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# A Sustainable Approach to Rice Cultivation in Punjab-Direct Seeding of Rice (DSR)

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## Abstract

Considering sustainable agriculture as the keystone of social and economic prosperity, promotion of Direct Seeded Rice (DSR) has been one of the pioneer steps in the Punjab Government's 2023-24 Budget. In the present study based on field survey of it was found that use of all the inputs was lower on DSR farms as compared to conventional Puddled Transplanted Rice (PTR) farms except seed, plant protection chemicals and some micro-nutrients. Though the yield in DSR (2769 kg per acre) was marginally lower than PTR (2801.3 kg per acre), the net returns over variable cost were higher by about 13 per cent in DSR (Rs 31482.14 per acre) than PTR (Rs 27788.41 per acre) because of lower variable costs involved in DSR. The cost in production of one kg grain using DSR was found to be lower (Rs 8.43 per kg) by about 15 per cent than in PTR (Rs 9.88 per kg) and the input energy involved in the same was Rs 7.84 MJ as compared to 8.86 MJ indicating that DSR has the potential to increase farmer's income and save scarce resources. DSR technology is a viable alternative to overcome the problems of rising cost of cultivation, labour and water shortages for sustainable rice production yet it has not been adopted at a very large scale. There is need for more research in development of high yielding rice cultivars suitable for DSR along with ensured and timely availability of agro-inputs and machinery. Also, there is a need to [3]generate more awareness of recommended DSR production practices among the farmers for its speedy adoption and thus achieving sustainable production.

**Keywords:** DSR, social and economic prosperity, farmers income, high yield rice, sustainable production

## Introduction

Rice is one of the most important food crops of India. About 70 per cent Indians use rice as their primary food source and it occupies 40-45 per cent of all the land under cereal crops in India. The growing demand of rice has to be met by producing more rice with less agricultural input usages. Different challenges like lowering of water table, labour shortage during peak times and declining soil quality necessitate an alternative establishment approach to maintain rice production as well as natural resources. When the future of rice production is in jeopardy due to worldwide water constraint, Direct Seeded Rice (DSR) presents a desirable alternative. The conventional Puddled Transplanting of Rice (PTR) is water, capital, energy and labour-intensive practice. There is an urgent need to switch from the traditional PTR to DSR because it is not only cost, input, energy and time saving but is also environment

friendly (Bandumula *et al.,* 2018; Jat *et al.,* 2022; Singh *et al.,* 2023a).

Punjab state has been playing a leading role in the agricultural transformation of the country. A sustainable production of rice in the state is crucial for the food security of India. The state has contributed about 25-30 per cent rice and 35-40 per cent wheat to the central pool during the last one decade (PAU, 2022). Water guzzling paddy is a dominant crop in the cropping pattern of the Punjab state and is putting the groundwater resources in a jeopardy situation. Out of 153 water blocks of Punjab, only 17 are safe and the remaining 136 (89%) are in alarming condition (Anonymous, 2022). Further, electricity demand is increasing for irrigating the paddy crop which undermines the viability of the power sector as power for agricultural use is fully subsidized in the state. In addition, yield stability and assured marketing of paddy makes it the most remunerative rainy (kharif) season crop.

During the COVID-19 lockdown, the return of migrant labour who were working in Punjab, to their native places, created a severe shortage of labour during the *kharif* season of 2020 in Punjab. During that time the DSR, which was being promoted in the State for a long time as a more water and labour efficient alternative of paddy cultivation, seemed more attractive to the farmers. They perceived that the economic losses of shifting to DSR were significantly less than shifting to alternative crops due to larger market risk and disruption of supply chains for alternative crops. Further, the Government of Punjab encouraged DSR by distributing about 4000 DSR machines at subsidized rates along with large-scale efforts on extension activities to promote this technology. Reportedly, about 5 lakh hectares (ha) area under paddy was sown through DSR during that time (Vatta *et al.,* 2021). But the results were not encouraging during the subsequent years as the paddy area cultivated with DSR technology was much lesser than the targets. During 2022 *kharif* season despite announcing incentives for farmers, the Punjab government missed its DSR target by a huge margin . Against the target of 30 lakh acres (12 lakh hectares), the government managed to bring only 1.68 lakh acres (5.6% of target) under DSR (HT 2022).Various studies (Kaur and Kaur 2017, Kaur and Singh 2017, Kaur *et al.,* 2017, Sidana *et al.,* 2020, Vatta *et al.,* 2021; Singh *et al.,* 2023b) listed poor initial germination, poor crop look, high weed infestation, problem of rodents, lesser yield, high risk to crop in DSR and non-availability of DSR drill as the reasons for shifting back to traditional technique of PTR cultivation. Further, there were considerable variations in the practices of cultivation followed by the farmers from the recommended practices (Kamboj *et al.,* 2022). Due to this they faced plenty of technical issues regarding the establishment of the crop and ploughed back the crop. Keeping all this in view, the present study was carried out in Punjab state with the following objectives.

**Objectives**

1. To examine the extent of DSR adoption in Punjab
2. To compare input use and energy consumption pattern in DSR and PTR
3. To study the reasons for non-adoption of DSR in the state.

## Materials and Methods

To study the extent of adoption of DSR in the Punjab state, secondary data for the year 2023-24 was gathered from the Department of Agriculture, Punjab. Further, to accomplish the objectives of the study, primary data was 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 was identified through consultation with officials of the Punjab

State Department of Agriculture. Keeping in view the concentration of DSR technology, two blocks namely Gidderbaha and Mukatsar were selected at the second stage **(Figure 1).** From each selected block, two villages were selected for the study, as shown in **Figure 1.**

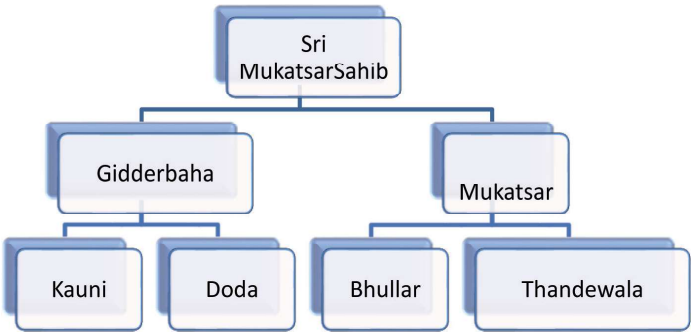



**Figure 1: Distribution of survey sample**

20 DSR farmers were chosen from each selected village for the study using simple random sampling technique. In order to undertake impact assessment of the DSR technology, ten PTR 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 DSR and 40 PTR farmers) 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 systems of rice cultivation 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 as 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), 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).

The data on inputs used in paddy cultivation and output (grain and straw) were converted to energy units using embodied energy equivalents for each input and output energy type and expressed in Mega Joules (MJ) using specific energy coefficients taken from the Research Digest on Energy Requirement in Agriculture Sector, Department of Farm Power and Machinery, PAU (Singh and Singh, 2002) as mentioned in **Table 1.**

**Table 1: Energy coefficients for energy calculation in paddy cultivation**

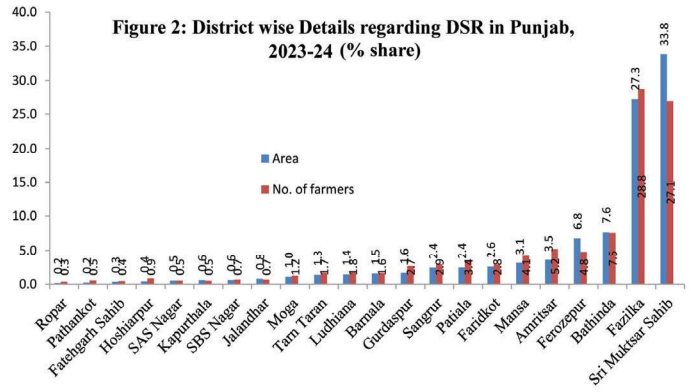
| Sr. No. | Energy source | Energy coefficient (MJ/unit) |
|---|---|---|
| 1 | Human labour (h) | 1.96 |
| 2 | Animal labour (h) | 14.05 |
| 3 | Fertilizer (kg) | |
| | N | 60.6 |
| | $P_2O_5$ | 11.1 |
| | $K_2O$ | 6.7 |
| 4 | Farmyard manure (FYM) in kg | 0.3 |
| 5 | Chemicals (kg and litre respectively) | 120 and 102 respectively |
| 6 | Machinery (h) | 62.7 |
| 7 | Diesel (litre) | 56.31 |
| 8 | Seed/Grain (kg) | 14.57 |
| 9 | Straw (kg) | 12.5 |
| 10 | Electricity (KWh) | 11.93 |

Source: Singh and Singh, 2002

### Status of adoption of DSR in Punjab

Considering sustainable agriculture as the keystone of Punjab's social and economic prosperity, promotion of DSR remained one of the pioneer steps in the Punjab Government's 2023-24 Budget.

About 17026 thousand famers have been provided with an incentive Rs1500 per acre for adopting the practice of DSR, for which Rs 19.92 crore has been paid during 2023-24. During 2023-24, the area under DSR was 53 thousand hectares forming only about 2 per cent of the total area under paddy. District wise analysis of the data revealed that the highest proportion of area under DSR was in Shri Mukatsar Sahib (33.8%) followed by Fazilka (27.3%), Bathinda (7.6%), Firozpur (6.86%) and Mansa (3.1%) while in other districts it was below 3 per cent as shown in **Figure 2.**



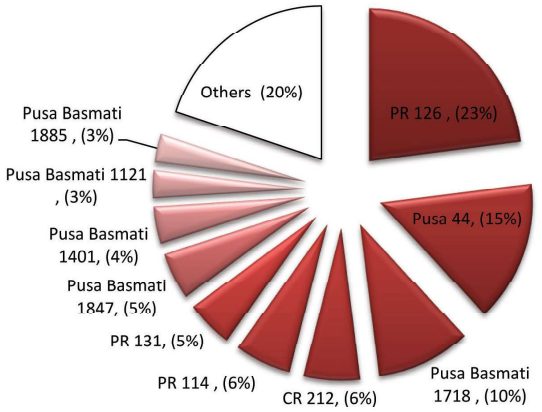

**Source: Department of Agriculture, Punjab**

In terms of number of farmers availing the subsidy, the maximum belonged to Fazilka (28.8%) followed by Shri Mukatsar Sahib (27.1%), Bathinda (7.5%), Amritsar (5.2%), Ferozepur (4.8%) and Mansa (4.1%).

Thus, DSR paddy adoption rate was higher 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).

According to estimates of Department of Economics and Sociology PAU, it was observed that maximum area under DSR during 2023-24 was under recommended non-basmati paddy variety PR126, requiring 120 days to mature followed by un-recommended Pusa 44 (15%) which is a long duration variety of paddy needing 155-160 days to mature (**Figure 3**). Among basmati varieties, Pusa Basmati 1718 occupied about 10 per cent of the DSR area followed by un-recommended Pusa Basmati 1847 (5%) and Pusa Basmati 1401 (4%) with rest being on less than three per cent of the DSR area.

**Figure 3: Variety wise area under DSR in Punjab, 2023-24 (% share)**




**Source: Department of Economics and Sociology, PAU**

## Comparison of DSR to PTR in terms of input use energy consumption

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 worked out to be 101.03 hours per acre on an average and 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.

**Table 2: Input use pattern, energy consumption and returns for paddy cultivation by DSR in Punjab**

(Per acre)

| Sr. No. | Input/Farm category | Small | Medium | Large | Overall (DSR) | PTR | Mean difference for DSR with traditional paddy cultivation | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Input use | Energy consumption |
| 1 | Human Labour (h) | 100.05 | 101.01 | 102.09 | 101.03 | 169.90 | -68.87** | -122.38** |
| 2 | Animal Labour (h) | 1.11 | 0.75 | 0.40 | 0.75 | 1.00 | -0.25 | -3.51 |
| 3 | Machine Labour (h) | 7.85 | 8.38 | 8.67 | 8.3 | 9.50 | -1.20** | -18.73** |
| 4 | Diesel (litre) # | 39.8 | 42.45 | 46 | 42.75 | 46.50 | -3.75* | -211.15** |
| 5 | Seed (kg) | 7.48 | 7.9 | 8.29 | 7.89 | 5.30 | 2.59** | 38.07** |
| 6 | Fertilizers, micro nutrients and FYM | | | | | | | |
| a | Urea (kg) | 143.0 | 141.0 | 147.5 | 143.80 | 170.62 | -26.82** | -1696.63** |
| b | Phosphatic (kg) | 6.21 | 6.53 | 6.90 | 6.54 | 6.80 | -0.26 | -2.89 |
| c | Muriate of Potash (kg) | 5.62 | 6.30 | 6.50 | 6.14 | 6.80 | -0.66 | -4.42 |
| d | **Zinc (kg)** | 4.50 | 5.20 | 5.70 | 5.13 | 6.50 | -1.37* | -28.63* |
| e | **Iron Sulphate (kg)** | 4.90 | 5.90 | 6.66 | 5.82 | 4.60 | 1.22 | 12.23 |
| f | Others (kg) ## | 2.50 | 3.20 | 3.60 | 3.18 | 2.70 | 0.48 | 4.80 |
| g | FYM (Ton) | 5.30 | 5.82 | 6.10 | 5.74 | 5.90 | -0.16 | -78 |
| 7 | Plant Protection Chemicals | | | | | | | |
| a | Rodenticide (kg) | 1.20 | 1.62 | 1.80 | 1.54 | 0.50 | 1.04** | 125.98** |
| b | Insecticide (litre andkg) | 2.30 | 2.60 | 3.20 | 2.70 | 2.23 | 0.47 | 47.98 |
| c | Weedicide (litre) | 2.80 | 3.30 | 3.55 | 3.21 | 1.20 | 2.01** | 205.22** |
| 8 | Electricity for irrigation (KWh) | **603.03** | **609.01** | 618.16 | 610.05 | 725.40 | -115.35** | -1376.12** |
| 9 | Output | | | | | | | |
| A | Grain (Qtls) | **27.20** | **28.01** | 27.88 | 27.69 | 28.01 | -32.30 | -1.15 |
| B | Straw (Qtls) | **36.72** | **37.81** | 37.63 | 37.38 | 37.81 | -43.61 | -1.15 |

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 * significant at one and five per cent level of significance

Source: Field Survey

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 kind of study for Punjab, maximum value for mechanization index was observed in the case of large farmers and maximum

animal labour index was observed in the case of marginal farmers (Kaur *et al,* 2017).

Further analysis revealed that the seed rate increased with rise in the farm size. On an average, 7.89 kg/acre seed rate was 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 behind this pattern are 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 namely urea, phosphatic fertilizers, muriate of potash and micro nutrients 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 respectively on an average and their use was also found to increase with the farm size. Almost similar results were reported by Saha *et al.,* 2020.

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 respectively 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) and large farms (27.88 Qtls per acre). The analysis revealed that the input use in DSR paddy cultivation increased with the farm size, except use of animal labour. However the differences existed among the different farm categories in input use was non-significant.

The results for comparative input use pattern under DSR and PTR method revealed that 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 kg) than PTR (2.23 kg) 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.

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 nutrient iron sulphate. The mean difference of major inputs such as human labour, machine labour, diesel fuel, seed rate, urea, rodenticides, weedicides, electricity differ significantly between DSR and PTR method of paddy cultivation. Accordingly, energy use was also lower in DSR system.

In terms of important economic parameters such as yield, total variable cost, gross returns, net income of DSR over PTR method of paddy cultivation the results are presented in **Table 3**.

**Table 3: Economic benefits of DSR vs PTR in Punjab**

(per acre)

| Sr. No. | Particulars | DSR | PTR | Advantage in DSR (%) |
|---|---|---|---|---|
| 1 | Yield (kg) | 2769.00 | 2801.30 | -1.15 |
| 2 | Total variable cost(Rs) | 23344.06 | 27677.33 | -15.66 |
| 3 | Gross returns (Rs) | 54826.20 | 55465.75 | -1.15 |
| 4 | Net returns over variable cost (Rs) | 31482.14 | 27788.42 | 13.29 |
| 5 | Cost of Grain production (Rs per kg) | 8.43 | 9.88 | -14.68 |
| 6 | Energy (MJ per kg) | 7.84 | 8.86 | -11.51 |
| 7 | Total Energy Input (MJ/Acre) | 21708.61 | 24816.79 | -12.52 |
| 8 | Total Energy Output (MJ/Acre) | 87431.18 | 88451.05 | -1.15 |

Source: Field Survey

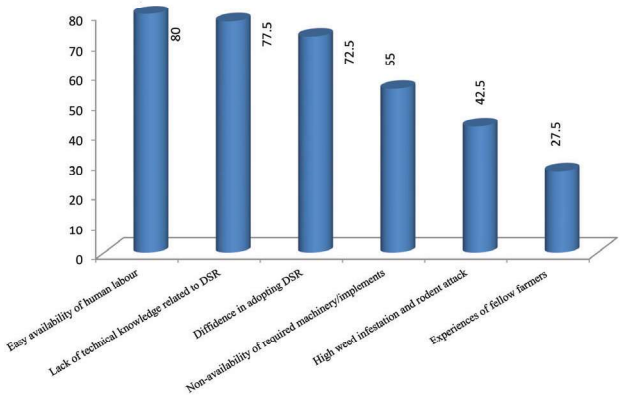
The results revealed that though the yield in DSR (2769 kg per acre) was marginally lower than PTR (2801.3 kg per acre), the net returns over variable cost were higher by about 13 per cent in DSR (Rs 31482.14 per acre) than PTR (Rs 27788.41 per acre). This is because of lower variable costs involved in DSR. The cost in production of one kg grain using DSR was found to be lower (Rs 8.43 per kg) by about 15 per cent than in PTR (Rs 9.88 per kg) and the input energy involved in the same was Rs 7.84 MJ as compared to 8.86 MJ.

Hence, the results of the present study indicated that DSR is an input saving as well as cost saving technology for paddy cultivation in comparison to traditional PTR method.

**Perceptions of the respondents regarding non-adoption of DSR**

Some genuine reasons and perceptions of the respondents for 'not adopting' the DSR has been presented in **Figure 4.** The results revealed that easy availability of labour for transplanting paddy emerged to be the major reason for not following the DSR by 80 per cent respondents. Other perceptions like lack of technical knowledge of DSR (77.5%), diffidence in adopting DSR (72.50%) and non-availability of required machinery/implements(55%) for sowing were the major reasons of not adopting the DSR.

Figure 4: Perceptions of respondents regarding non-adoption of DSR in Punjab (% share)




**Source: Field Survey**

Other reasons such as high risk of weed infestation and rodent attack and experiences of fellow farmers were reported by about 28 and 43 per cent, respectively. In a study by Kaur and Singh, (2017) at Punjab Agricultural University Ludhiana several constraints associated with shift from PTR to DSR included, high weed infestation, evolution of weedy rice, increase in soil borne pathogens (nematodes), nutrient disorders, poor crop establishment, lodging, incidence of blast, brown leaf spot etc.

## Conclusions and Suggestions

Currently, DSR is emerging as an option for sustainable rice production, owing to limited water availability, shortage of labour and rising cost of cultivation. Though the method is economically advantageous and also farmer-friendly, yet it needs technological advancement to reap the full benefits and speedy adoption. It points towards need for more research in development of high yielding rice cultivars suitable for DSR in various agro-climatic situations along with ensured and timely availability of agro-inputs and machinery at affordable prices. There is a need to generate more awareness of recommended DSR production practices among the farmers along with the benefits of such practices. Embracing of such standard practices especially judicious use of inputs like fertilizers, underground water and plant protection chemicals will not only optimize the energy use but also will minimize the cost of cultivation. 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 as change agents will help in fast pacing the adoption process of DSR.

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