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Resource Use Pattern and Adoption of Direct Seeded Rice (DSR) in Punjab

Gurpreet Singh, Sangeet Ranguwal and Jatinder Sachdeva

Department of Economics and Sociology, PAU, Ludhiana, India

Abstract

Present study was undertaken in Punjab during 2021-22 to examine the comparative input use pattern for DSR and Puddled Transplanted Rice (PTR). The primary data were collected through personal interview method from 120 selected respondents (80 adopters and 40 non adopters) using multi stage random sampling technique. The input use in DSR was found to increase with the farm size (except animal labour) and statistically non-significant differences existed across the farm categories. The use of different inputs was lower on DSR farms as compared to PTR farms except seed, PPC and micro-nutrients and the mean difference of major inputs such as human labour, machine labour, diesel fuel, seed rate, urea, rodenticides, weedicides, electricity differed significantly. The DSR generated significant savings in the use of human labour (40.5%), machine use (12.63%), irrigation water (15.90 %) and fertilizers (15.06%) than PTR though weed infestation and rodent attacks was the major problem in DSR which led to higher requirement of PPC in DSR along with the higher seed rate. DSR technology is a viable alternative for sustainable rice production and for its wider adoption; there is a need for capacity building by educating/training the farmers along with Government initiatives like subsidizing the cost of direct seeding of rice per acre. In this regard, Agro Service Centers in all co-operative societies need to be strengthened to ensure timely availability of required farm machinery/implements on custom hiring basis. There is a need for auxiliary research and development efforts in developing high yielding rice varieties with desirable traits, viz., vigorous growth, weeds suppressing ability, tolerance to micronutrient deficiency which is suitable for DSR.

Keywords: DSR, Inputs, Farm category, PTR, Savings, Rice

JEL Classification: A10, Q12, Q15, O13

Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops in the world, and staple food for more than half of the world population. Being the major source of food after wheat, it meets 43 per cent of calorie requirements of more than two- third of the Indian population (Kaur and Singh, 2017). The primary method of rice cultivation is the transplantation of nursery seedlings into puddled soil. However, in the recent years, increasing water scarcity, labour shortage and rising labour cost has triggered the search for alternative crop establishment methods like Direct Seeded Rice (DSR)which can increase the water productivity. DSR refers to the process of establishing rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery in flooded farm conditions. Further, in Punjab state, timely rice establishment through PTR depend exclusively on migratory labour requiring 50 million men days (Dhillon and Vatta, 2020). DSR is an alternative solution to the traditional puddled transplanted rice (PTR) as it is not only cost, input, energy and time saving but is also environment friendly(Jat *et al,* 2022). On the other hand, the conventional PTR is water, capital, energy and labor-intensive practice(Bhatt *et al*, 2019; Singh *et al*, 2020; Bhatt *et al*, 2021). With this backdrop, the present study was carried out to examine the input use pattern in paddy cultivation across different farm size categories and to analyse the adoption and extent of input savings in DSR in comparison to the PTR method.

Data Sources and Methodology

The present study carried out in Punjab is based on primary data collected by using multi-stage random sampling technique. At the first stage, one district namely Sri Mukatsar Sahib having the highest area under the DSR technology for paddy cultivation (during 2020-21) was identified through consultation with officials of the State Department of Agriculture. Keeping in view the concentration of DSR technology, two blocks namely Gidderbaha and Mukatsar were selected at the second stage (Table 1).

Corresponding author email: gurpreetsinghbhullar14@gmail.com

Table 1 Distribution of survey sample

District	Block	Village	DSR Adopters	DSR Non-Adopters	Total
SriMukatsarSahib	Gidderbaha	Kauni	20	10	30
		Doda	20	10	30
	Mukatsar	Bhullar	20	10	30
		Thandewala	20	10	30
Grand Total			80	40	120

Using simple random sampling technique, 20 DSR adopter farmers were chosen from each selected village for the study. In order to undertake impact assessment of the DSR technology, ten DSR non-adopter farmers from the same vicinity were also taken as a control group in the analysis. Thus, the total sample for the study comprised of 120 farmers (80 adopters and 40 non-adopters) spreading over different farm size groups based on operational holding i.e. small (up to 5 acres), medium (>5 to 15 acres) and large (more than 15 acres).

The primary data pertaining to the two cultivation practices i.e. DSR and PTR were collected from the sample farmers for the agricultural year 2021-22 through personal interview method. Requisite information relevant to various inputs used in paddy cultivation such seed, diesel fuel (consumed for various farm operations viz. seed bed preparation, inter-culture operations, harvesting, transport on farm etc.), fertilizers, farm yard manure (FYM), chemicals (insecticides, fungicides, herbicides), crop yield, total working hours of labour (men and women hours) as well as draught power used for different farm operations along with total working hours of agri-machinery were recorded. The information on capacity of the pumps used by the farmer for irrigating in terms of horse power (Hp) was also collected from the respondents. Data on paddy grain yield was used for the estimation of straw yield using crop to residue ratio method (Chauhan, 2012).

Results and Discussion

Status of adoption of DSR in Punjab

Considering sustainable agriculture as the keystone of Punjab's social and economic prosperity, promotion of DSR has been one of the pioneer steps in this regard in the Punjab Government's 2023-24 Budget. About 30 thousand famers have been provided with an incentive Rs1500 per acre for adopting the practice of DSR, for which an amount of Rs 25 crore has been paid (Figure 1). During 2021-22, the area under DSR was 84.9 thousand hectares forming only about three per cent of the total area under paddy (3144.6 thousand hectare). District wise analysis of the data revealed that the highest proportion of area under DSR was under Shri Mukatsar Sahib (20.8%) followed by Fazilka (19.28%), Bathinda (12.6%), Firozpur (6.86%) and Mansa (5.78%) while for other districts it lied below 5 per cent. In terms of number of farmers availing the subsidy, the maximum belonged to Fazilka (19.8%) followed by Shri Mukatsar Sahib (16.3.5), Bathinda (12.1%), Mansa (7.8%) and Sangrur (5.7%). As regards the subsidy availed, Shri Mukatsar Sahib ranked first (22.9%), followed by Fazilka (20.8%), Bathinda (12.8%), Firozpur (6%) and Mansa (5.9%) with rest districts having share of below five per cent in the subsidy availed.

Thus, DSR paddy had higher adoption in the south western districts of the state. One major reason behind this is that ground water is not fit for irrigation in most of the villages in this area. According to an earlier study, the adoption of DSR was higher amongst the farmers with relatively lower access to irrigation (Vatta *et al*, 2021).

Farm category-wise input use pattern and output in paddy cultivation by DSR

The resource use in paddy cultivation on different farm sizes under DSR method of cultivation selected for the present study is given in Table 2. Analysis of the data revealed that use of human labour (both male and female) worked out to be 101.03 hours per acre on an average, while the respective figures varied between 100.05 – 102.09 from small to large farms. Machine labour (use of machinery for various cultural operations comprising mainly land preparation, irrigation, harvesting and on farm post-harvest operations) ranged between 7.85 – 8.67 hours per acre and it was 8.3 hours per acre on an average. Thus, with farm size the use of human as well as machine labour increased. Consequently, the diesel fuel used in prime movers and oil engines/generators for running pumps on small farms (39.80 litre per acre) was lesser than on large farms (46.00 litre per acre) with average figure being 42.75 litre per acre. On the contrary, the animal labour use for on farm transportation showed inverse relationship with the farm size. The use of animal labour was reported to vary between 0.40 hours on large to 1.11 hours per acre on small farms and average figure worked out to be 0.75 hours per acre. In a similar study for Punjab, it was observed that among different farm categories, the maximum value for mechanization index exists for the large farmers and that for marginal farmers in case of animal labour index (Kaur *et al,* 2017).

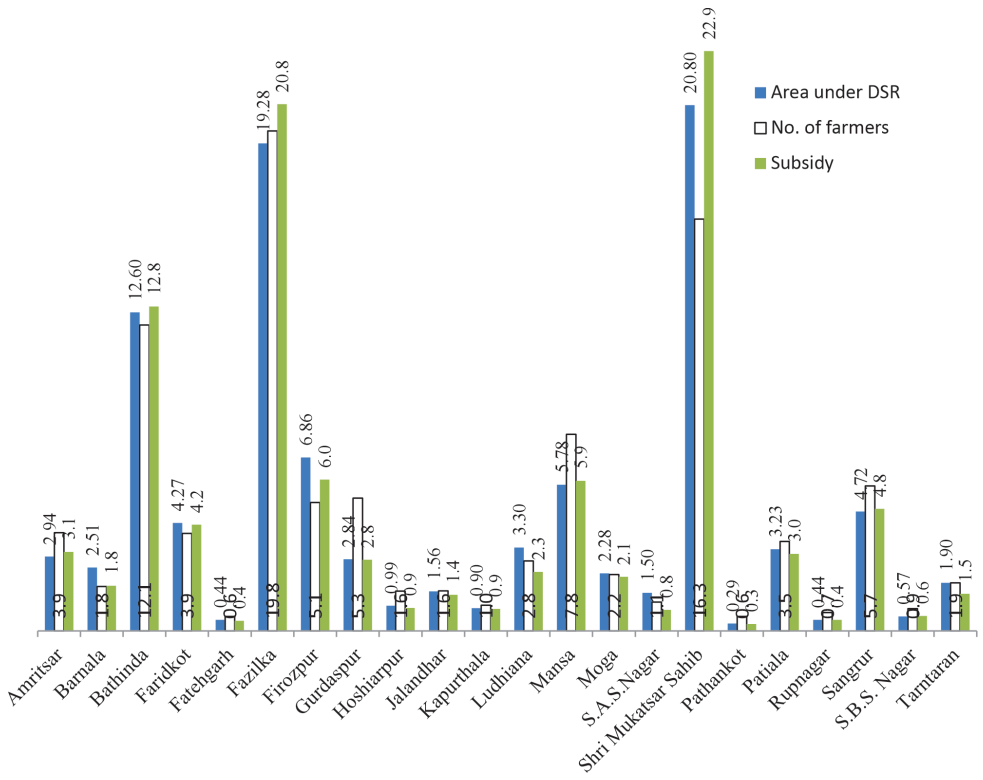

Figure 1: District wise area under DSR and subsidy provided for adoption of DSR in Punjab, 2021-22
(% shares to respective totals)

Source: Department of Agriculture and Farmers' Welfare, Government of Punjab

Seed rate is an important factor in optimizing the grain yield (Li *et al,* 2020). The crop establishment and germination of seed depends highly upon the seed rate (Ahmed *et al,* 2014). Analysis of the data revealed that the seed rate increased with rise in the farm size. On an average, 7.89 kg seed rate followed by DSR adopters as against recommended seed rate of 8 kg/acre and it was the highest on large farms (8.29 kg /acre), followed by medium (7.90 kg/acre) and small farms (7.48 kg/acre). On the other hand, dose of urea applied was higher for small farmers than the medium category farmers. Two main reasons were also observed behind this pattern i.e. lack of knowledge among farmers about the recommended package of practices and existing nutrient based subsidies on these chemical fertilizers. The DSR adopters were found to be using much higher dose of urea than recommended by the PAU (130 kg per acre). High magnitude of subsidies for nitrogen fertilizer extended by the government indirectly encouraged the farmers to apply larger quantities of nitrogen fertilizer for paddy crop. The average figures for the use of different chemical fertilizers and micro nutrients like urea, phosphatic fertilizers, muriate of potash, zinc, Iron sulphate and others (including seed treatment chemicals and growth regulators) were estimated to the tune of 143.80, 6.54, 6.14, 5.13, 5.82 and 3.18 kg per acre on an average and their use was also found to increase with the farm size.

The use of farm yard manure (FYM) was the highest on large farms (6.10 ton per acre) and the least on small farms (5.30ton per acre) and this happened due to high availability of FYM from large livestock with the large farmers. As regards the use of plant protection chemicals (PPC) is concerned, the average use of rodenticides, insecticides (both liquid and granular) and weedicides turned out to be 1.54 kg, 2.70 (litre and kg) and 3.21 litres per acre and their use was the highest by the large farm category. Similarly, the use of electricity for the irrigating one acre of DSR paddy turned out to be the highest on large farms (618.16 KW) as compared to small (603.03 KW) and medium farms (609.01 KW) though it was freely available to all the farm categories. The pumping of irrigation water from deeper layers of underground water through submersible electric pumps and electric motors has led to the high electricity consumption in the state. Further, on account of free of cost supply of electric power to agricultural sector in Punjab state, farmers had no incentive in saving electricity. The output from paddy cultivation in terms of grain and straw production of paddy was to 27.69 and 37.38 quintals on an average and it was the marginally high for the medium farm category (28.01 Qtls per acre) than small (27.2 Qtls per acre)

Table 2 Input use pattern and output in paddy cultivation by DSR method among different farm size categories, 2021-22 (Per acre)

Sr. No.	Input/Farm category	Small	Medium	Large	Overall
1	Human Labour (h)	100.05	101.01	102.09	101.03
2	Animal Labour (h)	1.11	0.75	0.40	0.75
3	Machine Labour (h)	7.85	8.38	8.67	8.3
4	Diesel (litre)#	39.8	42.45	46	42.75
5	Seed (kg)	7.48	7.9	8.29	7.89
6	Fertilizers, micro nutrients and FYM				
a	Urea (kg)	143.0	141.0	147.5	143.80
b	Phosphatic (kg)	6.21	6.53	6.90	6.54
c	Muriate of Potash (kg)	5.62	6.30	6.50	6.14
d	Zinc (kg)	4.50	5.20	5.70	5.13
e	Iron Sulphate (kg)	4.90	5.90	6.66	5.82
f	Others (kg)##	2.50	3.20	3.60	3.18
g	FYM (ton)	5.30	5.82	6.10	5.74
7	Plant Protection Chemicals				
a	Rodenticide (kg)	1.20	1.62	1.80	1.54
b	Insecticide (litre andkg)	2.30	2.60	3.20	2.70
c	Weedicide (litre)	2.80	3.30	3.55	3.21
8	Electricity for irrigation (KWh)	603.03	609.01	618.16	610.05
9	Total output				
	Grain (qtl)	27.20	28.01	27.88	27.69
	Straw (qtl)	36.72	37.81	37.63	37.38

Non-significant differences were observed among farm categories
#includes use of tractor for land preparation, irrigation, transport on farm and harvester combine
##includes seed treatment chemicals and growth regulators

and large farms (27.88 Qtls per acre).

The analysis revealed that the input use in DSR paddy cultivation showed increased with the farm size except use of animal labour and non-significant differences existed among the different farm categories for the input use.

Comparative assessment of input use and output in paddy cultivation using DSR and PTR method

The results for comparative input use pattern and output of paddy cultivation under DSR and PTR method is given in Table 3. Human labour use was found to be about 41 per cent higher for PTR (169.9 hours) than for DSR (101.03 hours) as the human labour requirements in DSR were reduced due to no need for transplanting the paddy seedlings. Machine labour use was also higher by about13 per cent for PTR (9.50 hours) than DSR (8.30 hours) and consequently about 8 per cent higher diesel use existed in PTR (46.5 litre) than DSR (42.75 litre). Compared to the average seed rate used by DSR adopters (7.89 kg), the PTR followers used only 5.30 kg of seed for sowing one acre of paddy because of self-confidence in their farming practices.

Among different chemical fertilizers, the use of urea, phosphatic fertilisers, muriate of potash, and micro nutrients-zinc and Iron sulphate, was higher for PTR than DSR except Iron sulphate (lower for PTR by 1.22%) and seed treatment chemicals and growth regulators (by 0.48%). On the contrary, the use of PPC was much higher by the DSR adopters. Due to huge weed infestation, almost double amount of weedicide application per acre (3.21 litre) was observed for DSR than PTR (1.20 litre). Further, use of rodenticides to avoid rodent attack was three times higher side in DSR (1.54 kg) than PTR (0.50 kg). Insecticide application was also higher in DSR (2.70) than PTR (2.23) though the difference was statistically non-significant. The use of electricity for the irrigation was higher on PTR (725.40 KW) than the DSR farms (610.05 KW) by about 16 per cent because of lesser number of irrigations and water application in DSR.

Table 3. Input use pattern and output from paddy cultivation using DSR and PTR method by the respondents, 2021-22 (Per acre)

Sr. No.	Input/Method	DSR	PTR	Mean difference	t-value
1	Human Labour(h)	101.03	169.90	-68.87**	129.34
2	Animal Labour(h)	0.75	1.00	-0.25	0.375
3	Machine Labour(h)	8.3	9.50	-1.20**	49.03
4	Diesel (litre)#	42.75	46.50	-3.75*	18.24
5	Seed (kg)	7.89	5.30	2.59**	15.40
6	Fertilizers and micro nutrients				
A	Urea (kg)	143.80	170.62	-26.82**	71.98
B	Phosphatic (kg)	6.54	6.80	-0.26	0.480
C	Muriate of Potash (kg)	6.14	6.80	-0.66	0.821
D	Zinc (kg)	5.13	6.50	-1.37*	2.125
E	Iron Sulphate (kg)	5.82	4.60	1.22	1.351
F	Others (kg)##	3.18	2.70	0.48	1.121
G	FYM (Tonne)	5.74	5.90	-0.16	0.752
7	Plant Protection Chemicals				
A	Rodenticide (kg)	1.54	0.50	1.04**	32.48
B	Insecticide (litre and kg)	2.70	2.23	0.47	1.658
C	Weedicide (litre)	3.21	1.20	2.01**	11.26
8	Electricity for irrigation (KWh)	610.05	725.40	-115.35**	371.66
9	Total output				
A	Grain (kg)	2769.00	2801.30	-32.30	1.34
B	Straw (kg)	3738.15	3781.76	-43.61	1.37

*** and * significant at one and five per cent level of significance*
#use of tractor for land preparation, irrigation, transport on farm and harvester combine
##include seed treatment chemicals and growth regulators

Output from paddy cultivation in terms of grain and straw production was estimated to be about 2801 kg and 3782 kg per acre on PTR farms, while the corresponding figures worked out to be about 2769 kg and 3738 kg per acre for DSR but this difference was statistically nonsignificant.

The analysis revealed that use of all the inputs was lower on DSR farms as compared to PTR farms except seed, plant protection chemicals (PPC) and micro-nutrients. The mean difference of major inputs such as human labour, machine labour, diesel fuel, seed rate, urea, rodenticides, weedicides, electricity differ significantly among DSR and PTR method of paddy cultivation. Besides urea, crop duration, plant protection and machine hours came out be significant factors in affecting the yield of the crop (Singh *et al*, 2021).

Extent of savings in use of different inputs in DSR in comparison to PTR method of paddy cultivation

Results for comparative input use share for DSR and PTR method is given in Figure 2. In the study area, human labour use was found to be about 41 per cent higher for PTR than for DSR. The farmers used tractor for land preparation, puddling as well as irrigation operations before transplanting rice seedlings in the PTR fields which was not so for the DSR. In PTR, water is required for raising rice seedlings in nurseries, puddling and transplanting operations. It also requires continues submergence of water in the field. The DSR does not require raising seedlings in nursery, puddling, transplanting operations and continued water submergence. Hence, DSR reduces overall water requirement for paddy cultivation. Thus, the DSR method generated significant savings in the use of machine (12.63%), fertilizers (15.06%) and irrigation water (15.90 %) in comparison to PTR.

On the contrary, weeds infestation and rodent attacks was the major problem in DSR paddy cultivation which led to higher requirement of plant protection chemicals (i.e. rodenticides, insecticides and weedicides) along with the higher seed rate (-48.87%) than the PTR. Similar results have been cited in an earlier study where the use of human labour, machine labour and irrigation water were saved by

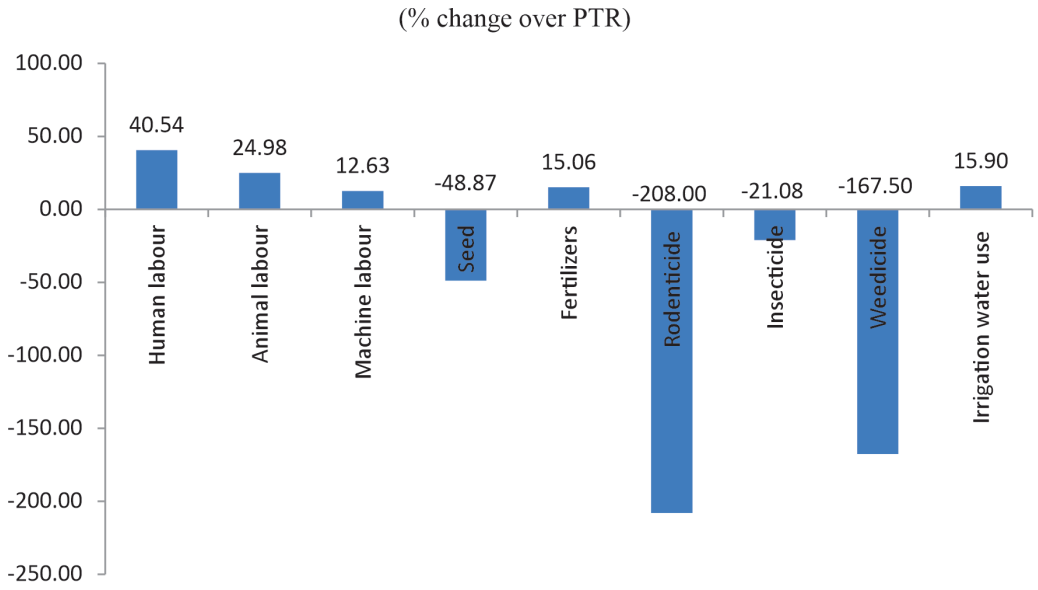

Figure 2. Extent of savings in inputs in DSR method of paddy cultivation by the respondents, 2021-22
(% change over PTR)

13.16, 41.34, and 11.88 per cent, respectively, in DSR as compared to the PTR method of rice production (Tripathi *et al,*2014).

Conclusions and Policy Implications

The DSR technology is a viable alternative to overcome the problems of rising cost, labour and water shortages for sustainable rice production yet it has not been adopted at a very large scale in the state. For wider adoption of DSR technology, there is a need to generate more awareness of recommended DSR production practices among the farmers along with the benefits of such practices. Government initiatives like subsidizing the cost of direct seeding of rice per acre can also help extension of area under DSR. In this regard, Agro Service Centers in all co-operative societies need to be strengthened so that timely availability of required farm machinery/implements on custom hiring basis could be enhanced for the benefit of the small farmers. There is a need for auxiliary research and development efforts in developing suitable agronomic practices, varieties and mechanized devices to overcome the problem of weeds. More research is needed to develop high yielding rice varieties with desirable traits, viz., vigorous growth, weeds suppressing ability, tolerance to micronutrient deficiency which are suitable for DSR. There is a need to focus more on capacity building by educating/training the young farmers for promotion of DSR. A campaign with the combined efforts of various stakeholders such as government agencies and non-government organisations including these change agents will help in speedy adoption of DSR.

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