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Is DSR More Profitable than Conventional Tillage? Evidences from Field Data in Punjab

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Abstract

Direct seeded rice is an effective replacement for traditional puddled transplanted paddy with high potential to conserve water, demand less labour and minimise greenhouse gas emissions. The present study was conducted to evaluate the impact of adoption of direct seeded rice on input use and profitability in Punjab agriculture. In order to accomplish the specific objectives, sample farmers from paddy-wheat crop rotation from two districts of Punjab namely Mansa and Sri Muktsar Sahib were selected. The variable cost per ha for paddy-wheat crop rotation came out to be less on DSR adopter farms (Rs. 70577.52) as compared to non-adopter farms (Rs. 76503.26).The net returns came out to be higher for adopters with Rs.1.53/ha and reduced by two per cent for the non-adopters. Lesser yield, higher amount of weeds and lower seed germination were major constraints in the adoption of DSR. The study suggests there is a need for capacity building of farmers for effective management of weed and pest in DSR.

Key words: Adoption, Crop Rotation, Direct Seeded Rice, Puddled Transplanted Rice

JEL Classification: Q16, Q18

Introduction

Paddy is not only a water intensive crop but the cultivation practices followed by the farmers also indiscriminately use ground water resources (Kaur, 2011; Kaur *et al,* 2012). The major method of growing paddy is by transplanting after puddling, which destroys the soil's structure and causes the creation of hard pans. Although puddling aids in water retaliation and effective weed management, it also necessitates more time, labour, energy, and tillage for a successful wheat harvest (Bhardwaj and Kaur, 2017). According to Mahajan *et al* (2009), paddy transplanting by hand also results in a low and irregular crop population, which lowers crop yields.

The inefficient use of inputs, increasing scarcity of resources, particularly water and labour, changing climate, the developing energy crisis and rising fuel prices, the rising cost of cultivation, and emerging socio-economic changes like urbanisation, labour migration, preferences for non-agricultural work, concerns about farm-relations all pose threats to the productivity and sustainability of rice-based systems (Kumar and Ladha, 2011). It is widely assumed that the paddy-wheat system has depleted the state's natural resources, requiring additional inputs to achieve the same production levels (Lal *et al*, 2004; Kaur *et al*, 2015; Vatta *et al,* 2018). As part of this strategy, resource conserving technologies (RCTs) play an important role in preserving and boosting productivity while lowering production costs (Singh *et al*, 2011; Sidana and Kumar,2011; Sharma *et al*, 2021).

In order to save labour, water, and energy expenses, direct-seeded rice was introduced in Punjab in 2009–2010 as an alternative to traditional manual puddled transplanted rice (Bhardwaj and Sidana, 2013; Sidana *et al*, 2020). Before 2009, drill sown DSR had not been used in Punjab; nevertheless, a few rice farmers there had begun small-scale DSR experiments. The increase in area under this technology from eight thousand acres in 2010 to eighty thousand acres in 2022 signifies the need to analyze cost and profitability under DSR in comparison to conventional tillage. Moreover, the area suddenly jumped to five lakh and six lakh hectares during 2020-22 in covid period due to shortage of labour in the state (Package of practices, 2021). This hasty jump in area under DSR technology in state in COVID period clearly reveals less requirement of labour which led to a sudden jump. The study also focussed on the constraints faced by DSR adopters in Punjab.

Data Sources and Methodology

The study was carried out in Punjab during 2021-22.

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Based on the criteria of the highest proportion of major crops i.e. paddy, wheat and cotton cropped area with respect to net sown area in these crops taken together, two districts namely Mansa and Sri Muktsar Sahib were selected from Punjab. Simple random sampling was used for the selection of the sample size. The primary data were collected from 60 farmers comprising of 30 farmers from paddy sown by puddled transplanted method following wheat sown by conventional method (P_{PTR}+W_{CT})and 30 farmers paddy sown by DSR (Direct seeded rice) technology followed by wheat sown by conventional tillage (P_{DSR}+W_{CT}). Personal interviews were used to collect primary data on a well-structured and pre-tested schedule. Simple statistical methods like percentages, averages, weighted mean, averages, and frequency were used to assess the data obtained in this study. Garrett ranking was used to evaluate the problems faced by farmers for adoption of DSR technology. The farmers were asked to rank the given problem according to the magnitude of the problem. The orders of merit given by the respondents were converted into ranks by using the following formula:

$$\text{Percent position} = \frac{100(R_{ij}-0.5)}{N_j}$$

Where,

R_{ij} = Rank given for the ith item by the jth individual

N_j= Number of items ranked by the jth individual

The percentage position of each rank thus obtained was converted into scores by referring to the table provided by Henry Garrett. Then for each factor the scores of individual sample farmers were added together and divided by the total respondents for whom scores were added. Thus, mean score for each problem was ranked by arranging them in the descending order.

The data was collected from DSR adopters and non-adopters following paddy-wheat crop sequence and then two scenarios were built for analysing the results of the study, which were

1. Adopters : P_{DSR}+W_{CT}

   P_{DSR} = Paddy sown by direct seeding technology

   W_{CT} = Wheat sown by conventional method

2. Non-Adopters : P_{PTR}+W_{CT}

   P_{PTR} = Paddy sown by conventional transplanting method

   W_{CT} = Wheat sown by conventional method

Results and Discussion

The results and discussions have been discussed through socio-economic characteristics,labour-use pattern, machine use pattern,variable cost and returns over variable cost of adopters and non-adopters. The study also highlights the important constraints in adoption of this technology and suggests measures to enhance its adoption.

Socio-economic characteristics

It was observed that young and more educated farmers had taken more interest in adoption of DSR as compared to non-adopters (Table 1). The non-adopters were more aged whereas adopters were more educated. There was no significant difference in farming experience of both adopters and non-adopters. It was interesting to note that DSR adopters, farmers had slightly more operational holding (7.44 hectares) as compared to non-adopters (6.63 hectares).

Labour use pattern

Human labour is a vital input to perform various on-farm and off-farm activities. An attempt has been made to examine the average human labour employment pattern in the cultivation of paddy-wheat and crop rotations for DSR adopters vs non-adopters used through tabular analysts. The total human labour hours used for performing different operations like preparatory tillage, sowing, manuring, weeding, spraying insecticides, harvesting etc. has been presented in table 2.The adoption of DSR provided 36 per cent labour saving compared to non-adopters. Such a saving in labour use is quite significant under the present scenario of agricultural labour scarcity. The major proportion of labour saving in P_{DSR}+W_{CT} accounts for land preparation and sowing operations consists of around 30 and 93 per cent respectively. Seeds are sown directly in the fields by using special seed drill in paddy sown by DSR technology involving

Table 1: Socio-economic profile of sample farmers, Punjab, 2021-22

Particulars	Adopters			Non-Adopters		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Age (years)	44	17	64	47	17	75
Qualification level (years)	10	0	16	8	0	16
Farming experience (years)	23	2	55	24	3	56
Family size (no.)	6	2	13	5	3	10
Operational land (ha)	7.44	1.5	122	6.63	2	25

the use of about five hrs/ha whereas in transplanted method 153 hrs/ha of human labour was used. The findings given by Kaur *et al*, 2020 for rice crop also establishes similar results. Saving of labour in land preparation mainly due to absence of puddling in case of DSR farms as compared to PTR farms. On PTR farms paddy is grown by transplanting the seedlings in puddled field, which is very labour intensive and water exhaustive practice (Bhardwaj and Kaur, 2017). This technique requires more tillage and continuous ponding of water during the initial 15 days of seedling establishment, thus causing more labour-use in tillage as well as during irrigation.

Plant protection and weeding labour use was higher in DSR adopters over non-adopters because of more weed attack in DSR practice. In case of PTR farms, due to puddling there is formation of hard pan and water is allowed to stand for most part of the season which restricts the growth of weeds (unwanted plants) and thus less labour is used for weeding and spraying chemicals than DSR practice of cultivation (Kaur *et al*, 2020).

Machine use pattern

The non-adopters used 282.79 hrs/ha of mechanical labour which was 19 per cent higher than adopters in paddy-wheat crop sequence Table 3. The considerable saving in machine use, was seen for paddy sown by DSR followed by wheat conventional tillage (P_{DSR}+W_{CT}) mainly in operations like preparatory tillage and irrigation ranging from 22 to 26 per cent, respectively. This was due to the fact that on direct seeded rice farms after preparing the field the sowing is done directly whereas in conventional method of paddy cultivation, firstly the field is prepared and puddling is performed with standing water in the field to transplant the seedlings in the field. In this way, tillage is done twice on conventional farms which involve more ploughing and machine use as compared to DSR farms.

Variable Cost

Variable cost for the paddy-wheat crop rotation was worked out through the cost of seed, fertilizer, agrochemical, human labour, machine labour and cost for machinery and

Table 2. Labour use pattern of DSR adopters vs non-adopters following paddy-wheat crop rotation, Punjab, 2021-22

(Hrs per ha)

Particulars	Adopters					Non- Adopters					Change in total labour use
	P_{DSR}+W_{CT}					P_{PTR}+W_{CT}					
	Paddy		Wheat		Total	Paddy		Wheat		Total	
	F+S	Hired	F+S	Hired		F+S	Hired	F+S	Hired		
Preparatory tillage	7.45	2.23	4.85	1.20	15.73	13.13	3.13	4.48	1.50	22.24	-6.51 (-29.27)
Sowing/Transplanting	1.88	2.88	5.13	1.28	11.17	5.15	147.83	4.03	2.28	159.29	-148.12 (-92.99)
Irrigation	60.88	0.00	50.38	0.00	111.26	80.63	0.00	52.00	0.00	132.63	-21.37 (-16.11)
Manures & Fertilizers	10.03	0.80	6.35	0.60	17.78	9.98	1.00	5.78	0.75	17.51	0.27 (1.54)
Weeding/ Hoeing	5.53	22.63	0.00	0.00	28.16	10.15	5.63	0.00	0.00	15.78	12.38 (78.45)
Plant Protection	16.95	5.35	7.73	4.18	34.21	12.28	1.30	7.63	3.28	24.49	9.72 (39.69)
Harvesting	4.95	2.78	7.35	6.13	21.21	5.13	3.13	5.43	6.88	20.57	0.64 (3.11)
Transportation & Marketing	3.20	1.20	5.63	1.23	11.26	3.25	1.23	5.13	1.40	11.01	0.25 (2.27)
Straw reaper	3.20	2.35	3.13	2.75	11.43	3.00	2.25	3.50	3.00	11.75	-0.32 (-2.72)
Residue management	4.40	0.00	0.00	0.00	4.40	4.18	0.00	0.00	0.00	4.18	0.22 (5.26)
Total	118.47	40.22	90.55	17.37	266.61	146.88	165.50	87.98	19.09	419.45	-152.84 (-36.44)

Note: Figures in parentheses indicate percentage difference for adopters over non-adopters. A positive change in total labour use represents increase for adopters over non-adopters and vice-versa.

transplantation (Table 4). The variable cost for DSR came out to be about Rs. 40 thousand/ha whereas it was Rs. 46 thousand/ha for PTR adopters. Such large differences between the two systems directly related to labour savings in DSR at the time of planting, which has been a major driver in the adoption of this new technology in the state (Bhullar *et al*, 2018). The adopter category $P_{DSR}+W_{CT}$ incurred as much as 23 per cent lower costs on irrigation, besides considerable saving in costs on inputs like seed (8.22%), human labour (37%) and machine labour (5.6%). Overall, there was a saving of eight per cent in cost by adopters over non-adopters.

Returns over Variable Cost

The net returns came out to be higher for adopters with Rs.1.53lakh/ha and reduced by 2.32 per cent for the non-adopters (Table 5). It was mainly due to less variable cost incurred in case of adopters than non-adopters. The gross returns were higher for non-adopters by one per cent than adopters. Earlier the studies have also shown higher economic returns and labour savings in DSR as compared to PTR (Gill *et al,* 2013).

Researchers' and farmers' experience shows that the productivity of wheat grown after DSR is greater than wheat grown after PTR. This beneficial impact of DSR on wheat was also reflected in this survey results (Table 5). The surveyed farmers reported 3.58 per cent higher wheat productivity in sequence with DSR as compared to PTR. Greater root development of wheat plants, owing to less water stagnation and yellowing in wheat after first irrigation, following DSR has been cited as one possible factor for higher wheat productivity compared to wheat sown after PTR (Aggarwal *et al*, 1995; Kumar and Ladha, 2011).

Problems Faced in Adoption of DSR By Farmers

Among various problems in adoption of DSR faced by sample farmers, yield penalty was observed to be top ranked with 68.83 Garrett's average score (Table 6). The second and third rank was given to increased cost of production due to more requirements of herbicides and low seed germination. More pesticide requirement was another problem in adoption of direct seeded rice.

Conclusions and Policy Implications

The study showed that the adoption of DSR resulted into labour and water saving to the extent of 36 per cent and 23 per cent respectively as compared to PTR. A significant saving of machine labour to the extent of 27 per cent for preparatory tillage was observed on DSR farms as compared to PTR farms because in PTR tillage was done twice, firstly for field preparation and secondly for puddling. The variable cost reduced by eight per cent in DSR fields as compared to non-adopters. The major problem faced by farmers in adoption of direct seeded rice technology came out be less

Table 3. Machine use pattern of DSR adopters vs non-adopters following paddy-wheat crop rotation, Punjab, 2021-22 (Hrs per ha)

Particulars	Adopters					Non-Adopters					Change in total machine use
	$P_{DSR}+W_{CT}$					$P_{PTR}+W_{CT}$					
	Paddy		Wheat		Total	Paddy		Wheat		Total	
	Owned	hired	Owned	hired		Owned	hired	Owned	hired		
Preparatory tillage	4.33	1.05	3.45	0.63	9.46	7.53	1.83	3.20	0.35	12.91	-3.45 (-26.72)
Sowing/ Transplanting	0.35	0.90	2.40	0.73	4.38	0.00	0.00	1.60	1.23	2.83	1.55 (54.77)
Irrigation	145.18	0.00	45.00	0.00	190.18	201.88	0.00	44.38	0.00	246.26	-56.08 (-22.77)
Plant Protection	4.38	1.68	1.13	0.63	7.82	2.88	0.80	1.03	0.75	5.46	2.36 (43.22)
Harvesting	1.18	2.00	1.25	1.13	5.56	1.13	1.95	1.30	1.25	5.63	-0.07 (-1.24)
Transportation& Marketing	1.35	0.80	3.88	0.75	6.78	1.30	0.85	3.61	0.30	6.06	0.72 (11.8)
Straw reaper	0.00	1.55	0.00	2.08	3.63	0.00	1.50	0.00	2.13	3.63	0.00 (0.00)
Total	156.77	7.98	57.11	5.95	227.81	214.72	6.93	55.13	6.01	282.79	-54.98 (-19.44)

Note: Figures in parentheses indicate percentage difference for adopters over non-adopters

Table 4. Variable cost of DSR adopters vs non-adopters following paddy-wheat crop rotation, Punjab, 2021-22

(Rs per ha)

Particulars	Adopters			Non-Adopters			Change in variable cost
	$P_{DSR}+W_{CT}$			$P_{PTR}+W_{CT}$			
	Paddy	Wheat	Total	Paddy	Wheat	Total	
Seed	1585.00	3219.75	4804.75	2012.50	3222.75	5235.25	-430.50 (-8.22)
Fertilizers							
Urea	2462.15	1923.23	4385.38	1926.58	1921.88	3848.46	536.92 (13.95)
DAP	1328.58	3385.83	4714.41	1331.40	3407.00	4738.40	-23.99 (-0.51)
Other fertilizers	2180.35	33.63	2213.98	2136.30	69.75	2206.05	7.93 (0.36)
Sub-total	5971.08	5342.69	11313.77	5394.28	5398.63	10792.91	520.86 (4.83)
Agrochemicals	10771.50	2258.03	13029.53	7542.25	2237.50	9779.75	3249.78 (33.23)
Irrigation	962.40	294.68	1257.08	1342.50	294.18	1636.68	-379.60 (-23.19)
Human labour							
Family+Attached	5711.25	4526.25	10237.50	7180.00	4141.25	11321.25	-1083.75 (-9.57)
Hired	2028.00	838.50	2866.50	8541.00	919.10	9460.10	-6593.60 (-69.70)
Sub-total	7739.25	5364.75	13104.00	15721.00	5060.35	20781.35	-7677.35 (-36.94)
Machine labour							
Owned	4141.13	3331.13	7472.26	4512.04	2885.63	7397.67	74.59 (1.01)
Hired	5720.18	8481.40	14201.58	6692.75	8879.08	15571.83	-1370.25 (-8.80)
Sub-total	9861.31	11812.53	21673.84	11204.79	11764.71	22969.50	-1295.66 (-5.64)
Marketing & Transportation	2167.50	1674.00	3841.50	2031.25	1593.13	3624.38	217.12 (5.99)
Grand Total	39058.04	29966.43	69024.47	45248.57	29571.25	74819.82	-5795.35 (-7.75)
Interest @9% per half of the period of crop on operational cost	878.81	674.24	1553.05	1018.09	665.35	1683.44	-130.39 (-7.75)
Variable cost	39936.85	30640.67	70577.52	46266.66	30236.60	76503.26	-5925.74 (-7.75)

Note: Figures in parentheses indicate percentage difference for adopters over non-adopters

Table 5. Returns over variable cost of DSR adopters vs non-adopters following paddy-wheat crop rotation, Punjab, 2021-22

(Rs per ha)

Particulars	Adopters $P_{DSR}+W_{CT}$			Non-Adopters $P_{PTR}+W_{CT}$			Change in returns over variable cost
	Paddy	Wheat	Total	Paddy	Wheat	Total	
Variable cost	39936.85	30640.67	70577.52	46266.66	30236.60	76503.26	-5925.75 (-7.75)
Main product (qtl)	69.08	39.00	108.08	72.05	37.60	109.65	-1.57 (-1.43)
Value of main product	135387.50	78585.00	213972.50	141218.00	75764.00	216982.00	-3009.50 (-1.39)
By product (qtl)	-	30.15	30.15	-	28.50	28.50	1.65 (5.79)
Value of by product	-	10552.50	10552.50	-	9975.00	9975.00	577.50 (5.79)
Gross returns	135387.00	89137.50	224525.00	141218.00	85739.00	226957.00	-2432.00 (-1.07)
Returns over variable cost	95450.15	58496.83	153947.48	94951.34	55502.40	150453.73	3493.75 (2.32)

Note: Figures in parentheses indicate percentage difference for adopters over non-adopters

Table 6. Problems faced in adoption of DSR by farmers

Problems	Garrett's Average Score	Rank
Yield penalty	60.83	I
Increased cost of production due to more requirement of herbicides	51.92	II
Low seed germination	51.00	III
Requirement of specific machinery	44.25	IV
DSR requires more pesticides	43.08	V

yield of crop. There is a need for capacity building of farmers for effective management of weed and pest in DSR. The state government provided financial assistance to the farmers opting for DSR at Rs. 1500 per acre during *kharif* 2022-23. This has boosted technology adoption. The development of shorter duration-high yielding varieties with greater adaptation for dry-seeding, further improvements in planting machinery, weed management practices and enhancement of grower skills through trainings were identified as the key areas for achieving even faster adoption and spread of this technology.

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