

Direct seeded rice is the answer

to water woes in rice cultivation

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Water, one of the most precious natural resource, is becoming increasingly scarce globally. Rice production and food security largely depend on the irrigated lowland rice system whose sustainability is threatened by fresh water scarcity and competition for water use. Aerobic rice is a potentially viable alternative to lowland rice when water scarcity is a limiting factor. Aerobic rice is a projected sustainable rice production technology, which can reduce water use in rice production and produce more rice with less water. Direct seeded rice (DSR) is an alternative establishment method of aerobic rice to sustain productivity of rice as well as natural resources.

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RICE is one of the most important cereal crop in the world and staple food of the global population. Being the major source of food after wheat, it meets 43% of calorie requirement of more than two third of the Indian population. The cultivation of rice in intensive subsistence agriculture becomes synonymous with agriculture.

In India, 49.5% (22 m ha) of the rice grown area is irrigated while 13.5% (6 m ha) is upland, and 32.4% (14.4 m ha) is rainfed lowland. Agriculture accounts for majority of the fresh water use and more than 50% is utilized to irrigate rice. A substantial portion of the rice supply comes from irrigated land. However, with water availability declining day-by-day, food security is challenged and threatened. In the coming years, more rice fields would suffer from physical water scarcity. Aerobic rice is a projected sustainable rice production technology, which can reduce water use in rice production and produce more rice with less water. Direct seeded rice (DSR) is an alternative establishment method of aerobic rice to sustain productivity of rice as well as natural resources and only viable option to reduce the unproductive water flows.

Direct seeded rice as a resource conservation technology, which has several advantages over transplanted puddle rice system (TPR). It helps in reducing water consumption as it does away with raising of seedling in nursery, puddling and transplanting. Thus, it reduces the labour requirement to the extent of about 40% and water saving up to 60% from nursery raising, field preparation, seepage, percolation and evaporation losses. It offers certain advantages viz., less labour, less water requirement, less drudgery, early crop maturity (7-10 days), low production cost, proper placement of seed and fertilizer, increase fertilizer use efficiency, improve soil health for crops and less greenhouse gas emission, in different cropping systems. Direct seeded rice (DSR), helps farmers to earn more carbon credits than transplanted rice (TPR) by mitigating methane emission and has higher economic returns, saves water and reduces labour requirement. DSR is the long-standing common technique practiced in many parts of the world, by broadcasting seeds directly on dry or puddled soils, dropping seeds in moist soil behind country plough or manual seeding.

Other than the management,

selecting varieties according to the availability of irrigation source and soil type is important to achieve desired yield. Therefore, early to medium duration varieties of 100-135 days and medium to late maturing varieties of 135-165 days are suitable for light textured sandy loam and heavy textured clay soils respectively. However, pre-requisites for a successful crop of DSR are land levelling with water management, good crop establishment, weed and nutrient management.

Seed priming

Seed priming is the most pragmatic approach to overcome the drought stress effects on seed. The priming process have the potential to improve emergence and stand establishment under a wide range of field conditions. These techniques can also enhance rice performance in DSR culture. Primed seeds usually exhibit increased germination rate, uniform and faster seedlings growth, greater germination uniformity, greater growth, dry matter accumulation, yield, harvest index and sometimes greater total germination percentage. For primed seed, treatment with fungicide or insecticide should be done post-soaking to control seed borne

diseases/insects. Seed can also be soaked in solution having fungicide and antibiotics for 15-20 hours. Use of biofertilizer like *Azospirillum* treatment had the highest shoot:root ratio during early vegetative growth and the maximum tillers. Seed priming also reduced the need for high seeding rates.

Water use efficiency

Precise water use efficiency, particularly during crop emergence phase is crucial in direct seeded rice. In DSR, seed-cum-fertilizer drill can take best advantage of residual soil moisture and had good grain yield. Reduce water input by water saving irrigation techniques and alternative crop establishment methods.

The productivity of water is very low in TPR system as it demands 3,000 to 5,000 L of water to produce 1 kg rice. It is evident from states of Haryana and Punjab, India, show a water table decline in the range of 3–10 m over the last two decades. Water management is essential, particularly during crop emergence phase of first 7-15 days after sowing with judicious moisture in the soil to avoid seedling rotting. Rice can be established by DSR once 150 mm rain or irrigation water has accumulated compared to 450 mm needed for transplanting.

Furthermore, because DSR establishes deeper roots and is more efficient at using soil moisture, less frequent irrigation is required during the growing season. Water saving of 35-55% have been reported for dry seeded rice sown into non-puddled soil with the soil kept near saturation or field capacity compared with continuously flooded (~5 cm) transplanted rice. During crop establishment phase, irrigations are required at the interval of 3-5 days after initial irrigation. Subsequently, irrigation should be done at an interval of 5-7 days in DSR. Established rice plant in DSR system is more efficient in using soil moisture, requires less frequent irrigation during the growing season due to deeper roots. Optimum moisture should to be maintained during active tillering phase (30-45 days after sowing) and panicle

emergence to grain filling stage by irrigating at 2-3 days interval to harvest optimum yield from DSR. The direct seeded rice has got potential to improve the efficiency of water use. Aerobic rice is a new practice of cultivating rice that requires less water than lowland rice.

Weed management

The major hurdle has been paucity of knowledge/awareness and contributing to high yield for weed management in direct seeded rice (DSR). Weeds are a major constraint to the success of DSR in general and to Dry-DSR in particular. In the absence of effective weed control options, yield losses are greater in DSR than in transplanted rice.

Most of the rice herbicides available have been developed for transplanted rice and these are not as effective in dry seeded rice. Application of pre-emergence herbicides and keeping fields submerged early in the season helps in controlling chlorosis and weeds. Moreover puddling doesn't have much influence on rice yields.

Weed can be managed through Integrated weed management practices which includes stale seed bed techniques in which weeds are allowed to germinate by giving irrigation and then killed by nonselective herbicides two days before seeding, using mulch and subsequently killed by 2,4-D at 30 DAS, and growing of rice varieties having greater ability to compete with weeds. However, 40-50% reduced weed densities are reported by mulching. Various mechanical methods are also available for weed control in direct-seeded rice such as manual weeding and using hand weeder. For chemical weed control, it is necessary to select the right herbicide depending upon the weed flora, and the herbicide should be applied with proper spray techniques. Glyphosate (systemic herbicide) or paraquat (contact herbicide) can be used as pre-plant herbicide. pendimethalin, pretilachlor, butachlor, thiobencarb, oxyfluorfen, azimsulfuron, cyhalofop butyl, and nitrofen are used as pre emergence herbicides, bispyribac-sodium, chlorimuron+metsulfuron-methyl

(almix), oxadiagryl, and fenoxaprop-p-ethyl, are the most effective post-emergence herbicide used to control the weeds of direct seeded rice. When the stale-bed technique is used to establish a direct dry-seeded rice crop, pre-plant application of glyphosate followed by the pre-emergence herbicide pendimethalin and post-emergence herbicides bispyribac-sodium, chlorimuron + metsulfuron-methyl (almix) azimsulfuron can eliminate weed problems in a DSR crop, including weedy rice.

Nutrient management

Precision land leveling not only improves water productivity but also the fertilizer use efficiency, especially N fertilizers. In South Asia, the general practice is to apply half of the N as basal with the balance top dressed in two equal splits, 40–45 and 60–70 days after sowing. Fertilizer, especially nitrogen fertilizer, is often applied in excess of the crop requirement and at inappropriate times in many intensively irrigated rice systems, which increases the risk of poor fertilizer recovery by the rice crop. Less than 35% of applied nitrogen (N) is uptake by rice and the remaining 65% is lost from soil-plant systems into the environment through volatilization, denitrification, leaching, and runoff, thus creating pollution problems. Significant improvement in N-use efficiency (NUE) is therefore crucial and can be made by adopting fertilizer, soil, water, and crop management practices that will maximize crop N uptake, minimize N losses, and optimize indigenous soil N supply.

A major concern is prevalent of micronutrient deficiency such as Zn and Fe, due to imbalanced N fertilization and high infiltration rates in DSR. Therefore, Zinc is recommended as basal in the form of zinc sulphate at the rate of 25-50 kg ha⁻¹ or can be top dressed within 45 days after sowing. To avoid imbalanced in N fertilization, leaf colour chart (LCC) is recommended, to adjust the dose based on the leaf colour during active tillering and panicle initiation stage. It has been reported that need-based N

management through use of leaf colour charts, shade 4, and a Soil Plant Analysis Development (SPAD) value of 42 reduces the N requirement by 12.5–25% without any reduction in yield. 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. 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.

Diseases, insects and pests management

Generally, direct seeded rice is relatively more susceptible to similar diseases, insects and pests than conventional transplanted rice; however, under some conditions there may be greater chance of outbreak of insect-pests and diseases in DSR with high rice plant densities. In wet-seeded rice, rats are big problems to crop establishment and it is susceptible to various diseases, rice blast being one of the devastating diseases, in both aerobic and direct-seeded cultures. Water deficit and shift from transplanting to direct seeding favours neck blast spread.

Sometimes the attack of arthropod insect pests is reduced in DSR compared with TPR, but a higher frequency of sheath blight and dirty panicle have been observed in DSR. In DSR, the other disease and insect problems reported are sheath blight and dirty panicle, brown spot disease and plant hoppers and soil borne pathogenic fungus (*Gaeumannomyces graminis* var. *graminis*) in dry-seeded rice in Brazil without additional irrigation. For poor Asian farmers use of natural plant derived biocides, such as, those from neem (*Azadirachta indica*) as it is cheaper, indigenously available and eco-friendly product. Also pathogens cannot easily develop resistance against neem products because the more than one molecule responsible

for biocidal activity. Neem products have been reported to have fungicidal, insecticidal and nematocidal, and antiviral properties. Cultivation of resistant crop varieties and summer ploughing is the pre requisite for efficient management of viral and other diseases/pests. Optimum rate of nitrogenous fertilizers avoid the incidence of brown plant hopper and blast attack. Fumigating the rat burrows with cow dung cake keeping the cow dung balls soaked in kerosene all over the field results in better control of rats and other borrowing animals. Root-knot nematodes pose a severe constraint when shift from PTR to DSR takes place. Root knot nematode, *Meloidogyne graminicola* is most damaging pathogen for aerobic rice.

Emission of greenhouse gas (GHGs)

Direct seeding of aerobic rice can help in reducing CH₄ emissions, but aerobic soil condition can also increase N₂O emissions. Agricultural practices play an important role in the emissions of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) —these three GHGs contribute to global warming. Agriculture's share in the total emissions of N₂O, CH₄, and CO₂ are 60%, 39%, and 1%, respectively. Rice production systems impact global warming potential (GWP) primarily through effects on methane, but N₂O and CO₂ effects can also be important in some systems. The GWP of CH₄ and N₂O is 25 and 298 times higher than that of CO₂.

Traditional flooded paddy fields have been identified as a major source of increasing atmospheric CH₄ accounting for approximately 5–19% of the annual global CH₄ emissions to the atmosphere. Although most N₂O emissions are produced in uplands, several studies on N₂O emissions from rice fields revealed that substantial N₂O emission results from the mid-season drainage and dry-wet episodes in rice fields. Methane is produced by anaerobic decomposition of organic matter in the soil under flooded rice cultivation. The absence of standing water drastically reduces emissions of

methane to the atmosphere. Adopting aerobic rice will help to minimize both methane and nitrous oxide emission rates from rice fields without affecting the productivity. Approximately, 50% reduction in CH₄ emission under aerobic rice and eco-friendly approach and safe for the environment. Simulated CH₄ emission in rice ranged from 25 to 59 kg/ha, and the farmers practice had the largest emission followed by unpuddled transplanting.

Economics

Studies were conducted to evaluate the performance of DSR compared to the conventional puddled transplanted rice. Results clearly elucidated comparable grain yield of DSR under seed-cum-fertilizer drill/ zero till/ reduced till system with less water use, more water productivity and greater net profit over that of conventional puddled transplanting. The DSR also had higher number of panicles per unit area, longer panicle length, more number of grains panicle⁻¹ and higher 1,000 grain weight. A major reason for farmers' interest in DSR is the rising cost of cultivation and decreasing profits with conventional practice (CTTPR). It is observed that direct seeding with drum seeder produced significantly higher net income ₹ 34,953/ha and returns per rupee investment (₹ 3.12) compared to net income ₹ 30,420/ha and returns per rupee investment (₹ 2.66) recorded in transplanted rice. Both the direct seeding practices registered the maximum net income of ₹ 19,039 and ₹ 18,587/ha with B: C ratio of 2.33 and 2.29 in manual broadcasting and drum seeder, respectively. The net income of DSR was higher than TPR due to lower cost of cultivation and it is due to substantial reduction in machineries (41.34%), irrigation (22.45%) and human labour (6.62%). Therefore, aerobic rice is a projected sustainable rice production technology, which can increase water use efficiency and reduce labour costs in rice production and produce more rice in appropriate eco-systems.

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