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Adoption of Mechanical Transplanting of Rice (MTR) Among Rice Growers in the Rice-Zone of Punjab, Pakistan

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ABSTRACT

We conducted this study to analyze the adoption of Mechanical Transplanting of Rice (MTR) in one of the prominent rice-producing districts Gujranwala of Punjab, Province. Rice has been a significant source of income in this area. A total of 220 rice growers, were selected using the non-probability method of selection from Wazirabad and Kamoki tehsils of district Gujranwala. Selected respondents were interviewed face to face on a structured questionnaire which was pre-tested and validated before final data collection. Collected data were analyzed using Statistical Package for Social Sciences (SPSS). Results were distributed into three sections (i) demographic profile, (ii) relative advantage of MTR and (iii) constraints analysis. Demography unveiled that young age farmers had less inclination towards rice growing, although the majority of respondents had formal education, had ownership of their lands and farmers were irrigating rice crops using tube well. As for as relative advantage was concerned, MTR relatively produced a high extent in terms of effectiveness ($\bar{X}$ = 4.04, SD=0.62) due to high efficiency, less labour intensive, and high yield. Mandatory use of lesser land levellers, maintenance issues of MTR, unskilled labour and inadequate training for the farmers were prominent consents aced by the MTR user. This study urges more technical backstopping from the concerned institutions to foster the adoption of MTR on the farm level.

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INTRODUCTION

Pakistan is all set to confront with a mammoth population in upcoming years. Thus, more food is required to feed an ever-increasing population in the country. Pre-dominantly, Pakistan fulfils the dietary requirements of the population through wheat and rice crop. Both crops are regarded as critical for many reasons including dietary, economic and raw material. It is worth mentioning that rice produced in Pakistan is highly acknowledged in the world due to its particular aroma. As result, the huge quantity of rice is expected each year. In Pakistan, rice is the second most important crop in terms of area sown, it was grown on 3537 thousand hectares of land in 2021–2022 and contributed 2.4% of value added in the agriculture sector and 0.5% to the GDP of Pakistan (GOP, 2022). More than 80% of fine rice is being produced by Punjab province due to favourable climatic and soil conditions. The district

Gujranwala, Sialkot, Hafizabad, Okara, Sheikhupura, Nankana, Jhang and Mandi Bahauddin produce more than 70% of Basmati rice in Pakistan (Ashfaq et al., 2017).

For the last many years, Pakistan's rice yield has dropped surprisingly at a compound annual growth rate of 0.1%, placing the country as the tenth lowest among the fifteen major global rice producers due to abrupt changes in the monsoon pattern (USDA, 2022). This has been predicted that in case the temperature continues to increase, rice yield in Pakistan might fall by 25% between 2040 and 2069 and by 36% between 2070 and 2099 (Ahmad et al., 2015). Similarly, a 6% drop in average precipitation is associated with a 29% rise in net irrigation water use for rice production (Ali & Erenstein, 2017).

Among different reasons for production decline, sowing methods are also involved in lowering production. Often adopted methods of rice cultivating in Pakistan include a direct seeded method and manual transplanting. The manual transplanting approach is perceived as more popular among farmers since it results in a high yield relative to direct sowing, even though it requires intensive labour and more effort (Verma, 2010).

The conventional technique of rice transplanting takes an average of 238 labour hours per hectare (Dixit & Khan, 2011). Whereas MTR adopters took three days to transplant 1 hectare of rice than the 33 man-days required for conventional transplanting (Manjunatha et al., 2009). For conventional transplanting, about 250-300 man hours ha^{-1} (25% of total labour) are required even resulting in a lower plant population (50000-60000 plants per acre) which surely decreases the yield by 20-25% (Haider, 2019).

Increasing the yield, and considering the rise in labour wages and labour scarcity compelled farmers to shift towards mechanical transplanting of rice (Rashid et al., 2018). Rice farmers were using the MTR due to a shortage of labour, low plant populations and uneven crop stand (Brar et al., 2015; V. P. Chaudhary et al., 2005; Hossen et al., 2018; Sreenivasulu & Reddy, 2014). Two types of mechanical rice transplanters i.e. riding type and walk-after type are used. The riding type is power-driven and can normally transplant six lines in one pass. While the walk-after type is manually driven self-propelled and can typically transplant four lines in one pass (Patil & Phate, 2016). In MTR practice, transplanting one acre of rice needs 8-12 labourers in a day. On the contrary, 3 labourers can transplant up to 6-8 acres in a day using a self-propelled mechanical transplanter (Rickman et al., 2015).

MTR is cost-effective, friendly in its operation, helps in maintaining soil physical properties and is considered useful for effective crop management and productivity point of view (Rashid et al., 2018; Saha et al., 2021). Although, the adoption of MTR is yet gloomy taking high initial investment into an account and the lack of knowledge among farmers in growing mat-type nurseries as compared to traditional transplanting (Guru et al., 2018).

The productivity and efficiency of land and labour can be enhanced with effective mechanization. The need of the hour is to enhance the production and export of rice by making it globally competitive making full use of the available technologies to their maximum potential (Basir et al., 2020). Adopting innovations and modern technologies can help in boosting crop yield. The adoption of advanced machinery helps in improving the economic situation of individual families (Guru et al., 2022). Rice is a consumable item not only in Pakistan, but even its use is also far-reaching across the impact. Thus, it has an important role in regional food intake, the economy, food security and poverty alleviation (Abdullah et al., 2015; Javed et al., 2020). Therefore, this study was planned to assess the adoption level, relative advantages and constraints in the adoption of mechanical transplantation of rice (MTR) in district Gujranwala. We believed the results of this study will help the concerned quarters in persuading farmers to adopt MTR and allow great access to the farmers at subsidized rates. Technological utilization and facilitation to the farmers are integral in the process of increasing agricultural production (Chaudhry et al., 2006).

MATERIALS AND METHODS

Study Area

This study was conducted in district Gujranwala, one of Pakistan's most important districts in terms of rice production. Gujranwala is the second-largest rice-producing district in Punjab, Pakistan (Junaid et al., 2014). Two tehsils (Wazirabad and Kamoke) of district Gujranwala were purposively selected for the study area.

Sampling Procedure

In this study, the survey-based research methodology was used. There are a variety of methods used in social science research to draw representative samples from a larger population. Each method has pros and cons (Langham, 1999). Considering the peculiarities of this research, non-probability sampling was employed to select the sample of the study.

Due to the limited resources, the scope of the research was further restricted to only two tehsils (Kamoke & Wazirabad) which were selected purposively, a well-known for their rich potential for rice production. A total of 110 rice growers were chosen purposively from each selected tehsil thereby making a sample size of 220 rice growers.

Data collection and analysis

A well-organized and pre-tested questionnaire was developed for data collection. The questionnaire used consisted of demographic information, questions related to the adoption of mechanical transplanting and a comparison of conventional transplanting with mechanical transplanting. Each item was given a numerical score so that the data can be analyzed quantitatively. Descriptive statistics were applied to explore the response of the respondents. For data analysis, computer software (Statistical Packages for Social Sciences SPSS) was used for tabulation and interpretation of the results.

RESULTS AND DISCUSSION

This section mainly consists of three sections including (i) demographic profile, (ii) relative advantage and (iii) constraints faced by the MTR users.

Demographic profile

Table 1 shows that one-fourth (25.45%) of respondents were aged 31-40 years followed by 35.45 and 33.18% of respondents aged 41-50 and above 50 years, respectively. Of the total respondents, approximately 6% were aged under 30 years. This implies that the old-age farmers were more involved in rice cultivation as compared to the young farmers. This is another notion, considering the impact of age on technology adoption, the technology adoption among rice farmers in the study area would have been poor. Results are endorsed with those of Ashraf et al. (2015) as they find that age and adoption were statistically significantly related. Around 82% of respondents had attended schools for formal education, whereas, the 17.73% didn't have received formal education. A large majority of farmers (88.6%) were owners of their lands and this could be the prominent reason for making rice a profitable crop for them. The land size in the study area was diverse. Around 43% of farmers had less than 10 acres of land followed by the 31.8% with land sizes ranging from 11 to 20 acres. Almost one in ten respondents was a large farmer with a land size exceeding 20 acres. Farmers had rice cultivation preferably in large areas as 44.5% of farmers had rice cultivation in the area ranging from 11 acres to more than 30 acres of land. More than half (55.5%) of respondents had rice cultivation on less than 10 acres. Table 1 indicates that about 79% of farmers had loamy soils, which is preferred for rice cultivation. The area under rice cultivation was being irrigated mostly (86.36%) by tube wells. Rice is a water-intensive crop, using a tube well definitely would have increased the cost of production for the farmers especially when the prices of fuel are high. Water-limiting conditions adversely affect the production of rice crops (Singh et al., 2021).

Table 1. Demographic descriptive statistics of the respondent farmers.

Categories of attributes	Frequency	Percentage
Age (years)		
Up to 30	13	5.91
31-40	56	25.45
41-50	78	35.45
Above 50	73	33.18
Formal education		
Yes	181	82.27
No	39	17.73
Tenancy status		

Owner	195	88.6
Tenant	9	4.1
Owner- cum-tenant	16	7.3
Land size (acre)		
Up to 10	95	43.3
11-20	70	31.8
More than 20	24	10.9
Above 30	31	14.5
The area under rice crop (acre)		
Up to 10	122	55.5
11-20	52	23.8
21-30	21	9.7
Above 30	25	11.9
Farming Experience (Years)		
Up to 10	12	5.6
11-20	65	29.4
21-30	79	36
Above 30	64	29.2
Type of Soil		
Sandy	10	4.55
Loamy	174	79.09
Clay	36	16.36
Source of irrigation		
Canal only	0	0
Tube well	190	86.36
Both	30	13.64

Adoption of Mechanical Transplanting technique of Rice

In this section, adoption of different attributes of the adoption of MTR is briefly explained including knowledge of farmers, years of adoption, the area under MTR, varieties and seed rate as adopted by the farmers.

Knowledge regarding MTR

Table 2 indicated that 76.82% of respondents knew the Mechanical Transplanting of Rice. During informal discussions, these farmers show a greater understanding of the MTR and perceived it as relatively effective as compared to the traditional mode of rice plantation. Pertinent to this extended knowledge 51.7, 26.4, 10.9, 7.3, 1.8 and 0.9% of respondents had adopted from 1, 2, 3, 4, 5, and 6 years, respectively (Figure 1).

Area under MTR

Table 2 further indicates that out of 220 respondents 110 were the adopters of MTR. Of the adopters, 62.73% had cultivated on less than 10 acres followed by one-fifth of respondents cultivating rice under MTR on 10-20 acres. Most of the adopters of MTR were using 25 days nursery to transplant into the field. Very few were applying for transplantation after 30 days as interpreted in Figure 2.

Seed rate

Figure 3 indicates that 30.7% of respondents were using 110 grams of seed for nursery development. The minimum seed that was used by the farmers for the nursery development was 80g, and the maximum was 135 g.

Varieties of the rice adopted by the farmers

Figure 4 indicates that different varieties were adopted in the study area by the farmers. About 32% of respondents had the adoption of PK 386 followed by PK 1121 (aromatic) and Kissan Basmati adopted by 23.64 and 13.64% of respondents, respectively.

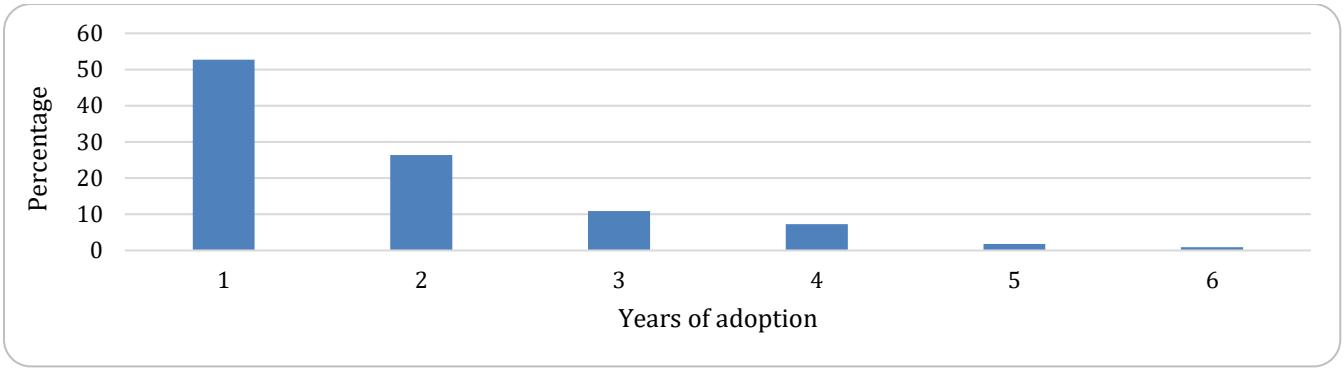

Figure 1. Years of adoption of MTR perceived by respondents.

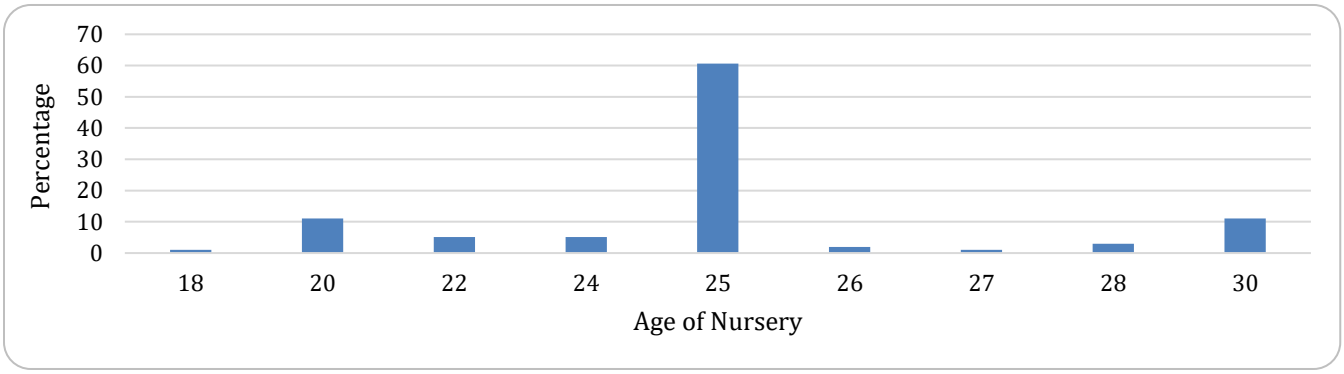

Figure 2. Age of nursery.

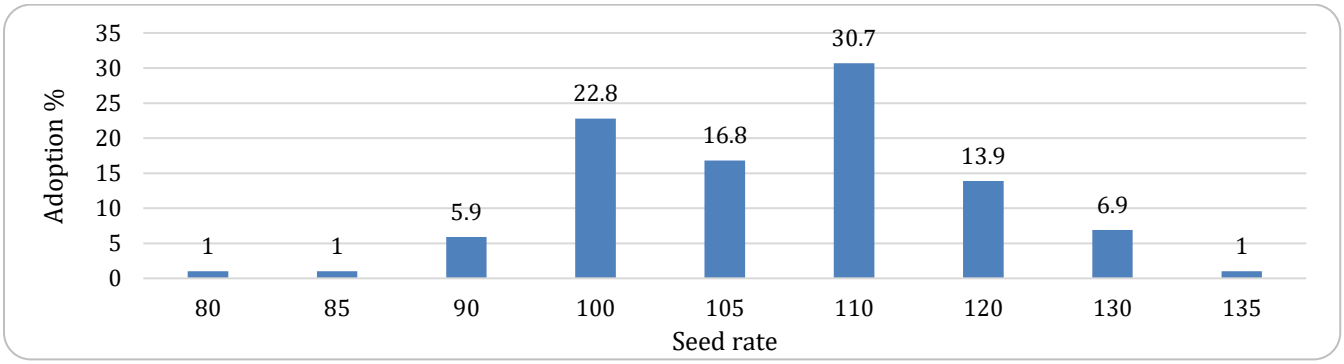

Figure 3. Seed rate as used by the rice farmers.

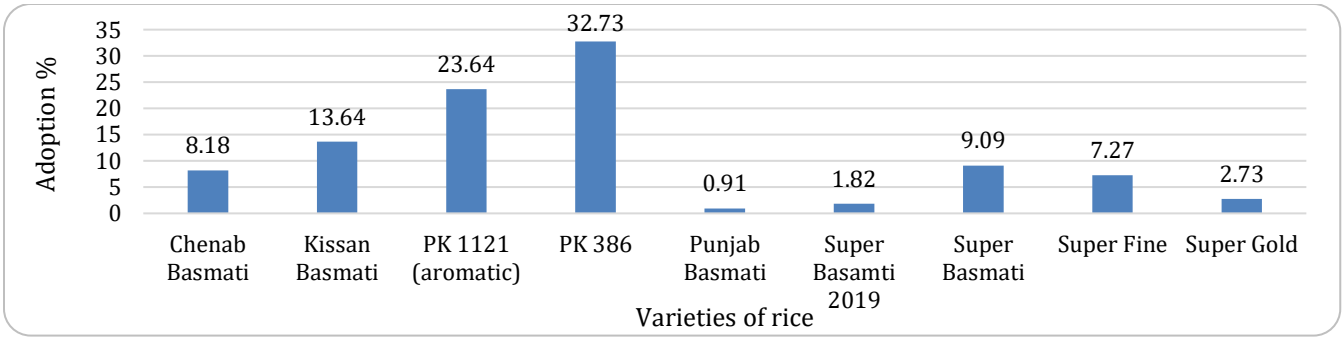

Figure 4. Varieties adopted.

Table 2. Data related to adoptability of MTR.

Categories of attributes	Frequency	Percentage
Knowledge about MTR		
Yes	169	76.82
No	51	23.18
Acres planted using MTR		
Up to 10	69	62.73
10-20	22	20.00
21-30	9	8.18
Above 30	10	9.09
Date of transplanting		
<10 June	18	16.36
11-20 June	35	31.82
<10 July	19	17.27
11-20 July	35	31.82
>20 July	3	2.73
Adoption of machine type		
Riding Type	94	85.45
Walk after	16	14.55

Date of transplanting

Table 2 indicates that farmers in the study area were transplanting rice in June and July. Around 16% of respondents transplanted rice before 10 June, 31.8% from 11-20 June and 17.27% transplanted before 10 July. Of the total respondents, 31.82 and 2.73% of respondents transplanted rice from 11-20 July and post 20 July, respectively.

Adoption of machine type

To transplant rice mechanically, over 85% of respondents reported the use of a Riding Type machine followed by the use of walk after machine as reported by 14.55% of respondents (Table 2). This implies that the riding type was a widely adopted machine perhaps due to its efficiency or economic viability.

Perceived relative advantages of MTR over conventional methods

Table 3 indicates that the average of thirteen items related to relative advantage appeared at 4.02±0.62. This implies that the relative advantage of MTR was perceived to a high extent. This could be the possible reason for more adoption of MTR as compared to traditional methods of rice sowing. Certain advantages of the MTR like being time efficient (*$\bar{X}$=4.90, SD 0.303*), better plant-to-plant distance ($\bar{X}$= 4.86, SD 0.429), reduction in labour ($\bar{X}$=4.85, SD=0.437) and being convenient relative to conventional planning ($\bar{X}$= 4.74, SD 0.442). This can be deduced that these relative advantages were of a high extent for the farmers adopting MTR as compared to those practicing conventional methods of sowing rice. Labor, time and convenience were the key benefits of helping farmers to conserve their resources, which might have fostered their inclination towards adopting MTR. Hossen et al. (2022) found in his study that mechanical transplanting of rice was cost effective and operation friendly. Farmers perceived that plant-to-plant population was improved using MTR ($\bar{X}$=4.33, SD= 0.571), less transplanting shock ($\bar{X}$=4.30, SD= 0.814) and better growth of crop ($\bar{X}$= 4.07, SD=0.643).

The farmers were convinced that they obtained a high yield of rice crops using MTR ($\bar{X}$=4.01, SD 0.525) as compared to the rice grown using the conventional method. Mechanical transplanting was found more promising in terms of saving cost and increasing the grain yield as reported by V. Chaudhary et al. (2005) and (Singh et al., 2006).

Constraints analysis

Table 4 indicated the different constraints faced by the respondents. The prominent constraint faced by the MTR adopter was the mandatory use of a lesser leveller ($\bar{X}$=4.87, SD 0.332) which is expensive equipment beyond the purchasing capacity of most of the farmers. Getting access to spare parts ($\bar{X}$= 4.64, SD= 0.515) and unskilled labour ($\bar{X}$= 4.28, SD=0.816) were reported by the respondents as serious constraints while adopting MTR. Of the different constraints, inadequate training

about the MTR ($\bar{X}$=4.22, SD= 1.014) was another foremost factor. This indicates that the farmers were might be technically untrained and institutional performance was not adequate to meet the needs of the farmers to apply MTR. Findings are endorsed by the findings of Hossen et al. (2022) as they found that adoption of mechanical transplanter was low because of high investment, inadequate knowledge, lack of repairing facility and non-availability of the spare parts. Difficulty in raising seedlings and nursery was another prominent constraint as perceived by the farmers ($\bar{X}$=3.48, SD 0.954).

Table 3. Farmers' response to relative advantages of mechanical rice transplanting.

Relative Advantage	Mean± SD
MTR is time-efficient as compared to conventional planting	4.90±0.303
In MTR, plant-to-plant spacing is better as compared to conventional planting	4.86±0.429
MRT reduces labour requirements as compared to conventional planting	4.85±0.437
MTR is convenient as compared to conventional planting	4.74±0.442
In MTR, plant population is better as compared to conventional planting	4.33±0.571
MTR ensures less transplanting shock as compared to conventional planting	4.3±0.814
In MTR, the growth rate is better as compared to conventional planting	4.07±0.643
In MTR, seedlings recover fast and mature uniformly	4.07±0.435
MTR provides more yield as compared to conventional planting	4.01±0.525
In MTR, less plant lodging is observed as compared to conventional planting	3.99±1.216
MTR reduces the rice transplanting costs	3.13±0.996
In MTR, manual weed control is easier due to proper space between the rows	2.83±0.607
In MTR, it is easy to use pesticides and fungicides due to the proper space between the rows.	2.68±0.669
Average	4.04±0.62

1: to very low extent 2: low extent 3: neutral 4: to high extent 5: to very high extent

Table 4. Constraints faced by the rice growers.

Constraints (percent of farmers)	Mean± SD
Laser levelling is mandatory but expensive	4.87±0.332
Repair/Maintenance of MTR is difficult	4.65±0.479
It is difficult to get the spare parts when required	4.64±0.515
Unskilled labour for nursery raising machine	4.28±0.816
There is no proper training regarding MTR	4.22±1.014
Higher cost of transplanting machine	3.77±0.721
You have/had experienced difficulty in raising seedlings and nursery management for MTR	3.48±0.954
MTR is difficult to operate in small plots	3.13±0.525
MTR frequently sinks into the puddled plot	3.01±0.67

CONCLUSION AND RECOMMENDATION

We found that the study area was rich in the potential of rice and implications for the use of Mechanical Transplanting of Rice (MTR) were high. Most of the farmers had knowledge and adoption of MTR in their fields. However, rice cultivation was mainly handled by old-age farmers, which could limit the future use of MTR as age has significant implications on the adoption of innovations. Contrary, most of the farmers had formal education. MTR users perceived MTR as relatively more advantageous as compared to the traditional method of sowing rice. The advantages were the outcome of other benefits associated with MTR like efficiency, less labour intensive, better crop management, high plant population and ultimately high yield. The future use of MTR was constrained by different factors including mandatory use of Lesser Land Leveler, high initial investment, problems of repairing and maintenance and inadequate training regarding the use of MTR. This study urges more involvement of institutions in making farmers aware of the MTR, enabling farmers to get new skills and knowledge about MTR through training,

seminars and workshops. Farmers should be provided with MTR on subsidies. There is also a need to initiate a motivational campaign for youth involvement in rice cultivation specifically in the rice zone.

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