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Direct seeded rice:

Prospects, constraints and future research work

Suraj Mishra*, Anand Kumar Chaubey and Jagannath Pathak

Banda University of Agriculture and Technology, Banda, Uttar Pradesh 210 001

The traditional method of cultivating rice involves transplanting after repeated puddling, which is not only time-consuming and labour-intensive but also consumes a lot of water. To maintain rice productivity and the sustainability of natural resources, it is necessary to implement alternate establishment methods due to issues such as declining water tables, workforce shortages during peak periods and worsening soil health. The oldest method of crop establishment, direct seeded rice (DSR), is becoming more and more popular because of its minimal input requirements. It provides a number of advantages, such as labour cost reductions, a decrease in the amount of water and manpower, early crop maturity, low production costs, improved soil conditions for succeeding crops, decrease in methane emissions, and more alternatives for being the best match in different cropping systems. Comparable yields in DSR may be achieved by putting different cultural practices, such as choosing the best cultivars, planting at the right time, using the appropriate quantity of seed, controlling weeds and always keeping the field moist.

Keywords: Aerobic rice, Conservation agriculture, Water saving, Weed management

Rice is one of the most significant food crops in the world, and fulfils the requirement of more than 50% of the global population. In the eastern part of India, 18 M ha of cultivable land is dominated by rice-based production systems which cover about 42% of the total area of national rice production systems. In India, rice is cultivated in traditional way where 20–25 days old seedlings are transplanted in main field. This method of rice cultivation has deleterious effects on the soil environment as well as succeeding wheat and other upland, crops and atmospheric environment through emission of methane gas. Additionally, this technique uses a lot of energy and is expensive, which makes the production system less economical. Therefore, it is suggested that alternate method of planting such as direct seeding should be adopted instead of conventional transplanting to reduce the water and labour demand, which would ultimately decrease the cost of production. Day by day increasing water scarcity, high water requiring nature of rice cultivation and increasing labour cost trigger the search for such alternative crop establishment methods which can increase water productivity. DSR is the only viable option to reduce the wasteful water flows. This article discusses the justifications for DSR adoption, several direct seeding techniques, potential advantages, challenges and solutions.

What is direct seeding rice (DSR)?

Direct Seeded Rice (DSR) describes the process of growing rice from seeds sown in the ground as opposed to transplanting seedlings from a nursery. Direct seeded rice is seen to be most productive, environmentally friendly and financially feasible rice production systems used today. Since 1950s, it has been recognised as the primary way of growing rice in countries that are developing. Pre-germinated seed can be sown directly into the ground using one of three methods: wet seeding, water seeding or dry planting onto a prepared seedbed. Farmers must be encouraged to switch from the conventional transplanting strategy to DSR culture by improved short duration and high yielding cultivars, nutrient management techniques, and weed control methods.

Major reasons responsible for using DSR

- ***Water-guzzling puddled transplanted rice:*** Traditional rice cultivation methods requires substantial amount of water. According to some sources, 1 kg of raw rice requires up to 5000 litres of water. A significant consumer of freshwater, rice accounts for around 50% of all irrigation water used in Asia, 24–30% of global freshwater withdrawals, and 34–43% of global irrigation water.

- ***The increasing competition for water resources from non-agricultural sectors***: Because of the growing population, declining water tables, decreasing water quality, ineffective irrigation infrastructure, and competition from non-agricultural industries, the percentage of water used for agriculture is rapidly diminishing.

- ***The rising cost and scarcity of labour at peak periods***: DSR reduces labour requirements by eliminating nursery raising, uprooting seedlings, transplanting, and puddling.

- ***Adverse effects of puddling***: Puddling creates a hard pan at shallow depth by destroying soil aggregates, dispersing small clay particles, and rupturing capillary pores.

- ***Best fit in cropping system***: Another factor for the quick adoption of DSR is the economic benefits brought out by the integration of an additional crop (crop intensification), in addition to the labour and water savings. DSR's earlier maturity compared to PTR's (transplanted rice) makes it a good fit for this crop in various cropping methods.

Methods of DSR

DSR can be established by 3 principal methods: transplanting, dry-DSR and wet-DSR.

Transplanting: In Asia, especially in tropical regions, transplanting is the prevailing method of crop establishment. This approach involves transferring seedlings from nurseries and planting them in prepared, waterlogged soil.

Dry DSR: In Dry-DSR, rice is established utilizing several different methods, including:

- Broadcasting of dry seeds on unpuddled soil after either zero tillage (ZT) or conventional tillage (CT) ;
- Using a dibbler technique in a prepared field and;
- Row-by-row seed drilling utilizing a power tiller-operated seeder, ZT, or raised beds after CT.

Wet DSR: Pre-germinated seeds (radicle 1–3 mm) are sown on or into puddles of soil using the wet-DSR technique. Pregerminated seeds are typically sown on the surface of puddled soil, and this is referred to as aerobic Wet-DSR. Pre-germinated seeds are usually sown or drilled into puddled soil, which creates an anaerobic Wet-DSR environment. Wet-DSR used with drum seeder or an anaerobic seeder with a furrow opener and closure. Seeds can be broadcasted or planted in line under aerobic and anaerobic conditions.

Production technology for DSR

Laser levelling and field preparation: Direct sowing requires precise levelling as a prerequisite. The best time to level the ground with a laser is at least before 1 month of sowing. The field should be watered after laser levelling to detect any irregularities that may be corrected by refine levelling. A fine seed bed is prepared by ploughing the field twice with disc harrows, 1 ploughing with cultivator, and then planking. During the summer, weed management is aided by field ploughing.

Sowing time: Sowing time varies from location to location. This is a crucial step to do in order to succeed with the DSR crop throughout the primary rice growing season (*kharif*). In north-west India, the first week of June is the best time for direct sowing coarse rice. The second week of June is the ideal time for direct seeded basmati rice.

Seed drill: Among the various seed drills utilized for direct seeding, such as the conventional seed cum fertilizer drill, zero till drill, inverted T-Tyne zero-till seed-cum-fertilizer drill, vertical plate metering mechanism, and inclined plate metering mechanism, machines equipped with an inclined plate metering mechanism are considered the most suitable for dry direct seeding (DSR). These machines effectively maintain consistent spacing between rows and seeds while minimizing seed breakage. For dry DSR, it is recommended to sow seeds at a depth of 2–3 cm, whereas for DSR following pre-sowing irrigation, the ideal sowing depth is 3–5 cm. The recommended distance between rows is 20 cm.

Selection of varieties: Selecting the right varieties is crucial to achieve the desired yield. The choice of varieties is determined according to the types of soil and the availability of irrigation water. In irrigated conditions, when dealing with light-textured sandy loam soils, it is advisable to opt early to medium duration rice varieties, ranging from 100 to 135 days. On the other hand, in the case of heavy-textured clay soils, it is recommended to cultivate medium to late duration varieties, which take around 135 to 165 days to mature. When it comes to direct seeding of basmati rice, the PR 115 variety of coarse rice, as well as varieties like Pusa Basmati 1121, Punjab Mehak 1, CSR 30, Pusa Basmati 1 and Taraori Basmati, are considered the most suitable options.

Seed priming: Seed priming consists of soaking seeds overnight in water and drying them in shade before sowing to promote germination. Under varying field conditions, seed priming technique helps to promote emergence and stand establishment.

Seed rate and its treatment: The optimum seeding rates using zero till ferti-drill sowing are 15–20 kg/ha for fine grains and basmati cultivars, 20–25 kg/ha for coarse grains, and 8–10 kg/ha for hybrids. When broadcasting rice seeds, it is necessary to use a higher seed rate ranging from 25 to 30 kg/ha. To mitigate the risk of seed and soil-borne diseases such as bacterial leaf blight, sheath blight, brown leaf spot, and other ailments, it is recommended to treat the rice seeds with fungicides like Streptocycline (1 g) and Bavistin (10 g) per 10 kg of seeds.

Seed depth: Seeding depth plays key role for good germination. For the required level of crop stand, depth should not exceed 3 cm. Because the top layer of soil moisture dries up quickly, planting seeds lower than 3 cm has a negative impact on the dynamics of seed emergence.

***Irrigation management*:** In heavy textured soils, DSR crop is commonly established by farmers with pre-sowing irrigation. A single or two irrigations are needed between the time when crops emerge and the beginning of the monsoon. No irrigation is required once the rains start, unless a dry period happens. The first irrigation after seeding can be delayed by 7 to 15 days, with following irrigations spaced 5 to 10 days apart. During the crucial stages of seedling emergence, vigorous tillering, panicle initiation and blooming, water stress must be avoided.

***Nutrient management*:** Nutritional requirement should be met on the basis of soil analysis of the crop field. If soil analysis is not performed, the following fertilizer regimen should be followed: Blanket application of 120–150 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha may be applied along with 25 kg $ZnSO_4$/ha. In light textured soil, ¼ N and full amount of P_2O_5 and K_2O should be applied basally. The remaining amount of N should be applied as top dressing into 2 splits at maximum tillering and panicle initiation stage. In DSR, iron deficiency usually occurs especially in light textured sandy loam soils. It leads to iron chlorosis in leaves. Application of iron sulphate ($FeSO_4$) could help to remedy this deficiency of Iron.

***Weed management*:** For DSR, weed control effectiveness is essential. During the wet season, weeds are a major threat in the DSR, and inadequate weed management leads to severe loss of grain yield but in puddled transplanted rice, standing water does not allow weeds to emerge. In conditions of DSR, weeds are more likely to germinate and compete with rice for nutrients, moisture, and sunlight, which results in significant yield losses.

Cultural practices such as the stale seed bed technique, utilization of surface mulch, incorporation of cover crops like *Sesbania rostrata*, *Phaseolus radiatus* and *Vigna unguiculata*, as well as brown manuring, can be employed to effectively manage weed growth. To mitigate weed pressure, an initial pre-emergence treatment with Pendimethalin @0.75 kg/ha can be applied, followed by a post-emergence application of Bispyribac (0.025 kg/ha) after 15–25 days from sowing to control grasses, broad-leaf weeds, and sedges.

Actual advantages from DSR

Direct-seeding of rice has the potential to provide numerous advantages to farmers and the environment when compared to conventional practices involving puddling and transplanting. The following are the listed benefits:

- Sowing can be completed within allotted time due to simpler and quicker planting.
- Crops mature 7–10 days' sooner than usual (115–120 days), allowing for the timely planting of successive harvests.
- Improved water management and a greater ability to withstand water stress.
- Reduces cultivation time, energy and cost.
- No plant stress from transplanting.
- More profitability especially under assured irrigation facilities.
- Improve soil physical conditions.
- Reduce methane emission: DDS (dry direct seeding)<WDS (wet direct seeding)<PTR (Transplanted rice).
- Increases total income by reducing cost of cultivation.

Constraints of DSR

Despite their potential benefits, DSR encounters certain limitations. One of the major challenges is the susceptibility to high weed infestation, particularly with weed species that are hard to manage. Farmers must be informed about crop rotation techniques and methods for managing herbicide resistance in order to prevent these negative effects. When rice is grown directly from seed, weeds appear in different flushes and cause issues. Because of this, the DSR mandates the use of herbicides, but farmers need additional guidance on how to do so safely and responsibly.

DSR system at tillering stage

DSR system before panicle emergence stage

Inappropriate use of herbicides could lead to the development of herbicide resistance in weed species, which would have severe impacts on agricultural costs and yields.

Way forward

Currently, DSR is emerging as an option, owing to water availability, shortage of labour and the need to reduce GHG emissions. The method has been shown to be economically advantageous and farmer-friendly, but it still needs technological advancement to reap the full benefits. The following points are suggested for consideration to the scientists, extension officers and policy makers:

- More research is required on development of high yielding rice cultivars suitable for DSR in various agro-climatic situations.
- To ensure the availability of agro-inputs, laser land levellers, zero till machines, LCCs, and cono weeders at affordable prices, a cooperative society with a cluster of villages needs to be strengthened.
- Weedy rice is becoming a concern in DSR, particularly in canal irrigated areas. It is imperative to handle this threat strategically.
- Due to the high level of technicality involved in herbicide application, rice farmers must get instruction about sprayer calibration, herbicide preparation, the significance of flat fan/flood zet nozzles and mode of application, and precautions.

SUMMARY

Direct Seeded Rice (DSR), when accompanied by suitable conservation practices, shows the potential to achieve comparable or even higher yields than Traditional Puddled Transplanted Rice (TPR), making it a viable alternative to address challenges related to labour and water scarcity. By implementing effective management approaches, it is possible to obtain yields from DSR that are comparable to TPR, despite initial concerns. While DSR significantly reduces methane emissions, it is essential to monitor greenhouse gas (GHG) emissions and develop strategies to mitigate increased N_2O emissions under aerobic conditions, ensuring a safer environment. Addressing pest and disease dynamics through effective management strategies can help overcome issues related to blast and insect infestation in DSR.

*Corresponding author's e-mail: surajmishras306@gmail.com