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# Comparative economics of direct seeded rice technology and transplanted rice in Punjab

**Baljinder Kaur Sidana, JM Singh, Hardeep Kumar, Jasdev Singh and Jatinder Sachdeva**

## Abstract
Direct Seeded Rice is a feasible alternative to conventional puddled transplanted rice with good potential to save water, reduce labour requirement and mitigate green house gas emissions. Though puddled transplanted rice is the most popular system but whether under the emerging scenario of acute shortages of water and labor, it would maintain sustainability in future is highly uncertain in Punjab state. The study aimed to highlight the changing pattern of labour use in resource conservation technologies in Punjab agriculture. The sample of 84 farmers (30 adopters and 54 non-adopters) from two districts of Punjab was selected through multi-stage random sampling technique. Data were collected by directly interviewing the farmers through well-structured schedule. The variable cost per hectare for paddy cultivation was less on adopter farms as compared to non-adopter farms. A significant saving in hours of irrigation i.e. 45 per cent was achieved for irrigating one hectare of the DSR farm as compared to non-DSR farm. A significant saving of machine labour to the extent of 44 per cent for preparatory tillage was observed on DSR farms as compared to non-DSR farms. Direct seeded rice was effective in saving of irrigation water to the tune of almost half of the PTR farms. The per hectare water productivity on direct seeded rice fields was 1.27 kg per $m^3$ whereas on puddled fields it was 0.61 kg per $m^3$ which means that DSR technology resulted in the enhancement of water productivity of paddy crop. Binary Logistic Regression was used in which direct seeding of technology adoption was regressed with no. of independent variables such as years of schooling, member of kisan club, training attended of DSR technology, Source of information, operational size of holdings per horse power of electric motor used, age of respondents, ratio of members engaged in agriculture to total members in family and age. The adoption of direct seeding of rice technology decisions were mainly influenced if the adopter was a member of kisan club and training attended of DSR technology which came out to be highly significant and positive. The estimated odds ratio for member of Kisan club and training attended of DSR technology was 11.76 and 6.3 respectively which suggested that one per cent increase in these variables will lead to increase in adoption by 11 times and 6 times. The important constraint in the adoption of this technology was non-availability of seed drill, high amount of weeds and lack of awareness. Subsidizing cost of direct seeding of rice per acre will increase the area under this technology as more farmers will go for its adoption. There is a dire need for capacity building of farmers for effective management of weed and pest in DSR.

**Keywords:** Direct seeded rice, puddled transplanted rice, labour use, resource conservation technologies

## Introduction
Labourers constitute a vital input in agricultural production, but they are migrating to different parts of the country for earning a better livelihood, adding to the existing imbalance between labour demand and supply of labourers (Deshingkar, 2003) [7]. The portion of agricultural worker to the total workers has been declining over the years while the corresponding ratio in the secondary and tertiary sector is on the rise. Pursuant to this, following impact have been predominantly noticed in agriculture in recent years i.e. delay in crop establishment, no or untimely weeding, irrational use of fertilizers, insufficient irrigation to crops, poor crop growth, reduction in cropping intensity, reduction in crop yield and changes in traditional cropping pattern (Kumar and Umesh, 2018) [15]. There are various mechanisms by which farmers try to cope with supply-demand gap of agricultural labour during busy agricultural

seasons, the most common among them are adopting alternative technologies and increased use of machinery (Singh *et al*. 2017a; Singh *et al*. 2017b; Singh *et al*. 2017c; Singh *et al*. 2018; Tiwari *et al*. 2018; Tiwari *et al*. 2019a; Tiwari *et al*. 2019b; Kour *et al*. 2019; Singh *et al*. 2019) [24, 25, 26, 27, 28, 29, 30, 31, 32].

The labour shortage had created a potentially vast opportunity for farm equipment makers through the adoption of alternative technologies. Population dynamics and labour shifts had led to changing farm landscape. Direct Seeding of rice is also one of such alternatives which not only overcomes labour shortage but also helps in conserving soil and water. Direct seeded rice refers to the process of growing rice crop by directly sowing seeds in the field rather than by transplanting rice seedlings from nursery. Direct seeded rice is a feasible alternative to conventional puddled transplanted rice (puddled transplanted rice) as in the conventional system of transplanting of rice, puddling of the soil disturbs the soil aggregates, reduces the soil permeability and creates hardpans at shallow depths which adversely affects the soil structure (Sharma *et al*., 2003; Bhardwaj and Sidana, 2014, 2019) [34, 4, 5], all of which have adverse affect on the following crop (Tripathi *et al*., 2005). The water and labour scarcity are driving forces to the farmers to shift from traditional transplanting method to direct seeded rice (Din *et al*., 2012; Rakesh *et al*., 2017).

The direct-seeded area in Asia is about 29 million ha, which is approximately 21% of the total rice area in the region (Pandey and Velasco, 1999). Dry seeding saves labor at transplanting, provide faster and easier crop establishment. It involves less drudgery, provides additional benefit in raising the crop through saving 29 per cent of total cost of production of the transplanted rice (Dhakal *et al.,* 2015). DSR reduces the irrigation requirement by 30 per cent of the total water required for rice culture (Gopal *et al*., 2010; Bandumul *et al*. 2018; Bhardwaj S, 2013) [10, 2, 19, 3].

It is therefore, imperative to promote alternative technologies that would help conserve the much needed but gradually depleting natural resources while boosting productivity growth in the long-run by maintaining soil health and production environment. Resource conservation technologies (RCTs) play a major role in sustaining and enhancing the productivity of the rice-wheat system at a lower cost of production (Singh *et al*., 2011) [33]. Intensive cultivation has increased farmer's dependence on groundwater for irrigation in Punjab state (Kaur *et al*., 2009, 2015) [13, 11, 12]. The excessive dependence on groundwater has led to its over-extraction, thereby threatening the sustainable development of agriculture (Kaur *et al.,* 2010; Sidhu and Vatta 2006; Sidhu *et al*., 2010) [14, 23, 35]. Increased availability of electric power, coupled with the policy of its subsidized or tariff-free provision for agriculture, has resulted in a considerable increase in the number of power operated tube wells in the state, leading to over exploitation of groundwater resources (Vatta *et al* 2018) [39]. In the scenario of fast paced depletion of ground water in Punjab and intensive cultivation of rice involving high amount of water and labour use, there is an urgent need to shift from traditional transplanting method of rice cultivation to DSR, as DSR tends to reduce water consumption, labour requirement and helps to maintain the soil structure. In this backdrop, the present paper, therefore, attempts to examine the labour as well as water saving due to the adoption of DSR vis-à-vis PTR and other determinants affecting its adoption in Punjab.

## Methodology

### Selection of Sample

Multi stage sampling technique was chosen for the study. At the first stage, two districts namely Ludhiana and Barnala from Punjab state were chosen and at the second stage two blocks were chosen from respective districts. Twenty villages were selected and then list of farmers who had adopted this technology was prepared for each of the selected villages. From these lists, using simple random technique, 30 adopters were taken for the study. In order to undertake impact assessment task of this technology, 54 non-adopters from the same vicinity were also taken as a control group in the analysis. Therefore, a total sample of 84 farmers (30 adopters and 54 non-adopters) covering twenty villages, two blocks and two districts were finally chosen for the ultimate analysis.

### Collection of primary data

The required information pertaining to the size of operational holding, human labour, seed, fertilizers and farm yard manure, pesticides, insecticides, machinery, area, production, productivity of paddy was collected from the selected adopters and non-adopters and also the data related to the age, education and family size were taken to account for the socio-economic characteristics. The data pertaining to the year 2018-19 was taken for the present study.

### Analysis of data

### Tabular analysis

The data was analyzed by using tabular method to show the extent of inputs used in crop production. Simple statistical technique such as averages, percentage was applied in the analysis.

### Factor affecting adoption of Direct Seeding Rice technology

Direct seeding of rice technology is new in the Indian context, and there is hardly any study discussing the factors influencing the adoption of this technology. To identify the factors influencing technology adoption, we have used the characteristics of DSR and non-DSR farmers in our study sample, i.e. we have focused on the static nature of adoption.

The dependent variable was taken as discrete variable, indicating whether or not the direct seeding of rice technology was adopted. The dataset can be analyzed by using binary choice models, which are appropriate when the choice between the two alternatives depends on the characteristics of the problem. Odds are just a ratio of the probability that an event will occur versus the probability that the event will not occur, or probability / (1-probability).

Hence, odds ratio can be used to give an idea of how strongly a given variable may be associated with the outcome of interest compared to other variables. The logit model was selected for the study and maximum likelihood technique was used for estimation. The dependent binary variable for the logit model was $Y_i = 1$, if farmer $i$ has adopted direct seeding rice technology 0, otherwise

The probability of adoption, $P$, for a given set of values of variables is given by the logit model

Where $\beta_i$'s are logit coefficients for the $n$ variables $X_i$'s, and $\varepsilon$ is the error term. In case of binary independent variables, exponential of the respective coefficient gives the proportion of change in odds for shift in the given independent variable. However, if the independent variable is continuous, exponential of coefficients is associated with the effect of per unit change in the given independent variable to odds ratio. In

both types of variables sign of coefficient reveals the direction of change.
The set of regressors, comprising personal and socio-economic variables influencing technology adoption, used in the model are listed in table below.

**Description of the variables used in logistic model**

| Dependent Variable | Description |
|---|---|
| Adoption status (Y) | 1 if the farmer adopts Direct Seeding Rice Technology; 0 otherwise |
| **Explanatory Variables** | |
| $A_g$ | Age |
| $Y_s$ | Years of schooling |
| $M_k$ | Member of kisan club |
| $T_r$ | Training attended of DSR technology |
| $S_o$ | Source of information govt./non-govt./others |
| $O_{hp}$ | Operational area per horse power of electric motor used |
| $R_a$ | Ratio of members engaged in agriculture to total members in family |

The characteristics and related variables assumed to be affecting the adoption of direct seeding of rice technology are given here:
1. Years of schooling of the respondent is expected to be positively related to the adoption.
2. Member of kisan club is expected to be positively related to the adoption
3. Training attended of DSR technology is expected to be positively related to the adoption.
4. Source of information govt./non-govt./others is expected to be positively related to the adoption.
5. Operational area per unit of the horse power of electric motor represents the intensity of electric motor in the study area. It is expected to be negatively related to the adoption of direct seeding of rice technologies.
6. Ratio of members engaged in agriculture to total members in family expected to be negatively related to the adoption.
7. Age of respondent is expected to be negatively related to the adoption.

The model used to analyze the factors affecting the adoption of direct seeding of rice technology thus becomes:

$$Y_i = \beta_0 + \beta_1 (Y_s) + \beta_2 (M_k) + \beta_3 (T_r) + \beta_4 (S_o) + \beta_5 (O_{hp}) + \beta_6 (R_a) + \beta_7 (A_g) + \varepsilon_i.$$

The data were analyzed by using simple tools such as averages, percentages etc.
In order to evaluate the farmer's perception with respect to constraints and advantages of different varieties, Garrett Ranking technique was used.
The farmers were asked to rank the given problem according to the magnitude of the problem faced. The orders of merit given by the respondents were converted into ranks by using the following formula:

$$\text{Percentage Position} = \frac{100\ (R_{ij} - 0.5)}{N}$$

Where,
$R_{ij}$= Rank given for the $i^{th}$ item by the $j^{th}$ individual
$N_j$ = Number of items ranked by the $j^{th}$ individual

The percentage position of each rank thus obtained was converted into scores by referring to the table given by Garrett and Woodworth (1971). 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.

## Results and Discussion
The results have been divided into four sections. The first section describes the socio-economic characteristics of adopters of direct seeding of rice technology in Punjab vis-a-vis PTR farms, the second section deals with the labour- use pattern of DSR and PTR farms and the third section describes the determinants affecting its adoption.
The last section highlights the important constraints in adoption of this technology and suggests measures to enhance its adoption.

### Socio-economic profile
It was observed that young farmers had taken more interest in adoption of DSR as compared to non-adopters. There was no significant difference in average educational level of farmers in case of both adopters and non-adopters. In case of DSR adopters, farmers had less agricultural experience (16 years) as compared to non-adopters (20 years).

**Table 1:** Socio-economic profile of sample farmers, Punjab, 2018-19

| Particulars | DSR farms | PTR farms |
|---|---|---|
| Average age (years) | 39 | 44 |
| Average education level | 11 | 10 |
| Agricultural experience (years) | 16 | 20 |
| Family size (No.) | 6 | 5 |

### Land Holding Pattern
Operational area among sample farmers is shown in table 2. The total operational area of DSR adopters was 6.47 ha whereas it was 10.52 ha in case of non-adopters which showed farmers adopting PTR technology had more operational area.
The average size of owned land was less in case of DSR adopters by 2.36 ha in comparison to PTR farms. Non-adopters of DSR leased in 4.90 ha of land whereas DSR adopters leased in 2.90 ha of land which was less than non adopters.
The lower holding size of technology adopters clearly revealed DSR farmers are mainly small and medium category farmers vis-a-vis large category farmers in case of PTR farms.

**Table 2:** Operational area among sample farmers, Punjab, 2018-19 (hectares)

| Area | DSR farms | PTR farms |
|---|---|---|
| Owned | 3.57 | 5.93 |
| Leased In | 2.90 | 4.90 |
| Leased Out | 0.00 | 0.31 |
| Total Operational Area | 6.47 | 10.52 |

**Labour-use pattern: Direct seeded rice v/s puddled transplanted rice**

Human labour, a vital input to conduct various on-farm and off-farm activities is generally provided by family members, permanent labour and casual labour. An attempt has been made to examine the human labour employment pattern in the cultivation of direct seeded rice and puddled transplanted rice through tabular analysis. For this, the human labour-use pattern studied for the year 2018-19 is presented in Table 3. It was observed that the total family and casual human labour-used was 91.01 hours and 42.11 hours per hectare respectively which was less as compared to non-DSR farms i.e. 120.43 and 182.62 hours per hectare. The casual labour-use accounted for the major use in the human labour employment pattern in the cultivation of paddy as most of the operations especially transplanting of paddy involves a lot of casual labour-use. The per hectare labour-use on transplanting of paddy was 171.70 hours but in case of DSR farms it was 5.07 hours, indicating a labour saving of 97 per cent, as the seeds are sown directly in the field by the seed drill.

**Table 3:** Labour- use pattern of paddy crop on DSR vs. PTR sample farms, Punjab, 2018-19 (Hours per Hectare)

| Particulars | Family Labour | | Casual Labour | | Total | |
|---|---|---|---|---|---|---|
| | DSR | PTR | DSR | PTR | DSR | PTR |
| Preparatory | 5.37 | 8.15 (34.11) | 4.15 | 3.42 (21.34) | 9.52 | 11.57 (17.72) |
| Sowing/ Transplanting | 1.62 | 15.5 (89.54) | 3.45 | 156.20 (97.79) | 5.07 | 171.70 (97.05) |
| Irrigation | 60.06 | 73.33 (18.09) | 0 | 0 | 60.06 | 73.33 (18.09) |
| Manures & Fertilizers | 5.25 | 5.63 (6.75) | 2.37 | 3.20 (25.93) | 7.62 | 8.83 (13.70) |
| Weeding/ Hoeing | 6.00 | 6.67 (10.04) | 22.50 | 10.65 (-111.26) | 28.50 | 17.32 (-64.54) |
| Plant Protection | 7.72 | 5.2 (-48.46) | 4.77 | 4.60 (-3.69) | 12.49 | 9.80 (-27.45) |
| Harvesting | 2.03 | 2.65 (23.96) | 3.90 | 3.85 (-1.29) | 5.93 | 6.5 (8.77) |
| Transportation & Marketing | 3.00 | 3.30 (9.09) | 0.97 | 0.70 (-38.57) | 3.97 | 4.00 (0.75) |
| Total | 91.05 | 120.43 | 42.11 | 182.62 | 133.16 | 303.05 |

* Figures in parentheses are per cent change in labour use of DSR over PTR farms

The labour use for preparatory tillage accounted for 9.52 hours per hectare in case of DSR farms in comparison to 11.57 hours per hectare in case of PTR farms. This saving of labour was 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 comprehensive, labour intensive and water exhaustive practice. 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.

Labour use for plant protection and weeding was 27 per cent and 64 per cent higher on DSR farms 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.

**Machine-use pattern**

It was observed that the per hectare owned and hired machine-use in paddy cultivation on DSR farms was 159.58 hours and 7.46 hours respectively which were less as compared to 231.08 hours and 7.9 hours on non-DSR farms, which resulted into a total saving of 30 per cent.

**Table 4:** Machine-use pattern of paddy crop on DSR vs. PTR sample farms, Punjab 2018-19. (Hours per hectare)

| Particulars | Owned labour | | Hired labour | | Total | |
|---|---|---|---|---|---|---|
| | DSR Farms | PTR Farms | DSR Farms | PTR Farms | DSR Farms | PTR Farms |
| Preparatory Tillage + sowing | 4.90 | 6.13 (20.06) | 1.70 | 5.65 (69.91) | 6.60 | 11.78 (43.97) |
| Sowing | _ | _ | 3.75 | _ | 3.75 | _ |
| Irrigation | 150 | 220 (31.81) | _ | _ | 150 | 220 (31.89) |
| Harvesting | 1.23 | 1.25 (1.6) | 1.43 | 1.55 (7.74) | 2.66 | 2.80 (5.00) |
| Transportation | 3.45 | 3.70 (6.75) | 0.58 | 0.70 (17.41) | 4.03 | 4.40 (8.40) |
| Total | 159.58 | 231.08 | 7.46 | 7.90 | 167.04 | 238.98 |

* Figures in parentheses are per cent change in machine use of DSR over PTR farms

Most of the sample farmers had their own tractor and other major tractor driven tools and implements. Thus, the owned machine-use was more than hired one for all the sample farmers. A significant saving of machine labour to the extent of 44 per cent for preparatory tillage was observed on DSR farms as compared to PTR farms. 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 the 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 involves more ploughing and more machine-use as compared to DSR farms. Irrigation is the most critical input for paddy cultivation. Farmers use electric motor, diesel engine or generator as a power source for irrigating the paddy crop. The average number of motor hours per hectare for paddy crop came out to be 150 on DSR farms as compared to 220 hours on PTR farms; accounting for water saving of 32 per cent. The harvesting of paddy is done by hiring combine harvesters on per hectare basis which accounted for the major share of hired machine-use.

**Binary Logistic Regression**

To identify the factor effecting adoption of direct seeding rice technology, binary logistic model was used in which adoption of direct seeding rice technology was regressed with independent variable listed in Table 5.

**Table 5:** Estimated results for Logistic Regression Model, DSR v/s PTR farms, 2018-19

| Variables | Estimated Coefficients | Standard Error | P-value | Odds Ratio |
|---|---|---|---|---|
| Constant | 0.735 | 2.385 | 0.758 | 2.085 |
| Age | -0.090** | 0.041 | 0.027 | 0.914 |
| Years of schooling | 0.177*** | 0.097 | 0.067 | 1.194 |
| Member of kisan club (0;1) | 2.465* | 0.756 | 0.001 | 11.761 |
| Training attended of DSR technology (0;1) | 1.845* | 0.750 | 0.014 | 6.329 |
| Source of information (govt./non-govt./others) (0;1) | 1.481** | 0.706 | 0.036 | 4.397 |
| Operational area per horse power of electric motor used | -0.654** | 0.292 | 0.025 | 0.520 |
| Ratio of members engaged in agriculture to total members in family | -1.482 | 3.357 | 0.659 | 0.227 |
| Log likelihood Ratio | 60.02 | | | |
| Nagelkerke $R^2$ | 0.61 | | | |
| Cox & Snell $R^2$ | 0.44 | | | |

*Significant at 1 per cent level; **Significant at 5 per cent level; *** Significant at 10 per cent level

The dependent variables in logistic regression is usually binomial, that is, the dependent variable can take the value 1 with a probability of success q, or the value 0 with the probability of failure 1-q. In the model, the dependent variable was “1” for adopter of technology and “0” for non-adopter of the technology. The explanatory variables were years of schooling, member of kisan club, training attended of DSR technology, Source of information (govt./non-govt./others), operational size of holdings per horse power of electric motor used, age of respondents, ratio of members engaged in agriculture to total members in family and age. The log likelihood ratio test is significant at one percent level indicating that the model has good explanatory power.

The co-efficient of multiple determination (Nagelkerke $R^2$) of the fitted model was 0.61 implying that 61 per cent of the variation in adoption of DSR technology could be explained by the variables included in the model. In this model the seven most relevant explanatory variables were included. Among these seven variables, member of kisan club and training attended of DSR technology was positively significant at one per cent level whereas operational size of holdings per horse power of electric motor used and age was negatively significant. While source of information and years of schooling were positively significant but ratio of members engaged in agriculture to total members in family came out to be non-significant. Odds ratio were also presented which shows the effects of individual independent variables of the possibility or chance of adoption of direct seeding of rice technology, others things being equal.

The odds ratio is computed by exponentiating the parameter estimates for each explanatory variable. The estimated odds ratio for years of schooling was 1.19 which means if the years of schooling increase by one year, the adoption of DSR technology will increase by 1.19 times. Similarly, the estimated odds ratios for members of kisan club and training attended of DSR technology were 11.761 and 6.329 respectively; meaning thereby that one per cent increase in these variables will increase adoption by 11.76 and 6.33 times respectively.

## Water and labour productivity of paddy crop

Ground water is the highly over-exploited and inefficient used resource in the Punjab state primarily due to cultivation of rice crop on large area. The water table has gone down drastically in Central Punjab and most of the development blocks have been categorized as ‘dark’. Direct seeding of rice reduces the use of water in rice crop without any adverse impact on productivity.

**Table 6:** Water and labour productivity of paddy crop of sample farmers, Punjab, 2018-19

| Particular | DSR farms | PTR farms | Savings (DSR farms over PTR farms) |
|---|---|---|---|
| Water-use (cu.m/ha) | 6480 | 9504 | -3024 (31.81) |
| Yield (kg/ha) | 6630 | 6780 | -150 (2.21) |
| Water productivity (kg/$m^3$) | 1.02 | 0.71 | 0.31 (43.66) |
| Labour-use( hrs/ha) | 133.16 | 303.05 | -169.89 (56.06) |
| Labour productivity (kg/hour) | 49.78 | 22.37 | 27.41 (122.53) |

Figures in parentheses indicate the per cent change of DSR farm over PTR farms

The table clearly revealed that direct seeded rice was effective in saving of irrigation water to the tune of 31.81 per cent on DSR farms. It is due to the fact that in direct seeding rice, the irrigation is applied at 3 and 4 days interval instead of continuous ponding during early establishment.

Further, as reported by the sample farmers, when the crop becomes one month old, the irrigation is applied at 7 to 9 days interval, thereby increasing the irrigation efficiency of crop. The mean paddy yield in direct seeded rice was 6630 kg as compared to 6780 kg per hectare on PTR farms.

The per hectare water productivity on direct seeded rice was 1.02 kg per $m^3$ and on non-DSR farms it was 0.71 kg per $m^3$ which means that DSR technology resulted in the enhancement of water productivity to the tune of 43.66 per cent. Per hectare labour-use was less on DSR farms as compared to non-DSR sample farms. About 56 per cent labour was saved on DSR farms over PTR farms.

## Constraints in the technology adoption

The analysis revealed that direct seeded rice required only 12-15 irrigations as compared to 22 to 24 irrigations in PTR farms, so reduction in water requirement was the major merit on sample farms (Table 1).

**Table 7:** Garrett’s rank for Merits of DSR farms, Punjab, 2018-19

| Merits | Garrett’s mean score | Rank |
|---|---|---|
| Reduction in water requirement | 6.94 | I |
| Reduction in cost of production | 5.76 | II |
| Reduce irrigation cost | 4.99 | III |
| Labour saving | 3.70 | IV |
| Yield enhancement | 3.58 | V |

The labour use on DSR farms was half on PTR farms, which gathered fourth rank in garrett ranking. Almost same yield was observed from both the sample sub-sets (i.e. adopters as well as non-adopters) so yield enhancement occupied fifth position.

**Table 8:** Garrett's rank for Demerits of DSR farms, Punjab, 2018-19

| Demerits | Garrett's mean score | Rank |
|---|---|---|
| Increased weed infestation | 6.93 | I |
| Non availability of seed drill | 5.52 | II |
| Need of recommended varieties | 5.42 | III |
| Yield loss | 3.56 | IV |
| lack of awareness | 3.61 | V |

The DSR farmers reported that growth of weeds are one of the most serious biological constraints in direct seeding of rice as they emerge simultaneously with rice crop due to absence of puddling. While non-DSR farmers reported that there is lack of awareness of the technology which, resulted into non-adoption. The availability of seed drill was the second major constraint for the adopters of the technology. The farmers who did not adopt the technology reported that they could not bear yield loss if happened so and also lack of capacity building about this technology is a hurdle in its adoption.

**Conclusion and Policy Implications**

The results showed that the adoption of DSR resulted into labour and water saving to the extent of 56.06 per cent and 31.81 per cent respectively as compared to PTR. A significant saving of machine labour to the extent of 44 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 exposure of the farmers as a member of kisan club, years of schooling and training attended of DSR technology helped the farmers in adoption of the technology. At the aggregate level, potential benefits from the adoption of DSR were substantial. The findings confirm the positive impacts of DSR and the results support promoting DSR as a strategy to enhance profitability of farmers and also as a water saving technology in the face of depleting water resources for agriculture in general and rice in particular. In spite of realizing the lower yield in DSR as compared to PTR, adoption of DSR led to the earlier harvest of the crop. There is a need to bring researchers, extension workers and farmers on a common platform to conceive end-to-end strategies to promote DSR.

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