, S2, and S3 were 5.3, 3.73, and 6.03 % respectively. Statistical analysis has shown that minimum SL (3.73%) was achieved at S2 (4km/h). The results of different speeds were significantly unalike with respect to each other at a 5% level of probability. Similar findings were acquired by [14] who found that percentage of SL were 3% for 6 rows rice transplanter.

Table 6. Seedling Losses of 8 rows Ride-On Rice Transplanter (SPV-8C).

Speed	Seedling Losses			Mean
S_1	5.1 a	6.5 a	4.5 a	5.3 a
S_2	3.5 b	3.4 b	4.3 b	3.73 b
S_3	5.7 c	6.3 c	6.1 c	6.03 c

Performance evaluation of Walk-After rice transplanter (SPW-48C): The performance of Walk-After Rice Transplanter was evaluated and the following results were obtained.

Effective field capacity: The effect of different speeds (S1 = 2 km/h, S2 = 2.16 km/h, S3 = 2.2 km/h) on the Effective Field Capacity (EFC) of Walk-After Rice Transplanter (SPW-48C) was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. The mean EFC at three speeds were 0.22, 0.25, and 0.27 ha/h respectively. Statistical study has revealed that maximum mean EFC (0.27) was attained at S3 (2.2 km/h) whereas the lowest mean EFC (0.22) was achieved at S1 (2 km/h). The results of different speeds were significantly different with respect to each other at a 5% level of probability. The discoveries of this research are in line with the outcomes of [15] who reported that EFC of 4 rows riding type rice transplanter is 0.20 ha/h.

Table 7. Effective Field Capacity of 4 rows Walk-After Rice Transplanter (SPW-48C).

Speed	EFC			Mean
S_1	0.22 b	0.23 b	0.23 b	0.22 b
S_2	0.25 c	0.24 c	0.26 c	0.25 c
S_3	0.27 a	0.28 a	0.27 a	0.27 a

Field efficiency: The effect of different forward speeds (S1 = 2 km/h, S2 = 2.16 km/h, S3 = 2.2 km/h) on the Field Efficiency (FE) of Walk-After Rice Transplanter SPW-48C was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. The mean FE at three speeds S1, S2, and S3 were 63.8, 66.1, and 68.1% respectively. Statistical analysis has shown that maximum mean FE (68.1%) was achieved at S3 (2.2 km/h) whereas the lowest mean FE (63.8%) was observed at S1 (2 km/h). The results of different speeds were significantly dissimilar as compared to each other at a 5% level of probability. The given findings are parallel with the outcomes of [10] who reported that FE of 4 rows walking type rice transplanter is 70%.

Table 8. Field Efficiency of 4 Rows Walk-After Rice Transplanter (SPW-48C).

Speed	FE			Mean
S_1	61.4 a	65.1 a	65.1 a	63.8 a
S_2	66.2 b	62.7 b	69.6 b	66.1 b
S_3	67.1 c	70.3 c	67.1 c	68.1 c

Seedling losses: Effect of different forward speeds (S1 = 2 km/h, S2 = 2.16 km/h, S3 = 2.2 km/h) on Seedling

Losses (SL) of Walking-After Rice Transplanter SPW-48C was observed. Data recorded were statistically analyzed by using Statistix 8.1 software as shown in the table. Mean SL at three speeds S1, S2, and S3 were 1.23, 1.96, and 2.38 % respectively. Statistical analysis has shown that minimum SL (1.23%) was achieved at S1 (2km/h). The results of different speeds were substantially dissimilar as compared to each other at a 5% level of probability. Similar findings were acquired by [10] who found that percentage of SL were 1.3% for 4 rows walking type rice transplanter.

Table 9. Seedling Losses of 4 rows Walk-After Rice Transplanter (SPW-48C).

Speed	Seedling Losses			Mean
S_1	1.23 a	1.19 a	1.27 a	1.23 a
S_2	1.51 b	2.28 b	2.10 b	1.96 b
S_3	2.76 c	2.31 c	2.07 c	2.38 c

Table 10: Cost Analysis of Ride-On and Walk-After Rice Transplanters

SPV-6CMD			SPV-8CMD			SPW-48C	
Annual Fixed Costs of Machine			Annual Fixed Costs of Machine			Annual Fixed Costs of Machine	
Initial Cost of Machine	3100000		Initial Cost of Machine	4,000,000		Initial Cost of Machine	700,000
Salvage Value	310000		Salvage Value	400000		Salvage Value	70000
Interest	136400		Interest	176000		Interest	30800
Insurance	62000		Insurance	80000		Insurance	14000
Tax	46500		Tax	60000		Tax	10500
Housing	46500		Housing	60000		Housing	10500
Total Annual Cost	601400		Total Annual Cost	776,000		Total Annual Cost	135,800
Cost per hour	1202.8		Cost per hour	1552		Cost per hour	679
Operating Cost of Machine			**Operating Cost of Machine**			**Operating Cost of Machine**	
Labour Cost	81.25	Rs/hr	Labour Cost	81.25		Labour Cost	100
Diesel Fuel	2736.76	Rs/ha	Diesel Fuel	3763.045	Rs/ha	Diesel Fuel	1343
Lubricants	554		Lubricants	1881		Lubricants	671.84
Repair Cost	558		Repair Cost	720		Repair Cost	315
Total Operational Cost	3930.01		Total Operational Cost	6445.295		Total Operational Cost	2429.84
Total Cost of Machine/hr	5132.81		Total Cost of Machine/hr	7997.295		Total Cost of Machine/hr	3108.84
Total Cost of Machine (rs/ha)	10475.12		Total Cost of Machine/ha	12898.86		Total Cost of Machine/ha	13516.7

Conclusion: For 8 rows ride-on rice transplanter (SPV-8C), the maximum outcome for mean EFC and field efficiency were observed as 0.67 ha/h and 73.6% at speed (s_3=5km/h) respectively, and minimum seedling losses were observed as 3.73% at speed (S_2=4km/h). The 6 rows ride-on rice transplanter (SPV-6CMD) with EFC and FE, 0.57ha/h and 63.1 % had comparatively less cost of operation but it takes more time as compared to SPV-8C. Total cost of operation per hour for T_1-SPV-6CMD (Rs.5132.81), T_2-SPV-8C (Rs.7997.295), T_3-SPW-48C (Rs.3108.84) and T_4-Rs.500/man-hr for conventional transplanting, while the total cost of operation per hectare for T_1 (Rs.10475.12), T_2 (Rs.12898.86), T_3 (Rs.13516.7) and T_4 (Rs.19760) was noted. This study recommends SPV-8C most suitable for rice transplanting.

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