Direct Seeded Rice as Resource Efficient Technology

Abstract:

Rice (Oryza sativa L.) is commonly grown by transplanting seedlings into puddled soil in Asia. This production system is labour, water and energy intensive and is becoming less profitable as these resources are becoming increasingly scarce. It also deteriorates the physical properties of soil, adversely affects the performance of succeeding upland crops, and contributes to methane emissions. Different problems like lowering water table, scarcity of labour during peak periods, deteriorating soil health demands some alternative establishment method to sustain productivity of rice as well as natural resources. Direct seeded rice (DSR) technique has received much attention and popularity nowadays because of its low-input demanding nature that can mitigate emission of green-house gases and adaption to climatic risks. DSR involves sowing of dry seed into a prepared seedbed, pre-germinated seed into a puddled soil surface and standing water. The development of early maturing varieties and use of efficient nutrient management practices along with increased adoption of integrated weed management techniques have encouraged many farmers to switch from transplanted to DSR culture. DSR technology is highly mechanized in some developed countries like USA, Australia, Japan, China, Korea etc. This shift from traditional rice to DSR will substantially reduce crop water requirements, soil organic-matter turnover, enhanced nutrient management, carbon sequestration, weed management, greenhouse-gas emissions and enhance crop intensification. There are several constraints associated with shift from PTR to DSR, such as high weed infestation, evolution of weedy rice, increase in soil borne pathogens (nematodes), nutrient disorders, poor crop establishment, lodging, incidence of blast, brown leaf spot etc. By overcoming these constraints DSR can prove to be a very promising, technically and economically feasible alternative to PTR.

Key words: Water saving, Weeds, green-house gases emission, Direct seeded rice, Labour intensive

Introduction:

Rice is the world's most important cereal crop and a major staple food for more than half (>3.5 billion) of the world's population (CGIAR, 2016) and covered about 11% of the world's cultivated land area (Kumar and Batra, 2017). It is widely cultivated and consumed in south Asia. India is second largest producer after china. It is cultivated in West Bengal, NW parts of India, Andhra Pradesh, Tamil Nadu, etc. Traditionally, rice seedlings are first grown in a nursery and then are transplanted in the main field. Continuous flooding in puddled soil is required for its transplantation. Puddling of soil, however, disturbs the soil structure, makes hard pan in soil and requires a lot of water. Rice consumes about half of total irrigation water used in Asia (Barker et al, 2020).

It was therefore necessary to identify alternative method of rice cultivation which is more economical, saves labour and irrigation water. In the areas, where limited irrigation facility is available rice is cultivated by direct seed rice (DSR) method. It is an oldest principle of crop establishment since 1950s in developing countries. Bhullar et al. (2018) reported that DSR method saved 14 person-day/ha and 18-20% irrigation water as compared to puddle transplanting method. DSR is gaining popularity even in poor farmer who has less land because of low input and more output, saves labour cost, less drudgery, early crop maturing, low methane emission, and helps in improving soil health condition. It also help reduce production risks in possible drought situations and when rainfall at planting time is variably high as reported by Kumar and Ladha, (2011). In recent year most part of country undergoes the water crisis and people face a problem even for drinking purpose. So, DSR gaining more popularity over conventional puddled transplanted due to 40-45% less water requirement and low inputs are used. On parallel to parallel it also reduces the methane emission and nitrous oxide, responsible for global warming. (Manish Raj et al, 2021).

Direct Seeded Rice (DSR) is a resource efficient technology that can overcome constraints and limitations of traditional cultivation technology. Various constraints of traditional cultivation technology like higher water and labour demand, extra expenses during raising nursery, uprooting and transplanting, uncertain supply of irrigation water and increased frequency of drought has necessitated alternative techniques like DSR that not only reduces the cost of production but also assure its sustainability.

In the North-Western Indo-Gangetic Plains (IGP), transplanted rice is predominantly cultivated. Transplanting requires at least 25 ha-cm of water for puddling operation, which creates a dense clay layer in the sub-soil to prevent seepage losses. The crop requires about 130 ± 10 ha-cm of irrigation in addition to adoption of suitable variety and application of recommended dose of fertilizers to realize yield levels of about 6 ± 2 t/ha. Generally, about 40% of all irrigation water goes to paddy cultivation in the region. It is estimated that flooded rice fields produce about 10% of global methane emissions. Also, injudicious use of nitrogenous fertilizers is a common feature in paddy cultivation which is a source of nitrous oxide emissions. In Punjab, farmers generally take up transplanting of coarse rice. The current practice of excessive exploitation of ground water has led to a decline in the quality of natural resources i.e. land and water.

Researchers have developed suitable direct seeding alternatives to transplanted paddy. In direct seeded rice (DSR) cultivation, raising of nursery for transplantation is done away with. Farmer can avoid the major problem faced in Punjab i.e., labour shortage for transplanting due to peak demand. In case of delay in monsoon or shortage of water, DSR gives the farmer flexibility to take up direct sowing of paddy with a suitable duration variety to fit into the left over season. This allows timely sowing of the succeeding rabi wheat. Direct sown rice consumes relatively less water compared to transplanted flooded rice. Energy demand for pumping of irrigation water is also less and saving can be much higher during deficit rainfall situations compared to transplanted rice. Direct sowing can be practiced for cultivating both coarse rice and basmati rice wherever feasible in the North-West IGP region.

Direct seeded rice (DSR) has emerged as an efficient and economically viable alternative to PTR as it saves scarce and expensive resources such as labor and water, and reduces GHG emissions. Recently, DSR has been widely practiced in many Asian countries such as Malaysia, Sri Lanka, Vietnam, Thailand, Cambodia, and the Philippines. Many other countries including South Asia are going through this transition from manual transplanting to mechanized DSR. In future, with labor and water becoming increasingly scarce and expensive; alternative rice establishment methods which are labor and water efficient, such as DSR, will be the preferred method of rice cultivation.

Direct seeded rice in un-puddled field: Direct seeding of drought tolerant varieties of rice in dry soil is done in June with pre-emergence herbicide application (pendimethalin 1 kg/ha) under sufficient soil moisture conditions followed by a post-emergence herbicide application (bispyribac sodium 25g/ha) at 25-35 days after sowing or hand weeding at 35-45 days after sowing to effectively manage weed problem. Direct seeding in moist field with receipt of rains in June or by using ground water along with the application of pre-emergence herbicide is another option attempted. Control of weeds by use of glyphosate followed by zero till direct seeding of rice after one day of herbicide use is also practiced. In Bihar, direct seeding of medium duration varieties (125 days) can be done during second fortnight of July in midlands followed by a post-emergence herbicide application. In uplands, direct seeding of rice can be taken up with the onset of monsoon rains. Direct seeding of rice is done with a zero till drill. The quantity of seed required is 20-25 kg/ha compared to transplanted paddy which required 60-80 kg/ha.

DSR with reduced tillage is an efficient resource conservation technology that holds great promise in the Indo-Gangetic Plains in view of the following advantages:

- Saving in water up to 25% in DSR
- Saving in energy up to 27% of diesel as pumping energy is saved for field preparation, nursery raising, puddling and reduced frequency of applying irrigation water
- Saving of 35 to 40 man days / ha
- Enhanced fertilizer use efficiency due to placement of fertilizer in the root zone
- Early maturity of crops by 7-10 days helps in timely sowing of succeeding crops
- Reduction in methane emissions and global warming potential
- Little disturbance to soil structure
- Enhanced system productivity
    - ➢ 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 resource 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.
    - ➢ 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.
    - ➢ 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. 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. 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. 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 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. Precise water management, particularly during first 7–15 days after sowing is very crucial in drill-seeded rice. 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.
- Effective and efficient weed management consists 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.
- 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.
- the significance of DSR show that lower the cost of cultivation and higher the net return and B C ration over transplanted rice and farmers practice. Gangawar et al., (2008) recorded higher benefit: cost ratio with direct seeded rice as compared to transplanted rice. Kumar (2011) also observed similar findings and found higher B C ratio (1.19-1.27)

in DSR as compared to (1.08) in manual puddled transplanted rice. These results are in conformity with the finding of Sidhu et al., (2014)

- For Bed-dry-DSR, a bed-planting machine is used, which, after land preparation, forms a bed (37-cm wide raised bed and 30-cm wide furrows), places fertilizer, and drills the seed on both sides of the bed in a single operation (Singh et al., 2009c). The seedbed condition is dry (unpuddled), and the seed environment is mostly aerobic; thus, this method is known as Dry-DSR. This method is traditionally practiced in rainfed upland, lowland, and flood prone areas of Asia (Rao et al., 2007). However, recently, this method has been gaining importance in irrigated areas where water is becoming scarce. Drill seeding is preferred over broadcasting in irrigated or favorable rainfed areas in both developed and developing countries as it allows line sowing and facilitates weed control between rows, saves seeds and time.

Direct seeded rice in puddled field by drum seeding:

Drum seeding technique involves direct seeding of pre-germinated paddy seeds in drums made up of fibre material to dispense seeds evenly in lines spaced at 20 cm apart in puddle and levelled fields. About 35 to 40 kg paddy seed/ha is soaked overnight in water and allowed to sprout. Care should be taken not to delay sowing as seeds with long shoot growth are not suitable for drum seeding. The sprouted seed is air-dried in shade briefly (<30 minutes) prior to sowing for easy dispensing through the holes in the drum seeder. Excess water in puddled field is drained out ensuring the soil surface is moist. Drums are filled with sprouted seeds (3/4th full) and pulled across the field maintaining a steady speed for evenly sowing. Number of drums could vary between 4 and 8 with number of lines sown ranging from 8 to 16 in one pass. Irrigation water should not be applied for 2-3 days after sowing to allow rooting and anchoring to soil. However, heavy rainfall immediately after sowing is likely to wash away the newly sown seeds. As the seedlings grow, water level in the field can rise for better weed control. Intermittent irrigation is given till the panicle initiation stage. Where weed problem is severe, herbicide is applied within 1-2 days after seeding and if necessary, a second application is given 30-35 days later. Line sowing permits operation of modified conoweeder (width between wheels reduced to 15 cm instead of 25 cm) between the rows in the same direction adopted for drum seeding. Drum seeding in one ha area can be completed in 5 to 6 hours time by three persons compared to transplanting operation which requires about 30 to 40 man days. This technique can help in saving seed, water, labour requirement apart from improving productivity because of line sowing (spacing of 20 cm between rows) and early maturity of crop (by 7-10 days). Drum seeding reduces the cost of cultivation as it does away with the requirement for raising paddy nursery and transplanting thereafter. The technique fits into contingency planning as it provides flexibility in timing of sowing in lands prepared using irrigation water or immediately after receipt of monsoon rains with a crop variety of suitable duration to fit into the left over season.

When pregerminated seeds are sown/drilled into puddled soil, the seed environment is mostly anaerobic and this is known as anaerobic Wet-DSR. In both aerobic and anaerobic Wet-DSR, seeds are either broadcast or sown in-line using a drum seeder (Khan et al., 2009; Rashid et al., 2009) or an anaerobic seeder with a furrow opener and closer (Balasubramanian and Hill, 2002).

Conclusion:

The shift from traditional rice to DSR will substantially reduce crop water requirements, soil organic-matter turnover, enhanced nutrient management, carbon sequestration, weed management, greenhouse-gas emissions and enhance crop intensification. There are several constraints associated with shift from PTR to DSR, such as high weed infestation, evolution of weedy rice, increase in soil borne pathogens (nematodes), nutrient disorders, poor crop establishment, lodging, incidence of blast, brown leaf spot etc. By overcoming these constraints DSR can prove to be a very promising, technically and economically feasible alternative to PTR.

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