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Comparative Analysis of Different Paddy Establishment Methods in Punjab

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Abstract

The manual transplanting method is the most prevalent method of paddy cultivation in Punjab, which is water, labour and energy intensive. Hence, it has threatened the sustainability of the paddy production system. Direct seeded rice (DSR) is an alternative technique among the farmers to get rid of these constraints. However, there are several constraints associated with shift from puddled transplanted rice to DSR. Therefore, a survey was conducted to understand the cultivation practices followed by the farmers, production constraints and cost-return analysis of different methods of paddy establishment in Barnala and Patiala districts of Punjab. As such, about 7 per cent, 74 per cent, 6 per cent and 14 per cent of surveyed farmers were involved in practicing of dry DSR, manual transplanted rice, mechanical transplanted rice and tar-wattar DSR, respectively. Analysis revealed that with non-significant yield differences, reduction in cost of cultivation by 29.5per cent, 29 per cent and 14.4 per cent was reported with the adoption of dry DSR, tar-wattar DSR and mechanical transplantation, respectively over manual transplantation. Also, about 20 and 40 per cent of irrigation water was saved with dry DSR and tar-wattar DSR respectively, over the manual transplanted rice.

Key words: *Tar-wattar* DSR, dry DSR, manual transplanting, mechanical transplanting, economic returns, water saving technique

JEL Classification: Q12, Q25

Introduction

Paddy is considered as one of the most important food crops of India. It is the staple food for more than two-thirds of the Indian population, thus, holds the key for food security and plays a pivotal role in the national economy (Mahajan et al., 2017). In Punjab, paddy was grown in the *kharif* season (2021-22) over 3.15 mha area and producing 20.37 million tons of paddy with a productivity of 6.48 t/ha (PAU, 2023). Puddled manual transplanting, which is water, capital, energy and labor-intensive practice (Bhatt et al. 2021), is the most prevalent method of paddy cultivation in Punjab. However, this method threatens the sustainability of the paddy production system as puddling of paddy fields alone consumes 79 to 150 mm of irrigation water (Yadav et al. 2011) and in transplanting system about 5000 liters of water is required to produce one kg of rice (Bouman 2009). The excessive pumping of groundwater for paddy cultivation under Punjab conditions has resulted in the decline of the water table by 0.4-1.0 meter per year, leading to increased pumping cost and water scarcity (Hira, 2009). In addition, transplanted paddy is a major source of methane (CH_4) gas emission, thereby, contributing to global warming and climate change (Dhillon and Mangat 2018). Given that, declining water table and deteriorating soil physical conditions associated with the conventional system of paddy establishment, alternative establishment methods have been recommended. Nowadays, direct seeded rice (DSR) is becoming popular due to its potential to save water, reduced labour intensity and less CH_4 emission (Bhullar et al.2018).

Under the DSR technology, sowing of paddy seeds is done directly in the soil for establishing the crop, rather than transplanting seedlings in puddled soil. Thus, DSR avoids repeated puddling, preventing soil degradation and plow-pan formation. Similarly, DSR facilitates the timely establishment of paddy as well as the succeeding crops, as the crop matures 10-15 days earlier as compared to puddled transplanting. Furthermore, DSR requires lesser tillage operations and thus, save energy, labour, fuel, and reduces the production cost. On the other hand, the adoption of DSR by the farmers may be hindered due to several constraints associated with

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it like, high weed infestation, micro-nutrient deficiencies in light-textured soil, poor crop establishment and rodent attack. Against this backdrop, the present study attempts to understand the cultural practices followed by farmers, production constraints, and cost- return analysis of different methods of paddy establishment in the study area of Punjab.

Data Sources and Methodology

The field survey was conducted covering two major rice-growing districts of Punjab *viz*. Barnala and Patiala covering three agro-climatic zones (northern plain semi-arid, northern plain dry sub humid and western plain arid zone) to understand the cultural practices followed by farmers, production constraints, and economics of different methods of paddy establishment in Punjab. Selection of farmers was done randomly while on field visits, farmers training camps and farmers visiting KVK/FASC for guidance. In total, 107 (62 farmers were from the Barnala district and 45 were from the Patiala district) randomly selected farmers during year 2021 were personally interviewed to fill a comprehensive questionnaire and data was compiled thereafter. All farmers in this study have irrigation facilities (tube-wells/bore wells and canal water) and were following rice-wheat rotation. The farmers were interviewed regarding different paddy sowing practices *viz* manual transplanting, mechanical transplanting, dry direct seeding of rice (Dry DSR) and *tar-wattar* direct seeding of rice (*tar-wattar* DSR). The total cost of cultivation was worked out by adding the cost of different farm operations in different sowing methods of paddy. Productivity of paddy in different methods of sowing was recorded and gross returns were calculated by multiplying the yield with the respective selling price per kg of paddy. The net returns of farmers per hectare were computed from the difference between gross returns and total cost of cultivation. Productivity, costs and income between different methods of DSR and conventional transplanted rice were compared using *Proc GLM* and *post hoc* test, *Duncan* multiple range test was used to compare means in SAS 9.3 software system.

Results and Discussion

The study resulted that 7 per cent, 74 per cent, 6 per cent and 14 per cent selected farmers were involved in practicing dry DSR, manual transplantation, mechanical transplantation and *tar-watter* DSR, respectively. The difference among these rice establishment methods is that, manual and mechanical transplanting are, generally, carried out after puddling process, whereas dry DSR and *tar-wattar* DSR are un-puddled rice sowing techniques. The major practice which makes *tar-wattar* DSR different from dry-DSR is the delayed first irrigation in *tar-wattar* DSR (at three weeks after sowing), offering higher saving in irrigation water, lesser incidence of iron deficiency, lesser weed germination, wider soil adaptability and yield/profit similar to puddle transplanted rice. The smaller area allocated to dry and *tar-wattar* DSR and mechanical transplantation of paddy might be due to the fact that manual transplantation method is an old and well-established technique and is still the predominant method of rice establishment (Chaudhary et al. 2023). Besides this, the risk involved in adopting a relatively new technology might also be the reason for the lesser area under new technologies of paddy establishment. Data in Table 1 revealed that majority of respondent were young (43.0 %) and middle aged farmers (36.5 %). Nearly, 34 per cent and 45 per cent farmers had senior secondary and matriculation level education, respectively. Only 2.8 per cent of respondents were illiterate. Furthermore, 25 per cent, 39 per cent and 35.5 per cent sample farmers have small, medium and large land holding, respectively.

It was a general fear among the paddy growing farmers that the yield of the crop might be reduced with the direct

Table 1.Socio-economic profile of interviewed farmers

Particular	Category	Number	Percentage
Age (years)	20-35	46	43.0
	36-51	39	36.5
	52-67	17	15.8
	68-83	5	4.7
Education level	Illiterate	3	2.8
	Primary	16	15.0
	Matric	37	34.4
	10+2	48	45.0
	Graduation	3	2.8
Operational land holding	< 5 acres	27	25.2
	5-15 acres	42	39.3
	> 15 acres	38	35.5

Table 2. Breakup of cost of cultivation as influenced by different paddy establishment methods

Establishment methods	Cost of cultivation (Rs. / ha)						
	Laser land levelling	Land preparation	Seed	Sowing	Weed management	Plant protection measures	Fertilization
Manual transplanted	1,710	6,515	680	9,743	1,365	6,075	3,160
Mechanical transplanted	1,605	6,438	900	5,168	1,938	5,208	3,575
Tar-watter DSR	2,075	4,483	880	2,458	2,573	4,465	3,538
Dry DSR	2,143	3,928	1,040	1,965	2,825	4,143	3,858

seeding of rice. However, this was true only to some extent as yield losses in dry and *tar-wattar* DSR in sampled farmers were only 3.1 to 6.2 per cent, as compared to the manual transplanted rice. Furthermore, it becomes clear from the economic analysis of the sampled farmers that dry or *tar-wattar* DSR are economically more profitable than manual and mechanical transplanted rice. The comparative cost of cultivation in different methods of DSR and transplanted rice in the area under study is presented in Table.2.

The average cost of laser land leveling ranged from Rs. 1605 per ha in mechanically transplanted rice to Rs. 2143 per ha in *tar-wattar* DSR. A large difference in the cost of land preparation was observed in different methods of DSR and transplanted rice, Rs. 6515 per ha were spent on land preparation in manual transplanted rice, whereas, Rs. 6438, Rs. 4483 and Rs. 3928 per ha were spent on mechanically transplanted rice, *tar-wattar* DSR and dry DSR, respectively. By, implying the method a monetary saving of about 40 and 31.2 per cent in dry DSR and *tar-wattar* DSR were observed respectively. The main difference in land preparation in transplanted and DSR is due to the puddling operation (a process where the soil is compacted to reduce water seepage). In both methods of DSR, no puddling is required, which, on the other hand, is a pre-requisite for both methods of transplanted rice to retain the irrigation water in the field. Further, there was a huge difference in the cost of sowing/ transplanting in different methods. The cost of sowing/ transplanting was Rs. 9743 per ha for manual transplantation of paddy, while only Rs. 5168, 2458, and 1965/- per ha were spent for mechanical transplantation, *tar-wattar* DSR, and dry DSR, respectively. In the DSR, weeds are considered the major constraint in technology adoption. The highest cost of weed management (Rs. 2825 per ha) was observed in the dry DSR closely followed by *tar-wattar* DSR (Rs. 2573 per ha). The lowest cost of weed management (Rs. 1365 per ha) was observed in the manual transplantation of paddy followed by the mechanical transplantation technique (Rs. 1938 per ha). Similarly, Bandumula et al. (2018) also reported that costs for weed management were significantly higher for DSR than for the transplanting method. This might be due to the combined effect of applying more herbicides along with the use of manual labor for weed management under the DSR method of paddy cultivation. The cost of plant protection measures(pest and disease management) was found to be the highest in manually transplanted rice followed by mechanically transplanted rice, *tar-wattar* DSR, and dry DSR in the study area, with the savings of Rs. 1932 and 1610 per ha in dry DSR and *tar-wattar* DSR, respectively over manually transplanted rice. Contrary to the plant protection measure, the cost incurred for fertilizer use was found to be the highest in dry DSR (Rs. 3858 per ha), whereas the lowest cost of fertilization was observed in the manual transplantation method (Rs. 3160 per ha).

Cost-return analysis of all the methods of direct seeding and transplanting showed that the highest total cost of cultivation per hectare was observed in manual transplantation (Rs. 28,993) which was statistically similar to the total cost of production of paddy sown using mechanical transplanting method (Rs. 24,830) and significantly higher than the cost of production of *tar-wattar* DSR (Rs. 20,470) as well as dry

Table 3: Productivity and cost-return of paddy as influenced by different crop establishment methods

Establishment methods	Yield (q/ha)	Cost of cultivation (Rs/ ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)
Manual transplanted	80.0[a*]	28,993[a]	1,50,227[a]	1,21,236[a]
Mechanical transplanted	77.5[a]	24,830[ab]	1,45,928[a]	1,21,098[a]
Tar-watter DSR	77.5[a]	20,470[b]	1,45,158[a]	1,24,688[a]
Dry DSR	75.0[a]	20,435[b]	1,43,840[a]	1,23,405[a]

**Values with same letters are not significantly different ($p<0.05$)*

Table 4: Comparison of irrigation applied in paddy as influenced by different crop establishment methods

Establishment methods	No. of irrigations	Saving of irrigation (%)
Manual transplanted	28.0	-
Mechanical transplanted	28.8	-3.12
Dry DSR	22.6	+19.3
Tar-watter DSR	16.9	+39.7

DSR method (20,435) (Table 3). The increase in the cost of cultivation in manual transplanting was mainly due to the cost of transplanting and the cost of puddling per ha. Thus, a reduction in the cost of cultivation by 29.5per cent, 29 per cent, and 14.4 per cent were reported with the adoption of dry DSR, *tar-wattar* DSR and mechanical transplantation, respectively over manual transplantation. The gross returns didn't differ statistically but in monetary terms, the highest gross returns were obtained with manual transplanting (Rs. 1.52 lakh) followed by mechanical transplanting (Rs. 1.46 lakh) and *tar-wattar* DSR (Rs. 1.45 lakh) while the lowest gross returns were obtained with dry DSR(1.44 lakh). However, the highest net returns were recorded with *tar-watter* DSR (1.25 lakh) followed by dry DSR (1.23 lakh) which recorded 2.84 per cent and 1.79 per cent higher net returns as compared to manual transplanting, respectively. Higher net returns in DSR over manual transplanted rice was also reported by Bhullar et al.(2018).

With similar economics, DSR holds importance as it helps to conserve a limited natural source i.e. water. Thus, water saving is considered one of the most important components of DSR methods. The conventional rice establishment system i.e., transplanted rice requires a substantial amount of water, up to 5000 liters is used to produce one kg of rough rice in this system (Bouman 2009). However, this volume can be reduced with DSR technology. It was observed in the present study that number of irrigations was very less i.e., 23 and 17, respectively for dry DSR and *tar-wattar* DSR as compared to the 28 and 29 irrigations in manual and mechanical transplanting, respectively (Table 4). Thus, the sampled farmers, who adopted dry DSR and *tar-wattar* DSR, saved an average of 19.3 and 39.7 per cent of irrigation water, respectively over the manual transplanted rice (Table 4).

After considering the productivity, economics and water saving in DSR technique of paddy transplanting, it was assumed that manual transplanting technique can be easily replaced by DSR technique. But the farmers are still reluctant about its adoption. After interviewing farmers, it was observed that the major lacuna in this technique is weed management. For scientific evaluation of farmers' viewpoint, they were also asked about weeds incidence in their respective rice crop. The findings are presented in Figure 1. After perusal of data, it was obtained that among the farmers who adopted *tar-watter* DSR, 40 per cent of them reported medium weed incidence, 13.3 per cent reported high and 26.7 per cent reported very high incidence. However, among farmers who planted rice with dry DSR, 24.3 per cent reported high and 40.0 per cent reported very high weed incidence. On the contrary, neither mechanical nor manual transplanted rice adoptee farmers reported high or very high weed incidence.

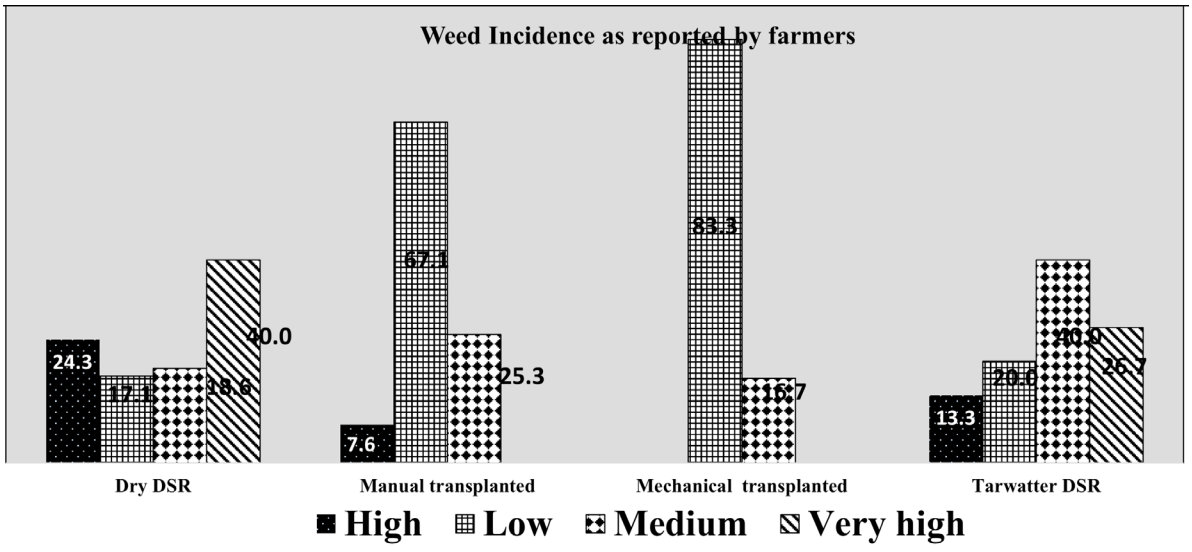

Fig 1: Weeds incidence as reported by farmers under different paddy establishment methods

Conclusions and Policy Implications

The results of this study suggest that farmers prefer the conventional method of paddy transplanting due to being well versed with the technology and reluctance to take risks in adopting a relatively newer technology such as DSR. Moreover, the traditional method does not necessitate the usage of the laser land leveler, which is a requisite factor in case of the *tar-wattar* and dry DSR techniques and increases the number of farm operations needed. Another major constraint in the adoption of DSR techniques is the higher weed incidence in the fields as compared to the puddled methods. It increases the cost of weed management in the DSR methods due to more amounts of herbicides and more manual labour involved. Although the final cost benefit ratio is better in the DSR methods, but even then, it is considered as an extra expenditure by the farmers, who prefer the manual transplanting method. Besides weed management costs, the expenditure incurred on fertilizer use is also more particularly in the dry DSR method, thus proving to be another reason for its non-preference. Furthermore, the gross returns are better in the manual transplanting method at least in the monetary terms which captivates the attention of the farmers more than done by the calculation of the net returns.

But the farmers should be made aware that the direct seeding method is better than the manual transplanting method both in monetary terms as well as for the conservation of natural resources, and just needs proper management. It needs lesser expenditure and time for land preparation and sowing, results in minimum water saving of 19 per cent as compared to the manual transplanting method, requires lesser number & cost of plant protection measures and even gives comparable yields with that of transplanted rice with lower cost of cultivation. Further water savings can be also be achieved with better management practices, including delaying the first irrigation. The weed incidence in DSR can be tackled with a more strategic and sustainable approach and the knowledge of the farmers should be updated regarding improved cultivation techniques developed for efficient weed management. Moreover, the farmers should be well informed that the net returns are better in the direct seeding methods as compared to the transplanting methods. On the other hand, adoption of mechanical transplanting is slower due to poor response from stakeholders because of the cumbersome process of growing paddy nursery in trays and mats and requirement of costly machinery.

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