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Reinventing Rice Cultivation: The Rise of DSR

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SUMMARY

Direct Seeding of Rice (DSR) is an advanced and resource-efficient method of rice cultivation in unpuddled soils that involves sowing seeds directly into the soil without transplanting rice seedlings. This technique contrasts with the conventional transplanting method, where seedlings are raised in nurseries and then transplanted into the puddled field. It has been attained much popularity, especially in water-scarce and drought prone areas, because it requires less amount of water (10-20% saving) compared to traditional transplanting method. The yields are comparable with transplanted rice if crop is properly managed. Additionally, it requires fewer inputs such as fertilizers and labour.

INTRODUCTION

Rice is the primary staple food for nearly half of the global population, providing essential caloric intake to over 3.5 billion people across Asia (Mohidem *et al*, 2022). Global rice production is projected to increase steadily from approximately 510 million tons in 2023 to around 550 million tons by 2030, and is expected to reach nearly 590 million tons by 2040. This upward trajectory is primarily driven by rising population demands and rapid economic development in developing nations (Yuan *et al*, 2021). Traditional rice cultivation methods in Asia include puddled transplanted rice (PTR), demands substantial water inputs (Pathak *et al*, 2013) and involves labour intensive practices, such as nursery bed preparation, seedling raising and manual transplantation (Farooq *et al*, 2008; Mallareddy *et al*, 2023). It also contributes significantly to methane emissions, a potent greenhouse gas, adversely impacting soil properties (Liu *et al*, 2015). In contrast, DSR involves sowing seeds directly into the main field, presenting a potential alternative to PTR.

Direct seeding is the oldest method of rice establishment practiced by humankind for ages, but was gradually suplanted by puddled transplanting for perceived advantages (Rao *et al*, 2007). Despite this shift, Several Asian countries such as Malaysia, Vietnam, Sri Lanka, Thailand, Cambodia, and the Philippines, have been continued to utilise the direct seeding techniques for decades. It also has a longstanding history of practice in India and has witnessed gradual expansion over the past few decades. Its adoption has been particularly notable in regions particurly characterized by erratic rainfall patterns and limited soil moisture availability. States such as Tamil Nadu, Jharkhand, Chhattisgarh, parts of Bihar, Odisha, Karnataka, and eastern Uttar Pradesh, seem to have good potential for DSR cultivation (Singh *et al*, 2021). One of the earliest and most well known demonstrations of DSR was conducted in the 1950s by Masanobu Fukuoka, a Japanese farmer and philosopher. The sustainability of rice production continues to be a critical concern due to change in climatic conditions. With the growing challenges posed by climate change such as water scarcity, rising temperatures, and labour shortages, it has emerged as a highly viable and resource-efficient alternative to conventional rice cultivation, offering a practical pathway toward climate-resilient and sustainable agriculture.

Types of DSR

There are three primary methods of DSR cultivation i.e Dry-DSR (DDSR), wet-DSR (WDSR), and water seeding (Chaudhary *et al*, 2023; Negi *et al*, 2024). Among these, WDSR involves sowing of pregerminated rice seeds using a drum seeder on puddled beds. This method offers advantages such as reduced labour requirement and physical drudgery along with improved and timely crop establishment. However, its successful adoption depends on precise field levelling and implementation of effective weed management strategies (Jat *et al*, 2022). WDSR has been reported to achieve water savings of approximately 18.0%–19.5%, where as DDSR demonstrates significantly higher water savings, ranging from 43% to 45%, in comparison with conventional paddy transplantation methods (Kumar *et al*, 2022). Water seeding, typically practised in irrigated lowland ecosystem, involves maintaining a water depth of 5 to 15 cm. In this approach, the field is prepared through dry plowing and harrowing without puddling, followed by broadcasting pre-germinated seeds in 10 to 15 cm deep standing water. Subsequent puddling is performed after wet tillage to facilitate seed anchorage and early seed establishment (Kumar *et al*, 2022; Chaudhary *et al*, 2023).

Benefits of DSR

Less water usage: Direct-seeded rice (DSR) significantly minimizes the requirement for continuous field flooding, leading to substantial water savings. This makes DSR a highly suitable and sustainable cultivation practice, particularly in regions facing water scarcity.

Reduced Labor Costs: DSR eliminates the labour intensive process of transplanting seedlings, thereby significantly reducing labour costs, a major expenditure in conventional rice cultivation. This method is particularly advantageous in regions experiencing labour shortages or high labour costs. Moreover, the adoption of mechanized tools such as seed drills, tractors, and other agricultural implements further reduces manual labour requirements and enhances operational efficiency.

Faster Crop Establishment: Direct sowing can lead to faster crop by eliminating the need for nursery raising and subsequent transplanting. This accelerates the overall growth cycle, potentially allowing for earlier harvests. The shortened duration of the crop is advantageous for optimizing crop rotation schedules and improving the temporal alignment of subsequent crops within the farming system.

Reduced methane emissions: Traditional rice cultivation practices involving continuous flooding create anaerobic soil conditions that promote methane (CH_4) emissions, a potent greenhouse gas contributing to climate change. In contrast, DSR involves intermittent or reduced flooding, thereby limiting anaerobic conditions and significantly reducing methane emissions. This makes DSR a more environmentally sustainable alternative to conventional transplanting methods.

Reduced Soil Compaction: Since fields are not continuously flooded, it may help reduce soil compaction, which can be a common problem in flooded rice fields. It allows for better root growth and facilitating more efficient water infiltration.

Bottlenecks of DSR:

Weed Management: One of the most significant drawbacks of DSR is weed control. In the absence of flooding, weeds may proliferate, competing with rice plants for nutrients, water, and sunlight, potentially reducing crop yield. Therefore, effective weed management through timely herbicide application or mechanical weeding is critical for the success of DSR.

Important weeds associated with DSR

Weed group	Weed species
Grassy	*Echinochloa colona, E. Crusgalli, Digitaria sanguinalis, Dactyloctenium aegyptium, Leptochloa chinensis, Eleusine indica, Cynodon dactylon, Paspalum distinchum, Ischaemum rugosum*
Broad-leaved	*Trianthema monogyna, Commelina benghalensis,Caesuliaaxillaris, Sphenoclea zeylaica, Marsila minuta, Ludwigia* spp., *Monochoria vaginalis*
Sedges	*Cyperus rotundus, Cyperus iria, Fimbristylis littoralis, Cyperus difformis, Scirpus juncoides*

Recommended rates and time of application of selected herbicides in DSR

Herbicide	Dose (kg a.i. ha^{-1})	Time of application	Target weed
Paraquat	0.5	1-2 DBS	All types of weeds
Glyphosate	1.2 -1.6	7-15 DBS	All types of weeds
Pendimethalin	1.0	1-2 DAS	Grasses,broadleaved
Pretilachlor +safener	1.5	1-2 DAS	All types of weeds
Ethoxysulfuron	15	10-15 DAS	Sedges, broadleaved
2,4-D	0.5	20 -25 DAS	Sedges, broadleaved

DBS, days before sowing; DAS, days after sowing (Source: Pathak *et al*., 2011)

Note#

Always spray herbicide in moist field and maintain proper soil moisture in field for one week after spray.

The leftover weeds may be uprooted before they produce seeds.

Lower Initial Yields: Even though DSR can result in good yields, initial yield potential may be lower compared to conventional transplanting methods, especially if the seeds are not sown correctly, or the soil conditions are not ideal. The uniformity of crop growth might not be as high as in transplanted fields, leading to variability in yield.

Pest and Disease Management: Direct seeding might expose rice crops to increased pest pressure like rice stem borers and other insects may be more likely to affect the crop in its early stages. Soil-borne diseases may also become major problem in it. These factors necessitate the implementation of integrated pest and disease management strategies to ensure successful crop establishment and productivity in DSR systems.

Technology and Expertise Requirements: DSR can significantly reduce labour requirements, its successful adoption depends on access to appropriate technologies such as seed drills and mechanized sowing equipment. Effective implementation also requires specialized knowledge and training in DSR practices. In the absence of proper technical guidance and knowledge, there could be a risk of poor crop establishment and inefficient use of inputs.

CONCLUSION

DSR presents a promising alternative to traditional rice transplanting, offering benefits such as water savings, reduced labour costs, and potential environmental advantages. Despite it also poses a significant challenges such as poor seedling establishment, weed competition, pest management, and substandard root architecture. Even though, with proper management and technology, it can significantly improve the efficiency and sustainability of rice farming. However, it requires careful planning, appropriate varieties, and adequate infrastructure to maximize its benefits and minimize the challenges. The system has been proved cost-effective and farmers friendly but require further improvement in technological approach to realize greater benefits.

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