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Comparative economics of manual and mechanical rice transplantation in District Sheikhpura

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Abstract

The study was designed to compare economics of mechanical transplanting of rice over manually transplanting method of rice cultivation in the context of low yield in manual transplanting over mechanical method. The primary data was collected through face to face farmer interviews for three different categories of rice varieties namely i) basmati ii) coarse and iii) PK-1121 by using a questionnaire. The results revealed that average paddy yield of Basmati , Coarse and PK-1121 rice varieties grown by manual transplanting method was 45, 49, 48 monds[1]/acre respectively as compared to 51, 52, 51 monds by mechanical transplanting method. However, per acre economic cost of production by manual means for Basmati (PKR 70847/acre), Coarse (PKR 62031/acre) and PK-1121 (PKR 64464/acre) rice varieties were less than with mechanical transplanting method i.e, PKR.77295, 72029 and 75445 respectively. Overall a significant rise in per acre economic profit was observed for Basmati and Coarse varieties grown by mechanical transplantation method i.e., PKR. 21186 and PKR. 9190 per acre as compared to manual method of transplanting i.e. PKR. 17376 and PKR.6601 per acre. BCR (Benefit-Cost-Ratio) for these three categories of rice varieties is greater for mechanical transplantation method i.e., 2.43, 2.03 and 2.44 as compared to manual means which is 2.33, 1.90 and 2.44 respectively for basmati, coarse and PKR-1121. Moreover, extent of harvesting with rice specific kaboota

[1] Mond is a local measure for weight (= 40kgs)

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harvester was more towards mechanically transplanted area as compared to manually transplanted area of all the 03 categories of rice namely basmati, coarse and PK-1121.

Keywords: Basmati, Variety, Service providers, Economic cost, Plant population, labour shortage
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Introduction

Rice shares 3.5% in value addition in Agriculture sector of Pakistan and contributes 0.7% towards national GDP (GoP-2020-21). It is 2nd most important staple food crop in Pakistan after wheat.

During 2020-21, total rice growing area in Pakistan was 3335.1 thousand hectares and total production was 8419.7 thousand tons (GoP, 2020-21). Punjab province is the largest producer of rice in Pakistan. According to statistics of GoPb (2020-21), the total area of rice cultivation in Punjab for the year 2020-21 was 2394 thousand hectares and contribution of district Sheikhupura in rice cultivation during the same financial year remained 239 thousand hectares. By revealing further details, Crop Reporting Service Punjab estimate the average paddy yield of Basmati as 21.70 monds/acre, while the average paddy yield for non-Basmati rice remained 24.91 monds/acre (Crop Reporting Service, GoPb 2020-21).

All over the world, rice is grown with two different methods; Direct Seeding Rice (DSR) and Transplanting of Rice (TPR). The DSR method involves sowing seeds directly in the field while TRP is the method of transplanting young rice seedlings in the field that are first grown in the nursery (Akhgari and Kaviani, 2011). In Pakistan, manual transplantation of rice is still the most common practice. It doesn't mean that mechanical transplantation of rice was not introduced in the past. Lot of efforts were done to replace the conventional, laborious and less fruitful manual transplantation method with mechanical means but there were many obstacles in this way.

Since the few decades, entire world was looking for such mechanical methods of rice cultivation in which labor should be reduced. This is all due to the ever increasing labor wages due to rapidly increasing earning opportunities in non-agriculture sectors. Development and adoption of rice transplanting machines is also the result of the need for enhancing rice productivity and decreasing the cost of crop production (Guru et al., 2012). In Pakistan, the key hindrances in adoption of mechanical transplantation technology are; use of conventional nursery raising technique instead of using mat-type nursery procedure, poor land leveling, high cost of imported mechanical transplanting machines, lack of awareness and training facilities (Ghafoor et al., 2008).

Now a days, efforts have been boosted to educate the farmers about benefits of adopting mechanical transplantation of rice. No doubt, the cost of production of rice by means of mechanical transplantation is slightly higher as compared to manual transplantation, but the higher yield due to increased plant population makes the mechanical transplantation method very profitable to adopt (Farooq et al., 2001). Moreover, by adopting the mechanical technique, nitrogen losses from rice cropping system can be reduced without affecting the crop yield (Huang and Zou, 2020).

Government of Punjab has also taken numerous steps to facilitate rice growers for rapid adoption of mechanical transplanting technology. In this regard, Directorate General Agriculture (Ext. & AR), Government of the Punjab, has initiated a project "National Program for Enhancing Profitability Through Increasing Productivity of Rice" (EPROC, Government of Punjab, PQD). The key objectives of this project is establishment of service providing units (SPUs) for promotion of mechanical transplanting method of rice cultivation and provision of subsidy for this purpose. One unit of mechanical transplanting equipment consists of riding-type/walk after type rice transplanter along with mat-type nursery raising machine accompanying 5000 plastic trays. In this project, 450 numbers of mechanical transplanting machines and 250 numbers of walk-after type rice transplanters are aimed to be provided to rice growers on 50% cost sharing basis. Training will be provided to selected applicants for mechanical transplanting machines and mat-type nursery raising equipment at Technology Transfer Centers (TTCs) i.e. Adaptive Research Farms of Sheikhupura and Gujranwala (Agriculture Department, Government of Punjab/Ongoing Projects).

Despite numerous steps taken in this regard by the Government of Punjab, the adoption and diffusion of mechanical transplanters is still low. Moreover, the slightly higher cost of production in case of mechanical transplantation method may be a reason to slow down the adoption of the mechanical transplanters amongst rice growers. Therefore, the present study has been designed to provide economic comparison (yield, cost of production and profit) of the manual and mechanical transplantation of rice production and highlight the key constraints in the adoption of mechanical transplantation.

Materials and Methods

Location: The research study titled was conducted in the Sheikhupura district of Adaptive Research Zone Sheikhupura that comprises of four districts namely Sheikhupura, Lahore, Nankana Sahib and Kasur.

Site Location: The study was conducted in district Sheikhupura which comprises of five tehsils namely Muridke, Ferozwala, Safdarabad, Sharaqpur and Sheikhupura. The primary data was collected from all the five tehsils of district Sheikhupura**.**

Farmer Location: At a first step, a list of farmers from these five areas, who were cultivating the rice with both manual and mechanical transplanting methods, was prepared with the help of field formation of Agriculture Extension Department of District Sheikhupura.

Sampling and Sample Size: A total of 100 farmers (50 adopters and 50 non-adopters) who were growing rice were interviewed for data collection. At the first step, lists of Mechanical Transplanting Adopters were prepared with the help of Agriculture Extension staff. At the 2nd step, the target farmers were located and interviewed with the help of service providers and the agriculture extension field staff through convenience sampling as extent of adopter farmers was very less. A well-structured questionnaire was prepared to collect data on basic information of the farmers, farm attributes and cost of production variables related to manual as well as mechanical method of rice cultivation. The collected data was entered in Excel format followed by necessary calculations and the use of SPSS for carrying out the data analysis.

Cost of Production: The procedure used by Chaudhry *et. al.,* (1992) and Ahmad & Chaudhry (1987) was adopted for cost of production estimation. Variable cost per acre for land preparation, seedling cost and transplanting, irrigation, plant protection measures, and

fertilizers, farm yard manure, harvesting and threshing was summed up. Total economic cost of production per acre was estimated by adding opportunity cost of family labour, land rent, management cost and cost of capital to the financial cost of production. Cost of production Publication of Crop Reporting Service (CRS) Punjab for the years 2020-21 was also used for estimation of opportunity cost of labour and management cost etc. (GOP, 2021).

Economic Cost of Production =Opportunity cost +Financial cost of Production

Gross Income: According to Ahmad & Chaudhry (1987) and Chaudhry *et.al.,* (1995), the gross income per acre was calculated by multiplying unit price with total paddy production. Net revenue is the difference between total revenue and total cost. Estimation of net income, the procedure adopted by Ahmad & Chaudhry (1987) was used. According to this procedure, net income per acre is the amount earned by the owner after paying all the crop production expenses. The formula used for estimation of net income is given as under:

Net Income= Total Revenue-Total Cost

Results and Discussion

Both personal and farming characteristics of famers affect the decision making for adopting latest agricultural technologies. As most of the farmers, interviewed for this research work, were exhibiting both methods of rice transplantation i.e., manual and mechanical, so mean values of both personal and farming attributes were taken. Average length of farming experience of the interviewed farmers for this research study was 20 years. Average numbers of family members were 10 and average number of earning hands was one. Small farmers with less than 12.5 acres of land comprised 33% of the total sampled farmers while 29% of the respondents were medium farmers with land area in the range of 12.51 to 25 acres and 38% were large famers with land area more than 25 acres. The Basmati variety wise frequency distribution of farmers and their respective areas with respect to manual and mechanical transplantation methods is shown in Table 1.

Table 1. Basmati Variety Wise Frequency Distribution of Farmers and their Areas with Respect to Manual & Mechanical Transplantation Methods

Basmati Varieties	Manual Transplantation				Mechanical Transplantation			
	Area Sown (Acres)	%age	Frequency of Growers	%age	Area Sown (Acres)	%age	Frequency of Growers	%age
Basmati 515	315	54.97	5	25.00	15	2.49	2	10.53
Basmati 1509	39	6.81	2	10.00	30	4.98	1	5.26
Chenab Basmati	14	2.44	1	5.00	116	19.24	2	10.53
Kissan Basmati	126	21.99	7	35.00	312	51.74	9	47.37

Super Basmati	79	13.79	5	25.00	130	21.56	5	26.32
Total	573	100	20	100.00	603	100.00	19	100.00

The Coarse variety wise frequency distribution of farmers and their areas with respect to manual & mechanical transplantation methods is shown in Table 2;

Table 2. Coarse variety wise frequency distribution of farmers and their area with respect to manual & mechanical transplantation methods

	Manual Transplantation				**Mechanical Transplantation**			
Coarse Varieties	**Area Sown (Acres)**	**%age**	**Frequency of Growers**	**%age**	**Area Sown (Acres)**	**%age**	**Frequency of Growers**	**%age**
Chenab Super	40	4.76	4	17.39	0	0	0	0
LP-18	16	1.90	1	4.35	0	0	0	0
PK-386	558	66.43	15	65.22	680	81.93	19	82.60
Super Fan	226	26.90	3	13.04	150	18.07	4	17.40
Total	840	100	23	100.00	830	100.00	23	100.00

The PK-1121 variety frequency distribution of farmers and their areas with respect to manual & mechanical transplantation methods is shown in Table 3.

Table 3. Pk-1121 variety frequency distribution of farmers and their area with respect to manual & mechanical transplantation methods

Varieties	**Manual Transplantation**				**Mechanical Transplantation**			
Pk-1121 Variety	**Area Sown (Acres)**	**%age**	**Frequency of Growers**	**%age**	**Area Sown (Acres)**	**%age**	**Frequency of Growers**	**%age**
PK-1121	465	75.00	9	60.00	154	25.00	6	40.00

Table 4 presents the economic costs of producing Basmati, Coarse and PK-1121 varieties of rice under manual and mechanical transplantation methods in the study area. The table also provides gross revenues, profits and benefit cost ratio for the three rice varieties under the two transplantation methods.

Table 4. Comparison of Average Cost of Production for Manual and Mechanical Transplantation

	Basmati		**Coarse**		**PK-1121**	
	Manual Transpl.	Mechanical Transpl.	Manual Transpl.	Mechanical Transpl.	Manual Transpl.	Mech. Transpl.
Total Financial Cost (PKR./acre)	37825	40499	36075	40093	35420	40294
Total Economic Prod. Cost (PKR./acre)	70847	77295	62031	72029	64464	75445
Average paddy yield (Monds/acre)	45	51	49	52	48	51
Gross Revenue (PKR./acre)	88001	98481	68631	81219	89383	98500
Financial profit (PKR./acre)	50397	59063	38915	42572	58585	58538
Economic profit (PKR./acre)	17376	21186	6601	9190	24919	23055
BCR	2.33	2.43	1.90	2.03	2.52	2.44

Comparison of Average Cost of Production for Manual and Mechanical Transplantation

To understand the comparison of average yield for manual and mechanical transplantation method between different rice varieties, it is necessary to have a look on cost of production of these varieties. Cost of production includes.

Comparison of Average Yield for Manual and Mechanical Transplantation Method

Results reveal that although total financial and economic cost of rice cultivation by mechanical transplantation is higher as compared to manual transplantation, but the average paddy yield from mechanical transplantation is much higher. The results are well supported by Farooq et al., (2001) who also observed the cost of producing mechanically transplanted rice was higher than the cost of producing manually transplanted rice. Moreover, they also observed better plant population and ultimately higher yield from mechanically transplanted rice. The graph below reveals that average paddy yield of manually transplanted Basmati rice is 45monds/acre that is lower than the average paddy yield of mechanically transplanted Basmati rice (51monds/acre). Similarly, in case of coarse rice varieties and PK-1121, there is same trend of getting higher yield from mechanically transplanted rice as compared to manually transplanted rice. The trend of average paddy yield from manually and mechanically transplanted rice of all three varieties can be observed in the graphical representation. The study results show that average paddy yield in mechanical method of rice transplanting is higher as compared to manual transplanting. The study results are in line with the results reported by Rupsikha Goswami et. al., (2020) according to which plant height (cm), number of plants per meter

square and grain yield in mechanical transplanting was more than manual transplanting.

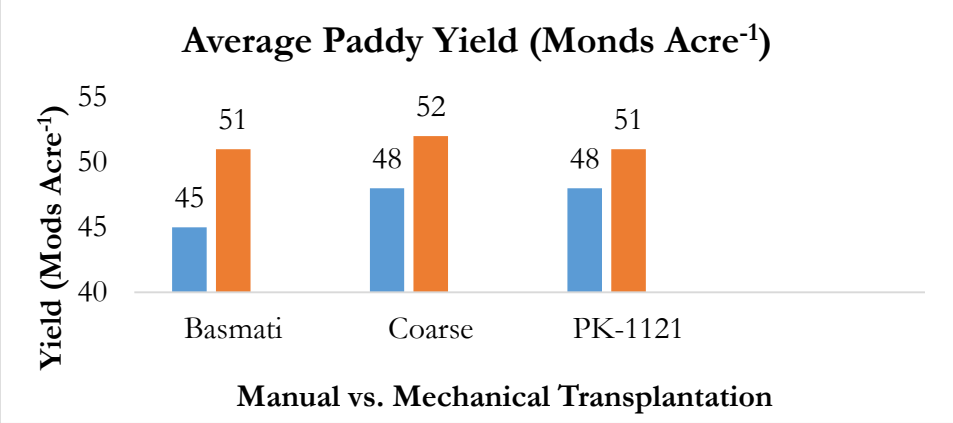

Figure 1. Average paddy yield for manual and mechanical transplantation methods comparison between per acre economic profit of manually vs mechanically transplanted rice

Results depict the clear difference between per acre economic profit of manually vs mechanically transplanted rice. For all categories of rice varieties, i.e., Basmati, Coarse except PK-1121, per acre economic profit from mechanically transplanted rice is higher as compared to manually transplanted rice varieties. For Basmati, Coarse and PK-1121 varieties, per acre economic profit is PKR 17376, PKR 6601 and PKR 24919 per acre for manually transplanted rice. However, for mechanically transplanted rice varieties, per acre economic profit is PKR 21186, PKR 9190 and PKR 23055 for Basmati, Coarse and PK-1121 respectively. Moreover, the Benefit-Cost-Ratio for all the rice varieties is much more in case of mechanical transplantation method i.e., 2.43, 2.03 and 2.44 while, in case of manual transplantation method, the BCR is 2.33, 1.90 and 2.44 respectively. These results are also supported by Xiwen et al., (2004) who observed that mechanical transplantation of rice resulted in high efficiency, high yield and higher economic benefits. Following is the graphical representation for per acre economic profit obtained by manually vs mechanically transplanted rice.

Comparison between Per Acre Economic Profit of Manually VS Mechanically Transplanted Rice

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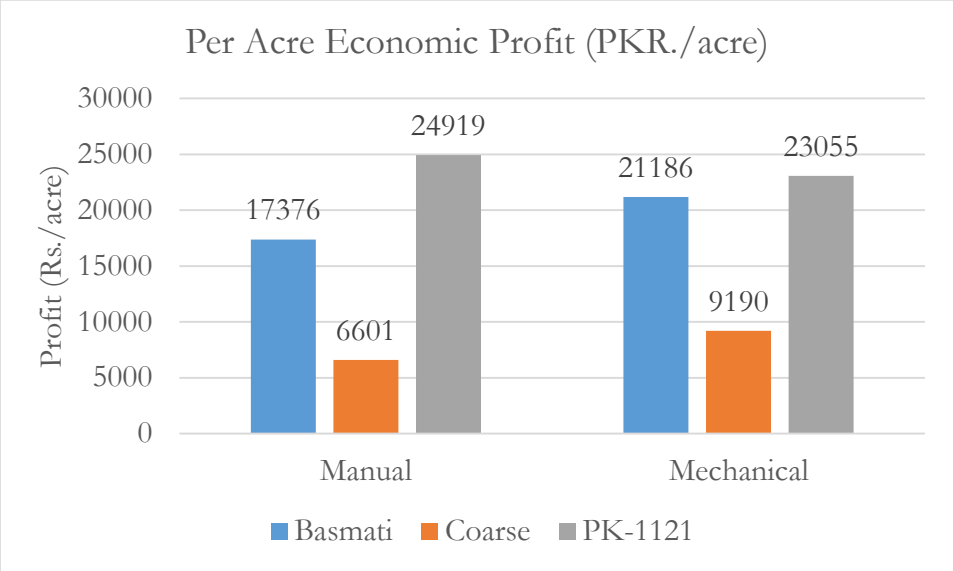

Figure 2. Economic Comparison of Profit (Manual Vs Mechanical Transplanting)

Comparison of Harvesting Methods for Rice Cultivation with Manual and Mechanical Transplantation Methods

Farmers are using different methods for harvesting the rice area. In order to know the extent of harvesting with different harvesting methods, they were asked about these methods of harvesting. Their response in terms of number of acres and extent of harvesting with these different methods are given in table 5.

Table 5. Area (acres) and Extent (%) of Area harvested with different modes of Harvesting

Transplanting Method	Kabooota	%	Combined Harvester	%	Manual	%	Total	%
Basmati Manual	129	22.5	444	77.5	0	0.0	573	100.0
Basmati Mechanical	190	31.7	409	68.3	0	0.0	599	100.0
Coarse Manual	80	9.4	765	90.0	5	0.6	850	100.0

Coarse Mechanical	202	45.8	239	54.2	0	0.0	441	100.0
PK-1121 Manual	205	24.3	639	75.7	0	0.0	844	100.0
PK-1121 Mechanical	69	40.8	100	59.2	0	0.0	169	100.0
Total	875	25.2	2596	74.7	5	0.1	3476	100.0

The results reveal that the respondent farmers are transplanting 83, 65 and 49 percent of their rice area manually in case of Pk-1121, Coarse varieties and Basmati varieties respectively. Whereas, 51, 34 and 16 percent of their rice area is being transplanted mechanically in case of Basmati, Coarse and Pk-1121 rice varieties respectively. It means that the extent of adoption of mechanical transplanting method is more in case of basmati varieties as compared to coarse and Pk-1121. The reason behind more adoption of mechanical transplanting in case of basmati varieties is that area under basmati varieties is more as compared to coarse and other varieties and at that time there is shortage of labour for manual transplanting which compels the basmati growers to opt for mechanical transplanting. Same is true for low adoption of mechanical transplanting in case of coarse varieties due to less area under coarse and other varieties. At that time there is no shortage of labour and coarse varieties are transplanted manually. Most of the coarse rice growers transplant themselves or get transplanted their coarse rice from the locally available labour. Similarly, the comparison of rice area being harvested by Kaboota, Combined harvester and manual harvesting methods reveals that those famers who are transplanting the basmati and coarse rice varieties by mechanical method are preferring harvesting with rice specific harvester i.e. Kaboota as compared to those farmers who are transplanting these rice varieties by manual method. The reason behind preference towards rice specific harvester (Kaboota) by mechanically transplanting farmers is that they want to minimize their harvesting losses too as harvesting losses with kaboota are minimal as compared to combined harvesting and manual harvesting methods.

However, the results are vice versa in case of combined harvesting i.e. the extent of area harvested with combined harvester is more in manually transplanted basmati, coarse varieties and PK-1121 as compared to mechanically transplanted rice. It can be deduced from the above results, that farmers transplanting manually prefer combine harvesting whereas farmers transplanting mechanically prefer harvesting with kaboota harvester.

Factors behind Adoption of Mechanical Transplanting

The adopter farmers were asked questions about factors behind for adoption of mechanical transplanting of rice. Their responses against each of the factors are given in Table.6 below:

Table 6. Frequency distribution of response w.r.t. factors behind adoption of mechanical transplanting

Factors	Yes	No	Total
Manual transplanting is very much expensive	49	2	51
Optimum level of plant population is not achieved with manual transplanting	47	4	51
There is a labour shortage at the time of rice nursery transplanting	49	2	51
Mechanical transplanting is economical	49	2	51
Mechanical transplanting covers more area in less time	51	0	51
Optimum level of plant population is achieved with mechanical transplanting	51	0	51
Plant spacing is maintained with mechanical transplanting	51	0	51
Mechanical transplanting is time saving as compared to manual	51	0	51
Mechanical transplanting is need of the hour	51	0	51

Almost 100% of the adopters responded that mechanical transplanting is time saving, covers more area in a given time frame, maintains plant to plant spacing and plant population along with being economical in the labour shortage time span. Since basmati varieties are transplanted on more area as compared to coarse varieties in district Sheikhupura, so there is labour shortage at the time of transplanting of basmati varieties. So mechanical transplanting is need of the hour for smooth and economical transplanting of rice especially the basmati varieties. According to Rupsikha Goswami *et. al.,* (2020), in main cropping season, the labour shortage and low cost of cultivation needs the mechanical transplanting technology

Major constraints faced to the farming community: Since mechanical transplanting is a new technique of rice cultivation, so there would be definitely some constraints faced to the farming community for its adoption. Some of the major constraints faced to the farming community are:

Availability of Mechanical transplanters: Only 23.5% of the adopter respondents (12 out of 51) had their own mechanical transplanters whereas 91.6% of the owners had riding type mechanical transplanters as only 01 out of 12 respondents had walk after type mechanical transplanter. Availability of Mechanical transplanters along with nursery raising machines in approachable vicinity is the real problem. According to Rajendran *etal.,* (2018) the main constraints faced by the farmers in mechanical transplanting were

no proper training on mechanical transplanting, non-availability of mechanical transplanter.

Technical Expertise Regarding Mechanical Transplanting: There is deficiency of technical expertise on the part of owners of mechanical transplanters who are carrying out mechanical transplanting of rice in the field. There should be training of tractor drivers who are conducting mechanical transplanting regarding land preparation with respect to different categories of land, age of nursery to be transplanted, special nursery raising method for mechanical transplanting etc. Land levelling is pre-requisite for mechanical transplanting but in the field this aspect is being neglected which leads to uneven plant stand establishment due to standing water at uneven parts of the field.

High Cost of Mechanical Transplanting

Currently mechanical transplanting is costly for the common farmers due to less availability of transplanters in the field. There is need to develop service providers for promoting mechanical transplanting of rice. Once service providers are developed in the area, cost of transplanting will be reduced due to competition amongst the service providers. High cost of the mechanical transplanting unit i.e. transplanter plus nursery raising machine along with plastic trays, is the main reason of high cost of transplanting. No doubt mechanical transplanting solves the problems of shortage of labour, less plant population and delayed sowing of rice especially the basmati varieties but its high cost (currently average cost of manual transplanting of basmati rice is PKR.6590 including cost of seed too whereas for mechanical transplanting PKR.7973 is being charged by owners of mechanical transplanters) is also amongst the major hindrances for adoption of mechanical transplanting.

Standardization of Seed Rates for Mechanical Transplanting

Currently mechanical transplanting is being carried out without standardization of seed rate and number of trays per acre. Moreover, age of seedlings to be sown through mechanical transplanting needs to be taken care of but no such care is being taken on the part of service providers. Govt. owned research institutes like adaptive research farms should take initiative in this regard. Currently 8 to 12 kg seed rate is being used for mechanical transplanting of basmati varieties.

Conclusion

The results of present research work clearly indicate the benefits of mechanically transplanted rice cultivation method over the manually transplanted rice production. Though there is a slight increase in the cost of production of paddy rice grown by mechanical means, however, it is ultimately fruitful in terms of better yield per acre which resulted in higher net economic profit per acre. Moreover, there are serious concerns of labor shortage due to day-by-day increasing opportunities in non-agriculture sectors and this shortage becomes more problematic during rice establishment season. As less labor is required in mechanical transplantation of rice, so problem of labor shortage can also be resolved in an efficient manner by adopting this mechanical method. So mechanical transplanting of rice solves the issues of labour shortage, plant population and delayed transplanting of basmati varieties etc.

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