A Monthly e Magazine
ISSN:2583-2212
June 2024 Vol.4(6), 2121-2130

Popular Article

Direct seeded rice: A resource conservation technique for reducing water footprints in rice-wheat cultivation

[1]Rajan Bhatt, [2]Mandapelli Sharath Chandra, [3]Govindaraj Kamalam Dinesh
[1]Rajan Bhatt, Associate Professor (Soil Science), Krishi Vigyan Kendra, Amritsar, Punjab, India
[2]AICRP OnIntegrated Farming System, Professor Jayashankar Telangana State Agricultural University, Rajendranagar,Telangana, India
[3]G K Dinesh, Assistant Professor (Environmental Sciences), SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Baburayanpettai – 603 201, Chengalpattu, Tamil Nadu, India
https://doi.org/10.5281/zenodo.11549951

Abstract

Rice is mostly grown in the Indo-Gangetic Plains (IGP) through the process of hand-transplanting the seedlings in puddled fields. This method requires a significant amount of irrigation water and a significant amount of labour from humans. The manually transplanted puddled rice system faced a substantial challenge in terms of its potential to remain viable in the long run due to the deterioration of the subsurface water table, the paucity of available labour, and the rising electricity prices. A dry, direct-seeded rice (DSR) production system is being forced upon researchers and farmers as a result of the water and labour shortages that are currently occurring. The success of DSR is mostly dependent on the utilisation of laser land levelling, drills of high quality that are equipped with enhanced seed-metering systems, and tractor operators that are experienced or knowledgeable. Furthermore, in order to effectively manage weeds, it is necessary to utilise cultivars that have a short duration and rapid growth, the stale bed technique, and the application of herbicides both before and after the emergence of the plant. We were able to save 10–20 percent of the water that was used for irrigation, 10–12 percent of the groundwater that was recharged, reduce the amount of labour that was required for transplanting, and save energy. Due to the absence of a hard pan, cropping systems that are based on DSR have a very positive impact on the yields of subsequent crops such as wheat. The timely vacation of the field is facilitated by the fact that DSR does not experience transplanting stress and matures seven to ten days earlier than a crop that has been transplanted during the same time period. The appearance of rice seedlings that are not owned by the farmer, poor crop emergence in situations where rain falls shortly after planting, and damage caused by rodents are the primary challenges that need to be thoroughly handled in order to facilitate the further horizontal spread of DSR.

Keywords: DSR, PTR, resource utilization, Laser land leveling, Weed management

More than half of the world's population relies on rice, also known as Oryza sativa L., as their primary source of nutrition. In the Indo Gangetic Plains (IGP), rice is mostly grown through the process of hand-transplanting seedlings into puddled fields, which represent wet culture method. During the puddling process, the soil is repeatedly plowed under submerged conditions, making it soft for transplanting and less permeable to water. This rice production system thrived well in the Indo-Gangetic Plains for many years due to easy farm labor availability and assured irrigation facilities. The following arrangement is still the most common method for establishing rice, but the continuous cultivation of rice in puddled transplanted fields has led to the overexploitation of underground aquifers and energy resources, the degradation of soil health, and an increase in greenhouse gas emissions. Additionally, it has resulted in secondary problems such as shifting weed flora, the evolution of herbicide-resistant weeds like Phalaris minor in wheat, and the burning of crop residues.

In the northern provinces of Punjab, Haryana, and Uttar Pradesh, where the widespread acceptance of paddy-wheat monoculture has increased farmers' dependence on irrigation water supplies, the reduction in subterranean water level is more noticeable than in other parts of the country. At the moment, there are over 15 lakh tube wells in the state of Punjab alone. These wells contribute to more than 70 percent of the irrigated area, and as a result, they pose a threat to the ground reserves of the state. In addition to this, the economy of India has seen a substantial transition over the course of the past ten years. Over the course of this time period, farm labour has been migrating to employment in industries that offer higher income and better working conditions than the conventional job that is done on farms. As a result of the fact that rice transplantation is primarily dependent on migrant labour, there is a growing scarcity of manpower capacity throughout the transplanting period. As a consequence, the labour prices increased, and the rice transplantation process was even delayed as a result.

Consequently, the shortage of labour and the decrease in the groundwater table have resulted in the necessity of developing rice production systems that are efficient in terms of labour, energy, and water. Because it yields higher crop, water, and labour productivity than puddle-transplanted rice, direct-seeded rice (DSR) is a new and emerging rice production technique in the North-West IGP. This is because DSR harvests the seeds directly from the plant. It is given in Table 1 that a comparison is made between rice that is planted directly and rice that is transplanted.

Table 1: Comparison between Direct-Seeded Rice *vs.* Transplanted Rice

Factors	Direct Seeded Rice (DSR)	Transplanted Rice (TPR)
Water Usage	Less water is required. Field preparation	More water is required. Nursery

	needs one pre-sowing irrigation, and flooding is unnecessary throughout the growing cycle.	preparation and puddling (creating a muddy field) for transplanting consume significant water.
Labor Requirements	Less labor intensive. There is no need to raise or transplant seedlings in a nursery.	More labor intensive. Requires raising seedlings in a nursery and then transplanting them into the field.
Crop Yield Comparison	Generally, yields are 12% lower than TPR but can be comparable or even higher with proper management.	Typically, yields are higher.
Water Footprint Reduction	Reduces water footprint due to lower overall water usage.	Higher water footprint due to water-intensive practices.
Economic Analysis	It can be more economical due to reduced labor costs. Seed cost might be higher due to increased seeding rate.	Generally, higher labor costs but lower seed costs.
Crop Growth Duration	May mature slightly faster due to no transplanting stress.	Maturity time can vary depending on variety.
Impact on Groundwater Levels	Less impact on groundwater levels due to lower water usage.	This can contribute to groundwater depletion due to higher water needs.
Weed Management Strategies	Requires effective pre-emergence herbicides due to early weed competition.	It can be easier to manage weeds through flooding and manual weeding.
Success Rate and Challenges	Success depends on proper management practices, soil type, and climate. Challenges include weed control, water management, and proper seed selection.	It is generally less challenging but might require more water for transplanting.
Environmental Benefits	Reduces water consumption and potential groundwater depletion.	Increases water consumption and potential groundwater depletion.
GHG Emissions	Potentially lower GHG emissions due to reduced water use and tillage.	Potentially higher GHG emissions due to iincreased water use and tillage.

Why Direct-Seeded Rice?

- 10-20% saving in irrigation water as compared to manual transplanted puddle rice
- Labor and energy-saving
- 10-12% higher groundwater recharge and no formation of hard pan
- Less prone to infestation of diseases
- About 100 kg per acre higher yield of succeeding wheat crop

Fig 1: Higher water and labor usage pattern in manual transplanted puddled rice

- Mature early as compared to transplanted crop
- Provide more time for paddy straw management and field preparation for *rabi* crop
- Lesser methane emission due to anaerobic conditions

Suitable textured soils: Only plant DSR in soils with a medium to thick texture. Its cultivation fails in light-textured soils because of weed infestation and a significant iron deficit, which reduces crop yields. Fields having a history of significant weed infestation and low soil fertility must not to be used for DSR farming. Additionally, since DSR in these soils is likely to be more affected by weed issues and iron deficiencies, direct rice seeding should not be done in fields that were previously planted to crops other than rice, such as cotton, maize, and sugarcane.

Laser leveling: In the past, direct-seed rice crops have not established well on levelled fields due to the frequent dikes and ditches inside the field. In addition to affecting drill efficiency, uneven soil surfaces can also affect crop performance through interactions between weeds, water, and nutrients. Reduced agricultural yields, increased irrigation expenses, and inefficient use of resources are the outcomes of 10–25% irrigation water loss during application due to poor management and uneven fields. To increase irrigation water use efficiency and guarantee greater germination, plough the field with a disc harrow, cultivate it with a cultivator and planking, and then level it with a laser leveller.

Fig 2: Laser land leveler before DSR

Seedbed preparation: During sowing, seed beds need to be carefully levelled and free of weeds for a successful DSR production. By using the stale seedbed technique in DSR, the seed bank of weedy rice and other weeds can be decreased. This method involves allowing volunteer rice, weedy rice, and other weed seeds to sprout following irrigation before eliminating them with tillage or nonselective herbicides.

Suitable varieties and sowing time: The selection of short-duration rice cultivars capable of high

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 09.06.2024

yields under aerobic conditions is essential for the successful implementation of the direct seeding strategy. Cultivars ought to be more efficient in translocating after flowering, tolerant of moisture stress during the early stages of growth, and weed-competitive.

Seed rate and time of sowing: While basmati rice can be sown from June 15 to 30, using 8 to 10 kg of seed per acre, the rice crop should be sown in the first two weeks of June.

Seed treatment: The high temperature during seeding and the shallow seeding technique cause the soil moisture content to drop below the necessary level for healthy germination. Seed priming helps to improve seed germination in these circumstances. This method of controlled hydration involves soaking seeds in low-osmotic potential solutions prior to germination and then re-drying them close to their initial weight to make handling easier. When seeds are re-immersed in soil, it speeds up germination and the emergence of seedlings. Rice seed is infused for 12 hours by immersing it in a 2% potassium nitrate solution (make a solution by dissolving 200 g of KNO3 in 10 litres of water for 8 kg of seed). After allowing the seed to dry in the shade, apply 3 g of Sprint 75 WS (mancozeb + carbendazim) per kg of seed.

Seeding depth: In DSR, seed depth is crucial because shallow or too deep of a seed location negatively impacts the dynamics of seed germination because of poor coleoptiles and quick soil surface drying during the hottest summer months. Drilling paddy seed at a depth of 3–4 cm will therefore maximise uniform crop establishment.

Planting machinery: To ensure optimal germination, direct seeding should be carried out using a multi-crop planter equipped with inclined plate seed metering systems and inverted T-type tynes. Seeds should be sown at a depth of 3–4 cm. Due to breakage and constant seed fall, standard fluted roller-type seed-cum fertiliser drills cannot achieve precise seed rate or plant-to-plant spacing. In general, there are two ways to directly seed rice:

1. **Direct seeding in *tar-wattar* fields**: After laser levelling the land, divide it into kiyaras of the desired size and apply rauni irrigation. When the field reaches tar-wattar conditions—a suitably high but manageable soil moisture level—prepare it kiyara-wise by cultivating it shallowly, then adding two to three planks, and then seed right away. For best outcomes, avoid doing sowing and field preparation at noon. For direct sowing, use the Lucky Seed Drill method, which concurrently applies pre-emergence herbicide and rice. Herbicides can be sprayed right away using a traditional rice drill equipped with an inclined plate metering mechanism. Using a press-wheel equipped Lucky Seed Drill for direct seeding helps prevent krand formation, preserve soil moisture in the soil profile, and increase the effectiveness of pre-emergence herbicide.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 09.06.2024

Fig 3: Direct seeding of rice under *tar-wattar* conditions

2. **Direct seeding in dry fields**: In a dry field, treated seeds are sown 2-3 cm deep in rows 20 cm apart, and irrigation is applied right away.

DSR Fertilization: Use 130 kg of urea per acre in three equal splits at 4, 6, and 9 weeks after sowing rice fields sown with DSR techniques; for basmati rice, use 54 kg of urea per acre in three equal splits at 3, 6, and 9 weeks after sowing. Apply potash and phosphorus after doing a soil test. Because of the aerobic conditions in DSR, the soil is not exposed to decreased conditions. In DSR's oxidised conditions, the crop's supply of Fe is inadequate. Chlorosis in seedlings caused by iron deficiency kills the plants, which frequently leads to crop failure. Apply two to three weekly applications of 1% ferrous sulphate solution (1 kilogramme of ferrous sulphate in 100 litres of water per acre) to protect the crop. Additionally, paddy crops also exhibit zinc deficit. Near the root, the lower leaves turn rusty brown before finally drying out. The zinc-deficient seedlings continue to be stunted. If past crops in this field have displayed signs of zinc shortage, apply 25 kg of zinc sulphate heptahydrate (21%) or 16 kg of zinc sulphate monohydrate (33%), per acre, at sowing, to control this disease. Apply this amount of zinc sulphate as soon as possible to growing crops where a deficit is visible.

Fig 4: Zinc and Iron deficiency in rice crop a). Zinc deficiency b). Iron deficiency

DSR weed control: Since weeds pose a major obstacle to DSR, choosing the field is the first step in integrated weed management. Always choose a field with a lower history of weed infestation for novices using DSR; ideally, the chosen field was once a paddy field. Second, for weed suppression in the early vegetative stage, select a fast-growing variety with strong and early seedling vigour and rapid leaf area expansion. For chemical weed management, 1.0 litre per acre of Stomp/Bunker 30 EC (pendimethalin) in 200 litres of water can be applied prior to emergence to suppress several broadleaf and annual grass weeds. In the case of tar-wattar DSR, spraying the herbicide right away after sowing if conventional rice drill is used, and concurrently if seeded using Lucky Seed Drill. When seeding in arid areas, water is sprayed right away, and herbicide is sprayed after the field reaches wattar condition, which usually happens one to two days after seeding. As indicated in Table 2, the post-emergence spray is carried out by choosing the herbicides according to the predominant weed flora and dissolving them in 150 litres of water per acre.

Table 2: Post-emergence spray details in DSR

Name of herbicide	Dose per acre	Target weed flora	Weed leaf stage at the time of spray
Nominee Gold 10 SC (bispyribac sodium)	100 ml	Swank, swanki, paddy mothas	2-4
Ricestar 6.7 EC (fenoxaprop-p-ethyl)	400 ml	Madhana, chini gha, chiri gha, takri gha	2-4
Almix 20 WP (chlorimuron ethyl 10% + metsulfuron methyl 10%)	8 g	Broadleaf weeds, paddy mothas, gandi wala motha	2-4
Vivaya 6 OD (penoxsulam 1.02% + cyhalofop 5.1%)	900 ml	Swank, swanki, chini gha, broadleaf weeds, paddy mothas	1-2
Council Activ 30 WG (triafamone 20% + ethoxysulfuron 10%)	90 g	Swank, swanki, chini gha, broadleaf weeds, paddy mothas, gandi wala motha	1-2

Caution:

- Always spray herbicide when weed plants are at the right leaf stage, as mentioned against each herbicide.
- Always spray herbicide in a moist field and maintain proper soil moisture (wattar) for one week after spray.

Irrigation: Delaying the first irrigation in tar-wattar DSR by up to 21 days after sowing has several benefits, including increased irrigation water savings, improved root development, a lower frequency of nutritional deficiencies—particularly iron—fewer weeds, and a wider range of soil adaptation. When direct seeding in arid fields, the first irrigation is given right away, and the second irrigation is given four to five days later. Depending on the type of soil, subsequent irrigations should be given

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 09.06.2024

every five to seven days. Rainfall-related adjustments can be made to the irrigation schedule. Ten days prior to harvesting, stop the irrigation. Comparing DSR to puddled transplanted rice, irrigation water savings range from 10% to 20%.

Major constraints in the horizontal spread of DSR: DSR is said to have produced a number of advantageous effects, such as reduced labour and energy consumption, improved plant stand, improved water relations, decreased soil compaction, increased soil biodiversity, and reduced greenhouse gas emissions. These effects are said to interact in a complex way to boost rice productivity and the sustainability of systems under the irrigated ecology of North-West India. Table 3 presents Ecosystem Services and Disservices: Direct Seeded Rice (DSR) vs. Transplanted Rice (TPR). Major advantages and limitations are shown in Fig. 5.

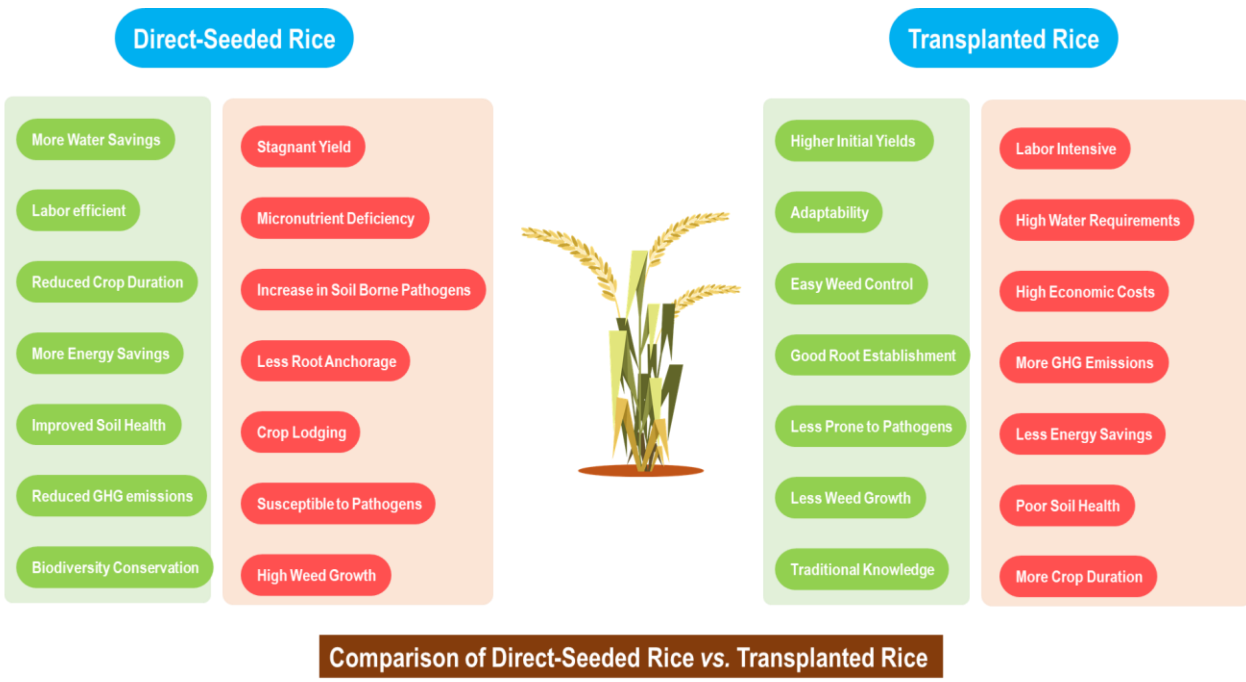

Figure 5: Comparison of Direct-Seeded Rice *vs.* Transplanted Rice

Table 3: Ecosystem Services and Disservices: Direct Seeded Rice (DSR) vs. Transplanted Rice (TPR)

Ecosystem Service Category	**Direct Seeded Rice (DSR)**	**Transplanted Rice (TPR)**
Provisioning Services		
Food Provision	Produces rice relatively lower grains	Produces relatively higher rice grains
Fodder production	May provide relatively lower straw	May provide relatively higher straw
Supporting Services		
Soil formation and fertility	Can improve soil health due to reduced tillage and potential for	May decrease soil organic matter due to puddling and more tillage

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com
Published 09.06.2024

	cover crops	
Habitat provision for beneficial organisms	Can provide habitat for earthworms and insects due to less soil disturbance	Can provide habitat for fish in flooded fields
Pollination	Supports pollinators like bees if flowering margin crops are used	Supports pollinators like bees if flowering field margins are present
Regulating Services		
Climate regulation	Potentially reduces greenhouse gas emissions due to lower water usage and less tillage	Potentially increases greenhouse gas emissions (methane) due to higher water retention, flooding and puddling
Water regulation	Reduces water usage, potentially improving water availability	Can contribute to waterlogging and salinization due to flooding
Erosion control	Less puddling leads to lower erosion control	May have higher soil erosion rates due to puddling and bare soil periods
Disservices		
Increased herbicide use	Requires effective pre-emergence herbicides for weed control	Increased selection pressure for herbicide-resistant weeds over time

The primary obstacles to the promotion of DSR include changes in weed flora, a smaller sink, a larger prevalence of rodents, the emergence of volunteer rice seedlings, and poor crop emergence, which mostly occurs when the field is not levelled and rain falls right away after sowing. In addition, cultivars with high and early seedling vigour and rapid expansion of leaf area during the early vegetative stage are desperately needed for weed suppression. The hour must locate agronomic instruments to pinpoint genotypes that are nutrient-efficient in order to supplement enhanced and sustainable agro-management choices in DSR. In an effort to produce greater yields, efforts would be undertaken to discover genotypes or increase the plasticity of genotypes with superior root systems that can better acquire N, P, and Fe. While DSR has the potential to lower CH_4 emissions, it can simultaneously raise N_2O emissions due to comparatively higher aerobic soil conditions. Therefore, in order to minimise negative environmental effects, measures for reducing N_2O emissions from DSR must be implemented.

Conclusions: Direct seeding of rice is a promising production system in Punjab and other parts of the North-West Indo Gangetic Plains. The looming water crisis and escalating labor shortage dictates the need to adopt Direct Seeded Rice. The success of DSR depends primarily on precise land leveling using laser levelers, good-quality drills fitted with improved seed-metering systems, and skilled tractor and pesticide operators. The manipulation of seeding depth is essential, as it varies according to soil types and moisture levels. Short-duration and quick-growing cultivars perform better under DSR. Stale bed technique and pre and post-emergence herbicide applications are necessary for effective weed management; however, the choice of herbicides depends upon dominant weed flora. Effective weed management in DSR depends on the weed stage, the method used, and the dose of herbicide at the time of application. Footrot and false smut incidence were lower in DSR; however, brown leaf spots and sheath blight were common in many farmers' fields. Due to the absence of a hard pan, DSR-based cropping systems may positively affect the yields of succeeding crops (e.g., wheat or corn). Due to the fact that directly seeded rice not received transplanting shift, hence matures 7 to 10 days earlier. Hence DSR crop can be easily incorporated in the different cropping sequences, which further reduces the overall water footprints. Reduced water footprints generally linked with DSR as it not requires any puddling operations but at some places yield reductions due to heavy weed pressure and due to severe iron deficiency also noticed. Further, immediate rain after seeding, deeply placed seed are some of other potential problems which hinders DSR spread in the region.

Official Website
www.thescienceworld.net
thescienceworldmagazine@gmail.com

Published 09.06.2024