Mini Review

Direct Seeded Rice: An Alternative Rice Establishment Method Over Conventional Transplanted Puddled Rice

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Received: Aug 27, 2020; Accepted: Oct 29, 2020; Published: Dec 30, 2020

CITATION: Shukla MK, Shukla AK, Singh S. Direct Seeded Rice: An Alternative Rice Establishment Method Over Conventional Transplanted Puddled Rice. Recent Adv. Biol. Med. 2021; 7(1): 9800011, Pages 1-6.

ABSTRACT
Water and labor for agriculture are becoming increasingly scarce resources in many rice production areas. The share of water in agriculture is declining because of its increased demand in other non-agriculture sectors. Groundwater is being depleted at an alarming rate, especially in South Asia and the same is the case in India mainly because of its heavy use for rice production. Similarly, labor availability for agriculture is declining because of increased demand in non-agriculture sectors associated with rapid economic growth in many Asian countries. These factors provide incentives for farmers to shift to direct seeding, which requires less water and labor. Direct seeded rice production system gives a similar result with respect to growth and yield as found in transplanted puddled rice. However, due to the lower cost of cultivation B:C ratio is higher in direct seeded rice as compared to transplanted rice.

KEYWORDS: Direct Seeded Rice; Transplanted Rice; Zero Tillage; Brown Manuring.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is considered a staple food by more than half of the world's population. Rice is a monocotyledonous angiosperm. The genus, to which it belongs, *Oryza,* consists of more than 20 species, only two of which are cultivated rice: *Oryza sativa* L., cultivated in South-East Asian countries, and *Oryza glaberrima* L. cultivated in West Africa. Rice was originally cultivated in tropical Asia, the oldest record dating 5000 years BC, but then extended to temperate regions. More than 90% of the world's rice is grown and consumed in Asia, where 60% of the world's population lives. Rice accounts for 35-60% of the caloric intake of three billion Asians. Over 150 m ha of rice is cultivated annually, covering about 10% of the world's arable land. In 1999-2000, this amounted to some 600 mt of rice seed, equal to 386 mt of milled rice. With the world population estimated to increase from 6.2 billion in the year 2000 to about 8.2 billion in the year 2030, the global rice demand will rise to about 765 mt, or 533 mt of milled rice. For almost three decades since the Green Revolution, the rice yield growth rate is only 2.5% per year. India covers about 43.95 million ha area with a production of 106.54 million tonnes and a productivity of 2424 kg/ha [1].

In India, the major rice cultivation method used is the manual transplanting of nursery-grown seedlings into puddled soil. Puddling, a process of cultivating soil in standing water that consumes a large amount of water. Moreover, water resources are depleting due to intensive use of toxic pesticides and also resulting in scarcity of water in many parts of the world, as there is a competition between industrial and agricultural consumptions of water resources. There is a great concern that Indian rice growers will probably have inadequate access to irrigation water in the future. Hence, a shortage of irrigation water threatens the sustainability of rice production in irrigated conditions. Industrialization also threatens rice production due to the migration of rural labor to cities in search of a job, which causes a shortage of manual labor during the peak period of rice cultivation. This results in late transplanting, less acreage under rice, low yield, and delays in the planting of the next crop. The main objective was to study the different types of direct seeded rice methods and their comparison with conventional transplanted rice systems.

2. BASIC REQUIREMENT OF DIRECT SEEDED RICE

This method is more suitable for economically weak, small, and marginal farmers who are not capable of investing more capital in rice production and for the area where the crop is taken and harvested at its full maturity. This technology is more beneficial to those who want to use input, viz. seed, fertilizers, irrigation, etc. at full efficiency on per unit area and more importantly for those farmers who cannot bear more risk.

Table 1. Classification of direct-seeded rice (DSR) system.

System of direct seeding	Seed bed condition and environment	Sowing method practiced	Suitable ecology/environment
Direct seeding in the dry bed	Dry seeds are sown in dry and mostly aerobic soil	Broadcasting, Drilling, or Sowing in rows at depth of 2-3 cm	Mainly in rainfed area, some in irrigated areas with precise water control
Direct seeding in the wet bed	Pre germinated seeds sown in puddled soil, maybe aerobic/anaerobic	Various	Mostly in favorable rainfed lowlands and irrigated areas with good drainage facility
Direct seeding in Standing Water	Dry or pre-germinated seeds sown mostly in the anaerobic condition in standing water	Broadcasting on standing water of 5-10 cm	In areas with red rice or weedy rice problem and irrigated lowland areas with good land leveling

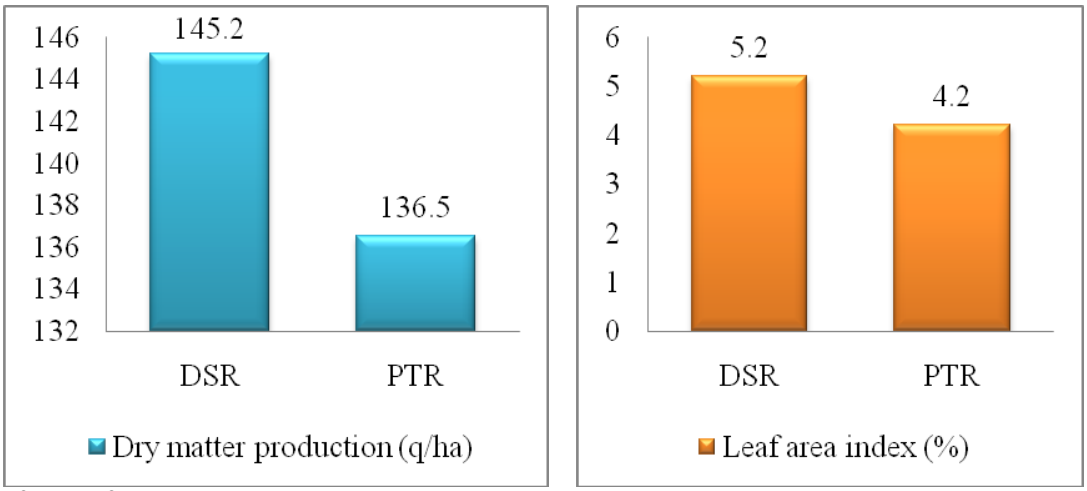
Source: [11]

Table 2. Comparison of grain yield in direct seeded rice and transplanted rice under different ecosystems.

Grain Yield		Rice Ecology	Country	References
DSR (t/ha)	PTR (t/ha)			
5.59	5.22	Favorable Irrigated	India	[18]
5.50	5.40	Shallow wetland irrigated	Japan	[9]
5.40	5.30	Favorable Irrigated	India and Nepal	[10]
5.38	5.32	Irrigated	S. Korea	[13]
4.64	4.17	Rainfed low land hills	India	[16]
3.83	3.63	Rainfed low land	Thailand and Cambodia	[15]
3.15	2.99	Unfavorable rainfed lowland	India	[17]

DSR - Direct Seeded Rice; PTR - Transplanted Puddled Rice

Figure 1. Effect of different seeding techniques on dry matter accumulation and leaf area index of rice.



DSR - Direct Seeded Rice; PTR - Transplanted Puddled Rice
Source: [7]

2.1. DRY RICE CULTIVATION

- Dry rice cultivation is followed in uplands where there is less possibility for water stagnation.
- Uplands are characterized by aerobic soil in which an attempt is made to impound water.

2.2. METHOD OF SOWING

- Three methods are commonly followed in sowing dry and semi-dry crop.
- These are broadcasting, drilling, or sowing in furrows behind the plough and dibbling.

2.3. LAND PREPARATION

- Plow the fields during summer to control emerging weeds.
- Leveling the fields well facilitates uniform irrigation and better germination.

2.4. SOWING TIME

- Sowing of the dry and semi-dry crop should be done at right time for getting maximum yield.
- The yield of the late sown crop has been found to be invariably low.
- To optimize the use of monsoon rain sowing DSR is about 10-15 days prior to the onset of monsoon [12].

2.5. SEEDING DEPTH

- The seeding depth of rice should not be more than 5 cm and preferably it must be 3-5 cm.

3. DIRECT SEEDING OF SPROUTED SEEDS IN PUDDLED SOIL

- This method is adopted in areas where there is a shortage of laborers or labor wages are very high and also where mechanical seeders are available.
- The field is prepared and puddled like in transplanted rice.

Table 3. Effect of different methods of rice crop establishment on growth and yield performance of low land flood-prone rice.

Treatment	Plant height at maturity (cm)	Panicles/m^2 (No.)	Grain yield (q/ha)	Straw yield (q/ha)
DSR (dry seeded)	121.0	156.0	33.3	62.9
PTR	102.0	96.0	26.1	30.9
CD (P=0.05)	5.0	9.0	1.8	3.8

DSR - Direct Seeded Rice; PTR - Transplanted Puddled Rice; Source: [6]

3.1. METHOD OF SOWING

- Two methods are commonly followed in sowing wet seeded rice crop.
- They are broadcasting and line sowing.
- Line sowing is done with the help of a drum seeder. Several seeders are available viz. IRRI multi-hopper seeder, CRRI seeder, IRRI drum seeder, and IARI seeder.

Table 4. Effect of different methods of rice crop establishment on yield performance of rice.

Treatment	Effective tillers/m^2 (No.)	Test weight (g)	Grain yield (q/ha)
DSR (broadcasting pre-sprouted seeds in puddled field)	245.9	22.74	48.3
PTR	200.7	22.64	42.8
CD (P=0.05)	4.7	NS	2.5

DSR - Direct Seeded Rice; PTR - Transplanted Puddled Rice; Source: [6]

3.2. SEED RATE

- Seed rate depends upon the duration and test weight of variety.
- An optimum seed rate should be adopted for the direct seeded crop so that the crop stand is neither too thick nor too thin.
- In general, a seed rate of 30-50 kg ha^{-1} is required for drilling (dry seeded), while 60-100 kg ha^{-1} is required for broadcasting in both dry seeded and wet seeded rice.

3.3. SPACING

- Spacing depends mainly upon the fertility of the soil and the duration of the variety.
- Row spacing of 15-20 cm is optimum for upland rice.
- For the low-land situation, the plant population of a direct seeded crop should be similar to that of a transplanted one.

4. NUTRIENT MANAGEMENT

- 120 kg N, 60 kg P, and 60 kg K per hectare gave maximum yield in direct seeded rice [8].
- 150 kg N, 30 kg P, and 30 kg K per hectare is suitable for the growth of direct dry seeded rice [14].
- Split application of Nitrogen at 0, 21, and 42 DAS with two sprays of Iron is beneficial for growing direct dry seeded rice [14].
- A spray of urea (2%) is also beneficial for the growth of direct seeded rice.

5. IRRIGATION MANAGEMENT

- The total water requirement and water use efficiency of wet sown and dry sown rice is:

Method of crop establishment	Water requirement (mm)	Water use efficiency (kg/ha/mm)
Wet seeded rice	1105	3.65
Dry seeded rice	1040	3.77

Source: [2]

- Generally, in direct seeded rice irrigating 5 cm depth one day after the disappearance of pounded water may be recommended for higher productivity and net return.
- In the areas of acute water scarcity, irrigating 2.5 or 5 cm depth 3 days after the disappearance of pounded water.
- Use pre- sowing hydration technique.

6. WEED CONTROL

New generations of weedicides have appeared in the market, allowing for very effective suppression of weeds without standing water. Some weedicides are:

- Pyrazosulfuron at 20 g ha^{-1}
- Ethoxysulfuron at 18 g ha^{-1}
- 2,4-D (ester) at 500 g ha^{-1} are effective by controlling broadleaf weeds and sedges.
- Pre- and post-emergence herbicides along with one hand weeding (effective and economical).

Tank mix application of herbicide was found most suitable for controlling all the three types of weeds.

7. ZERO TILLAGE DIRECT SEEDED RICE

- Establishment of the crop without any tillage practices (No tillage) with the help of non-selective herbicide.

8. REDUCE TILLAGE DIRECT SEEDED RICE OR MINIMUM TILLAGE RICE

- Rice seeded through ZT machine after two or three ploughings.

9. INPUT REQUIREMENTS IN BOTH ZT-DSR AND RT-DSR

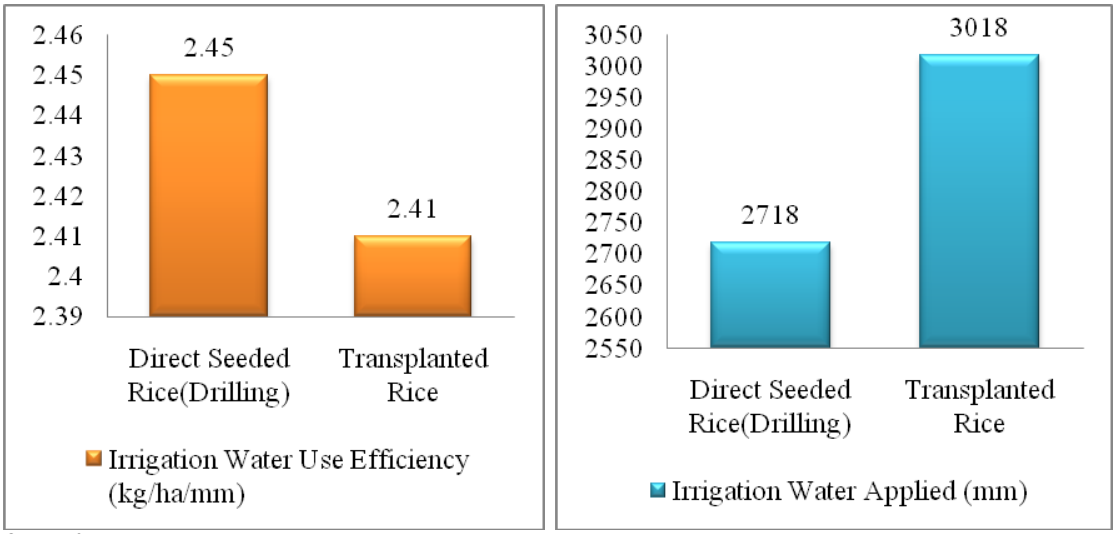
9.1. SEED RATE

- Bold seed: 35 - 40 kg/ha
- Medium seed: 25 - 30 kg/ha
- Fine seed: 20 – 25 kg/ha
- Hybrid seed: 15 – 16 kg/ha
- Seed depth 2 to 4 cm at proper moisture.

9.2. FERTILIZERS

- 120:60:40 :: N:P:K kg/ha
- Only granular fertilizers must be applied through machine.

Figure 2. Irrigation Water Applied and Irrigation Water Use Efficiency in different establishment methods of rice.



Source: [6]

Table 5. Effect of different establishment methods on total weed density of rice.

Treatment/Weed Control Methods	Weed Density (No/m²)		
	Preti fb Fx+E+2,4-D	Preti fb Fx+E	Weedy Check
DSR	41.6	51.0	256.2
WSR	49.6	58.4	145.9
PTR	86.4	100.0	102.1

DSR - Dry Seeded Rice; PTR - Transplanted Puddled Rice; WSR - Wet Seeded Rice; Preti.- Pretilachlor; *fb* - followed by; Fx - Fenoxaprop; E - Ethoxysulfuron;
Source: [3]

Table 6. Effect of different tillage systems and weed control treatments on grain yield of rice.

Weed control treatments / tillage system	Grain yield (t/ha)	
	Conventional tillage	Zero tillage
Oxadiazon *fb* fenoxaprop+ ethoxysulfuron	3.24	3.41
Oxadiazon *fb* penoxsulam+ cyhalofop	3.23	3.51
Control	2.87	2.02
Weed-free	3.63	3.63
LSD (same level of WCT)	0.45	
LSD (same level of tillage)	0.32	

WCT - Weed control treatments; *fb* - followed by; Source: [3]

9.3. BROWN MANURING

- The rice and *Sesbania* seeds are mixed and planted by the machine. *Sesbania* crop is knockdown after 30 to 32 days with a spray of 2,4-D ester @ 0.5 kg/ha.

9.3.1. BENEFITS OF *SESBANIA*

- It facilitates the emergence of rice seedlings.
- *Sesbania* works as a surface mulch.
- Reduce weed problem.
- Conserve soil moisture.
- 13.5 to 14.0 t/ha green biomass accumulated in the field.
- Add 30-35 kg N/ha on decomposition.

Table 7. Benefit-cost ratio of basmati rice as influenced by a different method of rice crop establishment.

Establishment Methods	Input cost	Net return	B:C Ratio
	Rs x10^3 /ha	Rs x10^3 /ha	
DSBR with brown manning	17.9	39.7	2.2
Conventional Practices	21.4	34.4	1.6

DSBR - Direct seeded basmati rice; Source: [7]

10. SOME OTHER COMPARISON BETWEEN DIRECT SEEDED RICE AND TRANSPLANTED PUDDLED RICE

Table 8. Benefit-cost ratio in rice-based cropping system as influenced by a different method of rice crop establishment.

Establishment methods	B:C Ratio		
	Rice-Wheat	Rice-Chickpea	Rice-Mustard
Direct Seeding DB UP	1.17	1.19	1.06
Drum Seeding WB UP	1.21	1.24	1.12
Manual Transplanting Puddled	1.03	0.91	0.89

DB - Dry bed; UP - Un-puddled; WB - Wet bed; Source: [5]

Table 9. Effect of different methods of rice crop establishment on bulk density and available water content of the soil.

Method of crop establishment	Bulk density (g/cc)	Available water content (%)
Direct Seeded Rice (Drilling)	1.60	12.97
Transplanted Rice	1.63	12.46

Source: [7]

Table 10. Effect of different methods of crop establishment on crop duration of rice.

Crop establishment methods	Variety (duration in days)	
	Mahamaya	PR-115
DSR	118	113
PTR	126	125

DSR - Direct Seeded Rice; PTR - Transplanted Puddled Rice; Source: [7]

10.1. ADVANTAGES OF DIRECT SEEDING OF RICE

- A cost-effective way of establishing a rice crop.
- Crop weeds are controlled.
- Grain yield is similar to the conventional method.
- The crop matures faster.
- Less labor and water requirement.

10.2. DIRECT SEEDING LEADS TO INDEPENDENCE

- The most promising option for the future is to adopt direct sowing of rice in place of transplanting, reducing its dependence on labor and water, and for farmers to become familiar with the correct use of herbicides.

11. CONCLUSION

Due to the water, labor, and energy-intensive nature of puddled transplanted rice, today dry seeded rice with zero or reduced tillage and wet seeded rice is being adopted as a viable alternative. If proper weed management is practiced in DSR, this method gives a similar response with respect to growth and yield as transplanted Rice.

CONFLICT OF INTEREST

None.

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