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Original article**Paving the Way for Change: Direct Seeding in Punjab's Rice Fields****Anmol Singh, Ashish Santosh Murai, Narinder Singh, Gurpreet Singh and Simranpreet Singh Bola****ICAR-Agricultural Technology Application Research Institute, Ludhiana, Punjab***Corresponding author: simranpreetagr@gmail.com**Received: 10/07/2025**Published: 13/07/2025***ABSTRACT**

Traditional puddled transplanted rice cultivation in Punjab is highly water-intensive and labour-dependent, contributing to severe groundwater depletion, soil degradation, and increased methane emissions. These environmental and socio-economic challenges have intensified interest in Direct Seeded Rice (DSR), a method aligned with conservation agriculture. This article explores the potential of DSR as a sustainable alternative to TPR in Punjab, evaluating its agronomic performance, environmental benefits, and implementation challenges. DSR eliminates the need for puddling and manual transplanting, reducing water usage by up to 30%, cutting labour costs, and lowering greenhouse gas emissions. Field observations show that DSR can increase grain yields by approximately 10% and reduce production costs by ₹3,000 per hectare. Moreover, early crop maturity under DSR allows for timely wheat sowing and reduced stubble burning. The article also discusses various DSR methods—Dry, Wet and Water Seeding—and their suitability under different agroecological conditions. Despite its advantages, DSR adoption faces constraints such as weed pressure, uneven crop stands, and limited mechanization. The article outlines key strategies including varietal selection (e.g., herbicide-tolerant basmati lines), seed priming, and integrated weed and nutrient management to enhance DSR performance. Recent policy incentives and awareness campaigns are accelerating DSR adoption in Punjab. With appropriate technical support and extension services, DSR can significantly contribute to sustainable rice cultivation in the Punjab region.

Keywords: Direct Seeded Rice (DSR), Punjab rice cultivation, Sustainable agriculture, Water conservation, Weed management

INTRODUCTION

Water is a vital resource for life, yet its availability is rapidly declining due to unsustainable agricultural practices, particularly traditional rice cultivation. In India, the transplanted puddled rice (TPR) system, widely adopted in Punjab, consumes large quantities of water for puddling, transplanting, and irrigation. Producing just 1 kg of rice can require between 3,000 to 5,000 liters

of water (Surendran et al., 2021). Additional losses due to seepage, percolation, and evaporation exacerbate the stress on water resources. Punjab, a leading rice-producing state, faces severe groundwater depletion, with levels dropping from a surplus of 2.44 million acre-feet in 1984 to a current deficit of 11.63 million acre-feet (Bindu, 2021). Overextraction has not only threatened agricultural sustainability but also led to the contamination of groundwater with toxic substances like arsenic and fluoride. Moreover, the labor-intensive nature of TPR became evident during labor shortages caused by the COVID-19 pandemic, highlighting the state's dependency on migrant laborers from Bihar and Uttar Pradesh (Chaba and Damodaran, 2022). These pressing challenges have led to growing interest in Direct Seeded Rice (DSR), a technique that can potentially reduce water use, alleviate labor dependency, and improve environmental sustainability.

Direct Seeded Rice (DSR): A Sustainable Alternative

In Southeast Asia, the adoption of DSR is increasingly driven by water scarcity and high labor costs (Chaudhary, 2023). DSR aligns with conservation agriculture principles, eliminating the need for nursery raising, puddling, and manual transplanting. This method reduces water usage by approximately 30%—equivalent to saving 0.9 million liters per acre (Choudhary and Machavaram, 2022).

Yield and cost advantages

DSR has shown promising outcomes, with average yields of 3.15 tonnes per hectare, compared to 2.99 tonnes under TPR. Benefits include higher panicle density, better kernel weight, and reduced sterility (Mishra et al., 2022). DSR also allows early maturity by 10–15 days, providing a longer window for wheat sowing and reducing the need for residue burning. It lowers production costs by Rs. 3,000 per hectare and increases yield by about 10% (Chaudhary et al., 2023). However, some studies report inconsistent yield benefits, which may depend on environmental factors such as rainfall and temperature.

Environmental Impact

Switching from TPR to DSR significantly reduces methane emissions, a major greenhouse gas in flooded rice cultivation. In Punjab, this transition could lower the Global Warming Potential (GWP) by 16.6% (Singh and Ranguwal, 2024).

Different Methods of DSR

DSR comprises several methods suited to different agroecological conditions:

- 1. Dry-DSR:** Seeds are sown directly into unpuddled soil using methods like broadcasting, dibbling, or drilling after conventional tillage or zero tillage practices. This method is suitable for rainfed uplands and areas prone to floods where water availability is limited (Kaur et al., 2025).
- 2. Wet-DSR:** Involves sowing pre-germinated seeds into puddled or non-puddled soil using methods like broadcasting or row seeding with drum or anaerobic seeders. It can be aerobic (on the soil surface) or anaerobic (subsurface) depending on the seeding method and soil conditions (Bhatt, 2023).

- 3. Water Seeding DSR:** Ideal for areas with weed infestation issues, this method requires pre-germinated seeds to be broadcasted into standing water, whether puddled or non-puddled soil. It is particularly effective in flood-prone areas where water cannot be easily drained from the field (Shrestha et al., 2021).

Direct seeding of rice should not be performed on light-textured sandy soils. Instead, the tar-wattar DSR technique is ideal for medium and heavy-textured soils such as sandy loam, loam, silt loam, and clay loam, which cover approximately 87% of Punjab's area. To begin with, the field should be laser leveled to minimize water wastage, and then divided into appropriately sized *kiyaras* (plots). *Rauni* (pre-sown irrigation) should be applied and once the soil reaches *tar-wattar* condition (sufficiently moist yet workable condition) and then *kiyaras* should be prepared with shallow cultivation, followed by 2-3 passes with a planker loaded with three sandbags. Seeds can then be sown immediately at a depth of 3-4 cm in rows spaced 20 cm apart. For best results, field preparation and sowing should be avoided during noon hours. To manage annual grasses and some broadleaf weeds, a spray of 1.0 liter per acre of Stomp/Bunker 30 EC (pendimethalin) mixed in 200 liters of water can be applied. Ideally, a Lucky Seed Drill should be used, which simultaneously sows rice and applies pre-emergence herbicide, or a conventional rice drill with an inclined plate metering system, followed by immediate herbicide application. (Anonymous, 2024).

Challenges in Direct Seeded Rice (DSR) cultivation

- 1. Weed infestation and management:** DSR faces significant challenges from a variety of weed species, including grasses, sedges, and broadleaf weeds. These weeds compete with rice for resources such as light, nutrients, and water, leading to potential yield losses ranging from 15-50%. Effective weed management strategies are crucial to mitigate these impacts and ensure a successful DSR cultivation. Managing weed populations requires a combination of cultural practices, mechanical control, and also herbicide applications to keep them in check and reduce competition with the rice crop.
- 2. Poor crop stand and establishment:** Uniform crop establishment is critical for the success of DSR systems. Factors such as sowing techniques significantly influence the uniformity of crop emergence. Poor crop stand can result in reduced yield potential and increased susceptibility to weeds and diseases. Ensuring proper sowing method and providing optimal conditions for seed germination and seedling growth are essential for achieving a robust and evenly established rice crop.
- 3. Yield reduction:** Yield reduction in direct-seeded rice compared to puddled rice is a major concern. Direct-seeded rice often experiences lower yields than puddled rice due to several factors such as less effective weed control, lower seedling vigor and challenges in soil and water management. Puddling, a traditional method involving the preparation of a flooded and muddy seedbed, typically provides better weed suppression, improved seedling establishment, and enhanced nutrient availability leading to higher yields.
- 4. Water management challenges:** Efficient water use is a major challenge in DSR cultivation due to the reduced water availability compared to traditional flooded rice systems. Proper water management techniques, such as laser land leveling and precise irrigation scheduling, are

crucial for optimizing water use efficiency. These practices help ensure that the rice crop receives the appropriate amount of water at different growth stages, reducing water wastage and improving overall crop performance.

- 5. Nutrient management:** Effective nutrient management is vital for ensuring optimal crop growth and yield in DSR systems. This involves techniques such as soil testing to determine nutrient needs, applying balanced fertilizers to meet those needs, and using organic amendments to maintain soil fertility. Proper nutrient management practices help address any deficiencies, support healthy crop development, and ultimately contribute to achieving the desired yield outcomes in DSR cultivation.

Opportunities and Ideal Management strategies

- 1. Varietal selection:** Choosing the right rice varieties is crucial for the success of DSR, with an emphasis on traits such as drought tolerance, early vigor, and resistance to pests and diseases. The Pusa Basmati 1979 and Pusa Basmati 1985 varieties are particularly notable as they contain a mutated acetolactate synthase (ALS) gene, which allows farmers to use Imazethapyr, a broad-spectrum herbicide, for effective weed control. Developed by ICAR's Indian Agricultural Research Institute (IARI), these are the country's first non-genetically modified (non-GM) herbicide-tolerant rice varieties. They offer significant advantages in water and labor savings compared to traditional transplanting methods, making them ideal for DSR cultivation.
- 2. Sowing techniques:** Effective land preparation techniques, such as laser land leveling, combined with timely sowing are crucial for enhancing crop establishment and yield in DSR. Seed priming technologies which include soaking seeds in a 2% potassium nitrate solution (prepared by dissolving 200 g KNO_3 in 10 liters of water for 8 kg of seed) for 12 hours boost germination rates and early crop vigor. These practices are essential for achieving uniform stands and maximizing the crop's potential. For optimal results 8-10 kg of seed per acre can be used. (Anonymous, 2024).
- 3. Weed management strategies:** Integrated Weed Management (IWM) should be employed for effective weed control in DSR combining cultural, mechanical, biological, and chemical methods. For pre-emergence weed control applying 1.0 liter per acre of Stomp/Bunker 30 EC (pendimethalin) in 200 liters of water is recommended. When using a Lucky Seed Drill herbicide application occurs simultaneously with sowing and if farmer is using a conventional rice drill herbicide should be applied immediately after sowing. In dry fields irrigation should follow sowing with herbicide application once the field reaches *wattar* condition, typically within 1 to 2 days. For post-emergence weed control, herbicides such as Nominee Gold 10 SC (bispyribac sodium) at 100 ml per acre or Ricestar 6.7 EC (fenoxaprop-ethyl) at 400 ml per acre can be used depending on the weed flora and growth stage (Anonymous, 2024).
- 4. Water use efficiency and irrigation management:** Precision irrigation scheduling, aligned with crop phenology, is crucial for minimizing water use while maximizing yield in DSR. Additionally, techniques such as soil solarization and mulching play a significant role in water conservation and weed control ensuring efficient use of resources and improved crop performance.

5. Pest and disease control: Foot rot is a significant disease affecting Basmati rice and controlling it requires mandatory seed and seedling treatment. Seeds should be smeared with a talc formulation of *Trichoderma harzianum* at 15 g per kg of seed immediately before sowing, and seedlings should be dipped in a *T. harzianum* solution (15 g per liter of water) for 6 hours before transplanting. Alternatively, seeds can be treated with Sprint 75 WS (carbendazim + mancozeb) by preparing a slurry of 3 g fungicide in 10 ml of water for 1 kg of seed to manage other seed-borne diseases. Integrated Pest Management (IPM) practices are crucial for monitoring and managing pest and disease outbreaks in DSR. For stem borer control, neem-based biopesticides like Ecotin (80 ml per acre) or chemical options such as Coragen 18.5 SC (60 ml per acre) are effective. To manage diseases like foot rot and blast, using disease-free seeds, appropriate seed treatments, and targeted fungicide applications such as Amistar Top 325 SC (200 ml per acre) or Indofil Z-78 75 WP (500 g per acre) is essential. Additionally, resistant varieties like Punjab Basmati 7, 5, and Pusa Basmati 1847, 1718 are recommended to control bacterial blight, supported by sound management practices (Anonymous, 2024).

Advantages of DSR over TPR

DSR offers several advantages over Traditional Paddy Rice (TPR) that make it a favorable choice in modern agriculture. DSR significantly conserves water which is a crucial benefit in the face of dwindling water resources by reducing water consumption compared to TPR. This method also enhances labor efficiency by eliminating the need for nursery raising and transplanting which not only alleviates labor shortages but also lowers associated costs. Economically, DSR provides a higher cost-benefit ratio by reducing production costs related to labor and water while also minimizing physical strain on farmers thereby improving their overall well-being and productivity. Furthermore, DSR yields are comparable to those of TPR ensuring food security while using fewer resources. It also promotes soil quality improvement over time and contributes to long-term sustainability. The ability to mature crops earlier with DSR offers greater flexibility in crop planning and management. Additionally, DSR reduces methane emissions compared to the flooded conditions of TPR thus supporting environmental preservation. Overall, DSR enhances sustainability in rice cultivation, making it a more resource-efficient and environment friendly option.

Recent Initiatives and Adoption in Punjab

The Tribune News Service (2022) reported on June 16 that the District Agriculture Department is actively promoting DSR in Khalchian Village, Punjab, with Agriculture Extension Officer Satwant Kaur highlighting the provision of technical support to farmers adopting this method. Similarly, on May 3, 2022, The Times of India noted that Punjab Chief Minister Bhagwant Mann urged large-scale adoption of DSR technology in Sangrur district as a measure to reduce water consumption in paddy cultivation. Further reinforcing this initiative, Drishti IAS (2022) reported on May 6 that the Punjab government has announced an incentive of ₹1500 per acre to encourage farmers to adopt DSR practices. Notably, by 2021, approximately 18% of Punjab's rice-growing area—equivalent to 5.62 lakh hectares—had already transitioned to DSR, underscoring growing support for this approach. Collectively, these initiatives aim to promote water-use efficiency, enhance soil health, and ensure the long-term sustainability of agriculture in Punjab. By reducing dependency on groundwater and encouraging more efficient irrigation practices, the shift toward

DSR represents a strategic effort to mitigate environmental challenges and secure the future of rice farming in the region.

Conclusion: Towards a resilient and sustainable future

Transitioning from Transplanted Puddled Rice (TPR) to DSR is imperative for ensuring long-term sustainability in rice cultivation. TPR not only contributes significantly to water depletion and labor costs but also degrades soil health—both physically and chemically—while emitting high levels of methane, a potent greenhouse gas. In contrast, DSR presents a cost-effective and environmentally sustainable alternative, aligning with the principles of conservation agriculture (CA) critical to securing the future of farming. Despite its many advantages, the widespread adoption of DSR is hindered by several challenges, including weed infestation, poor crop establishment, and limited access to appropriate mechanization. Overcoming these barriers necessitates the implementation of integrated weed management strategies tailored to local agro-climatic conditions. Approaches such as stale seedbed preparation, mulching, and crop rotation, coupled with advancements in varietal development and genetic improvement, are key to unlocking the full potential of DSR. Equally important is building awareness among farmers through targeted extension efforts that highlight the resource-use efficiency and ecological benefits of DSR compared to traditional practices. Strengthening research and fostering innovation in technology and management practices will further support this transition. In summary, the shift to direct seeded rice offers a promising pathway toward sustainable agriculture by conserving water, reducing production costs, and minimizing environmental impact. Realizing this potential will require coordinated efforts in research, extension, and policy to overcome current limitations and ensure the broad adoption of DSR for a more resilient and climate-smart agricultural future.

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