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AV Dahiphale
Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

UP Singh
Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Sandeep Kumar
Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Hari Singh
Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Sanjeev Kumar Kashyap
Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Correspondence
AV Dahiphale
Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Dry direct seeded rice: A potential resource conservation technology for sustainable rice production: A review

AV Dahiphale, UP Singh, Sandeep Kumar, Hari Singh and Sanjeev Kumar Kashyap

Abstract
Conservation agriculture (CA) practices are recognized as a powerful tool to address the issues related to land and environmental degradation. CA has great relevance to restore the degraded ecologies where farm income and fatigue in yield have become major concern. Resource conservation technologies such as dry direct seeded rice sown with minimum soil disturbance, providing a soil cover through crop residues for achieving higher productivity of soil. Conventional puddled transplanting is intensive and need heavy tillage it leads to the shifting towards resouece conservation technologies for sustainable rice yield. Because dry-seeded rice (Dry-DSR) with zero or reduced tillage (ZT–RT) has emerged as a viable alternative. In this paper an afford has made to review all the key component which emphasize the dry direct seeded rice as a potential option for cultivation of rice.

Keywords: Resource conservation technology, dry direct seeding, crop establishment

Introduction
Conservation tillage systems are systems of managing crop residues on the soil surface with minimum tillage. Retaining crop residues on the soil surface provides a source of plant nutrients, improves organic matter level in the soil and increased soil water content by reducing evaporation and increasing infiltration rate (Chastin *et al*., 1995). it is important Dry direct drill seeding has great scopem and as an alternative to the conventional practice of puddled transplanting to overcome emerging threats to the resource constraints, It is alternate solution to the crises of labor, water, and energy shortages, and to address the increasing cost of cultivation.

The most important conditions for a successful crop of dry direct drill- seeded rice are (a) Levelled land, (b) precise water management (c) effective weed management. These are discussed in detail below.

1. Precise land leveling
Nicely levelled land is of prime importance for the success of DSR because it (a) facilitates uniform germination, (b) good water management (c) Improved cultivation area, (d) improves input use efficiency (e) increases crop productivity (Jat *et al*., 2006, 2009; Lantican *et al*., 1999; Rickman, 2002) [17-23-36-24, 29, 35]. The average field slope in the IGP varies from 1 to 3% in the northwest (India and Pakistan) and from 3 to 5% in the eastern region (eastern India, Nepal, and Bangladesh). Laser land leveling is the single most popular technology in the IGP, where it has spread rapidly on about 1.0 million ha in India and 0.16 million ha in Pakistan.

2. Crop establishment
For conventional-tillage dry drill seeding (CT-dry-DSR), the soil should be well pulverized to maintain good soil moisture for drilling and good soil-to-seed contact. In sandy or silt loam, an excellent seedbed can be prepared with reduced or minimum tillage, thereby conserving soil, and reducing cost. In zero-till dry drill seeding, it is important to control annual and perennial weeds with a non-selective herbicides.

Planting dates
Rice in South Asia is mainly grown during the monsoon season (wet season). In India and Nepal, it is commonly known as *kharif* and in Bangladesh as the *aman* season. To effectively use monsoon rain, the optimum time for planting wet-season rice is about 10–15 days prior to the onset of monsoon (based on forecast or historical weather data) (Gopal *et al*., 2010;

Gupta *et al*., 2006) [1617-23-36]. In some areas rain continues for a few days, seed rotting and seedling mortality can occur due to submergence, resulting in poor crop stand. Optimum sowing time in relation to onset of monsoon for dry direct-seeded rice in rice based cropping system in India is depicted in following table 1.

Table 1: Optimum sowing time in relation to onset of monsoon for dry direct-seeded rice in

Area	Onset of monsoon Optimum	Time of seeding
Punjab, India	July 1–15	Mid-June to third week of June
Haryana, India	June 20–July 1	First fortnight of June
Western Uttar Pradesh, India	June 20–July 1	First fortnight of June
Eastern UP and Bihar, India	June 10–15	Last week of May to early June
West Bengal, India	June 1–15	Last week of May

This table is Adapted from Gopal *et al*. (2010) [16]

Priming of seeds and seed treatment

Seed Priming has positive effects on the emergence, tonnage, and quality of direct-seeded rice (Farooq *et al*., 2006a) [12]. In dry drill seeding, good CE is constrained by subsurface soil drying associated with high temperature. Hence, priming of seeds (pre-hydration) offers the advantage of early and improved emergence, and early vigor. Priming is accomplished by soaking seeds in water for 10–12 h and then drying them in shade prior to sowing. This treatment helps in easy flow of seed during seeding operations. It is must to seed sown shortly after priming to avoid degradation. Emergence of primed seeds will be affected if lack of moisture in soil initially. Therefore, seeding with primed seeds should be sown on wet soil. Both dry and primed seed can be treated. For primed seed, treatment with fungicide or insecticide should be done post-soaking. Damage by rice Thrips on emerging seedlings could also be controlled by using proper seed treatments to the seed initially before sowing.

Seed rate

The literature summarized that in most of cases seed rates of up to 200 kg ha ^{1} to grow a DSR crop (Guyer and Quadranti, 1985) [18]. However, it is not clearly known whether a high seed rate is primarily used to control weeds or is really a requirement to raise a good crop of DSR. The use of more seed rate per unit area is for getting more getting more number of panicle and higher seed rate (Bhattacharjee, 1978) [5]. Significance of seed drill for seeding, is leads to less requirement of seed. Literature also concluded that in the IGP, a seed rate of 20–25 kg ha^{-1} has been found optimum. High seed rates increases crop-crop competition can result in huge yield losses due to excessive vegetative growth before flowering and by slow down the rate of dry matter accumulation after flowering, it resultd in higher spikelet sterility percentage and less number of grains per panicle (Baloch *et al*., 2007; Kabir *et al*., 2008; Tuong *et al*., 2000) [4, 25, 42]. At same time dense plant populations at high seed rates can create favorable conditions for diseases infection in rice (e.g., sheath blight; and insects (e.g., brown plant hoppers) and make plants more prone to lodging (Islam *et al*., 2008) [21-33]. Adverse effect of the higher seed rate drastically decreases tillering and panicle density which is more dependent on primary tillering than on secondary or tertiary tillers. Since panicles from primary tillers are more productive we should focus on optimizing the spacing to have more panicles from primary tillers by protacting crop -crop competition (De Datta, 1981) [10].

Planting machinery (drills/planters)

For accurate and precise seeding, the crop should be drilled using a multi-crop planter with a precise seed-metering system (e.g., inclined plate, cupping system, or vertical plates) (Gopal *et al*., 2010; Gupta *et al*., 2006) [16, 17-23-36]. With these precise seed-metering planters, rice can be established with a lower seed rate and more precise plant-to-plant spacing can be maintained. It is difficult to drill rice at a low seed rate of 20–25 ha 1 with a fluted roller seed drill because it breaks the seeds. Modernization in different machines can help in maintaining proper plant stand under loose residue, especially after combine harvest in IGP (Gopal *et al*., 2010; Sharma *et al*., 2008) [16, 36]. Some of the machines that can be used for seeding rice with surface residues are- Turbo seeder, PCR planter, Double-disc coulters, Rotary-disc drill etc.

Depth of seeding and moisture

Seeding depth is important for all rice but more so for semi-dwarf plant types because of their shorter mesocotyl length compared with conventional tall varieties (Blanche *et al*., 2009) [6]. Therefore, rice should not be sown more than 2.5 cm to ensure good seed stand and must have sufficient moisture during the germination period. As sowing is done during peak summer when the open-pan evaporation rate is as high as 8–12 mm day^{-1}, the soil surface can dry very quickly and the seed zone can experience moisture stress (Gopal *et al*., 2010; Tabbal *et al*., 2002) [16, 40].

Precise water management

Precise water management, particularly during first 7–15 days after sowing is very crucial in drill-seeded rice (Kumar *et al*., 2009) [24-28]. Maintain the moisture and avoid the saturation level is a key to avoid seed rotting. Light irrigation to crop under water stress condition is recommended just after sowing in dry soil (Bouman *et al*., 2007) [7]. Such kind of water management will not only ensure good rooting and seedling establishment but also give scope for germination of weed seeds. It is needful that, early weed management with an effective preemergence herbicide is very important to check weed emergence and growth.

Gopal *et al*. (2010) [16] recommended avoiding water stress and keeping the soil wet at the following stages: tillering, panicle initiation, and grain filling. Once the crop is established following water management options are available as per availability water should give to the crop precisely with the aim of achieving high yields. Alternate wetting and drying irrigation interval in Dry-DSR is longer than that in CT-TPR because of less soil cracking in the former than in the latter (Humphreys *et al*., 2010) [19].

In DSR with need based residue retention would also require appropriate irrigation scheduling and water management as residue mulch would check evaporation, infiltration, and transpiration very differently than conventional practice. Residue mulch in Dry-DSR may significantly reduce ET, before commencement of mansoon when ET is very high and plants just emerged (Jalota and Arora, 2002) [22]. Kahlown *et al*. (2007) [26] found that sprinkler irrigation increased the grain yield of CT-TPR by 18% and reduced water application by 35% compared with the traditional irrigation system.

Effective and efficient weed management

Approach of IWM consist of combination of cultural,

chemical, mechanical, and biological control of weeds. Some of the studies that have shown effective management strategies that can be effectively manage weeds in Dry-DSR. IWM can also be enhanced through an understanding of the biology and ecology of specific problematic weeds to help identify weak points in weed life histories that can be efficiently targeted for management.

1) **Cultural approach-** this includes stale seed bed technique, Proper crop stand and Establishment methods, choice of cultivar, Crop rotations, Cover cropping options for weed management.

2) Mechanical Approaches- should include the following techniques for weed management Laser land leveling, Soil solarization, Use of weeders, Mulching

3) Chemical approach – weed infestation based use of pre and post emergence herbicidal spray is one of the effective strategy foe weed control under

4) Biological approach- Some of the bio-herbicide can used to control or suppress the growth of weed species.

Fertilizer management

General recommendations for NPK fertilizers are similar to those in puddled transplanted rice, except that a slightly higher dose of N (22.5– 30 kg ha^{-1}) is suggested in DSR (Dingkuhn *et al*., 1991a; Gathala *et al*., 2011) [11, 14]. This is to compensate for the higher losses and lower availability of N from soil mineralization at the early stage as well as the longer duration of the crop in the main field in Dry-DSR. Early studies conducted in Korea indicated that 40–50% more N fertilizer should be applied in Dry-DSR than in CT-TPR (Park *et al*., 1990; Yun *et al*., 1993) [31, 46], although higher N application also leads to disease susceptibility and crop lodging. The general recommendation is to apply a full dose of P and K and one-third N as basal at the time of sowing using a seed-cum-fertilizer drill/planter. This allows placement of the fertilizer just below the seeds and hence improves fertilizer efficiency. Split applications of N are necessary to maximize grain yield and to reduce N losses and increase N uptake. Split applications ensure a supply of N to match crop demand at the critical growth stages.

The remaining two-third dose of N should be applied as topdressing in equal parts at active tillering and panicle initiation stage. In addition, N can be managed using a leaf color chart (LCC) (Shukla *et al*., 2004; Alam *et al*., 2005) [38, 1]. Two options are recommended for applying fertilizer N using an LCC (IRRI, 2010) [20]. In the fixed-time option, N is applied at a preset timing of active tillering and panicle initiation, and the dose can be adjusted upward or downward based on leaf color. In the real-time option, farmers monitor the color of rice leaves at regular intervals of 7–10 days from early tillering (20 DAS) and N is applied whenever the color is below a critical threshold value (IRRI, 2010) [20].

Since more N is applied in Dry-DSR and losses are higher than in CT-TPR, more efficient N management for Dry-DSR is needed. Slow-release fertilizers (SRF) or controlled-release N fertilizers (CRFs) offer the advantage of a "one-shot dose" of N and the option to reduce N losses because of their delayed release pattern, which may better match crop demand (Shoji *et al*., 2001) [37]. One-shot application will also reduce labor cost. Also slow release of nutrient fulfill demand of crop throughout growth period, when it is needed. Nutrients are released slowly and have relatively more tuning with crop nutrient uptake and release of nutrient from fertilizer material thereby improving fertilizers use efficiency. Fashola *et al*. (2002) [13] reported that CRF improves N use efficiency and yield compared with untreated urea. Higher N recovery of co-situs (placement of both fertilizer and seeds or roots at the same site) application of CRF with polyolefin-coated urea of 100-day type (POCU-100) than conventional ammonium sulfate fertilizer applied as basal and top dressed in zero-till direct-seeded rice in Japan. In contrast to this, Wilson *et al*. (1990) [44], Wells and Norman (1992) [43], and Golden *et al*. (2009) [15] reported inferior performance of SRF or CRF compared with conventional urea top dressed immediately before permanent flood establishment.

Split application of K has also been suggested for direct seeding in medium-textured soil (PhilRice, 2002) [32]. In these soils, K can be split, with 50% as basal and 50% at early panicle initiation stage. Deficiency of Zn and Fe is more common in aerobic/non-flooded rice systems than in flooded rice systems (Singh *et al*., 2002a; Hongbin *et al*., 2006; Choudhury *et al*., 2007; Pal *et al*., 2008; Yadvinder-Singh *et al*., 2008) [39, 41, 30, 45]. Therefore, micronutrient management is critical in Dry-DSR. To avoid zinc deficiency, 25–50 kg ha^{-1} zinc sulfate is recommended (Anonymous, 2008, 2010) [2-3]. Basal application of zinc to the soil is found to be the best. However, if a basal application is missed, the deficiency can be corrected by topdressing up to 45 days (Anonymous, 2010) [3]. Zinc can be supplied by foliar application (0.5% zinc sulfate) two to three times at intervals of 7–15 days just after the appearance of deficiency symptoms. For iron, it has been observed that foliar application is superior to soil application (Datta *et al*., 2003; Anonymous, 2010) [9, 3].

Conclusion

Conventional puddled transplanting is the most common practice of rice production in Asia. Because of the water, labor and energy intensive nature of this system, and rising interest in CA, dry-seeded rice (Dry-DSR) with zero or reduced tillage (ZT–RT) has emerged as a viable alternative. Projections and trends seem to suggest that Dry-DSR will likely be a major rice culture in many countries in the future.

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