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Experiences, impact and scope of direct seeded rice in Ambala, Haryana

■ GURU PREM, AFZAL AHMAD, UPASANA SINGH AND RAMESH KUMAR

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SUMMARY : More than half of the world's population depends on rice for daily food requirements. Depletion of groundwater levels, shortage of labor and poor soil properties drawn attention on finding the alternative of traditional puddled rice (TPR). Direct seeded rice (DSR) production technology attracted farmers for its multiple benefits, which helps in improving system productivity. During 2011-12, the average yield of Pusa-1121 under DSR and TPR was 40.10 q/ha and 41.00 q/ha respectively. However, wattar sowing is suitable on light soils and dry seeding on heavy soils. The highest yield of Pusa-1121 was obtained with 17.5 kg/ha seed rate. Better water management needed for its early crop emergence and timely weed management are the keys of success in direct seeded rice. Water, labor saving and improved soil physical structures are the benefits, which is helpful in improving system productivity.

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Author for correspondence :
GURU PREM
Krishi Vigyan Kendra,
AMBALA (HARYANA)
INDIA
Email: gpgrover@yahoo.co.in
See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

Rice is an important cereal on which world's more than half of the population is dependent for daily food requirements. It is also the most important cereal food crop of India, where on about 24 per cent of gross cropped area, it is cultivated. Its production has increased from 250.30 lakh ton during first five year plan to 857.30 lakh ton during the tenth five year plan (Adhya, 2011). Groundwater is the major source of fresh water on the earth and India is the biggest user of it for agriculture purposes in the world (Shah, 2009). Importance of groundwater to Indian agriculture can be judged from the fact that about 61 per cent of irrigation was done with groundwater in the country in between 2000-01 and 2006-07 (Indian Agriculture statistics, 2008).

In this concern it is important to note that, due to large area and high water consumption, rice is the major user of available freshwater *i.e.* groundwater. The exploitation of groundwater for the traditional puddled transplanted rice (TPR) would be the major threat to the sustainability of the Indian agriculture. The traditional puddled rice creates and facing some problems such as groundwater depletion, labor shortage, negative impact of puddling on soil, delayed transplanting of rice due to shortage of labor. The delayed transplanting of rice not only cause reduced rice yield, but also delayed sowing and reduced yield of wheat, the another major crop of north India. Due to such directly or indirectly linked problems, there is a scope for farmers, who want to shift in rice production technologies. This can be understood though the statement that, the rice can be successfully dry seeded into unpuddled soils, with or without prior cultivation in the north Indo-Gangetic plains (Hobbs *et al*., 2002; Qureshi *et al.*, 2004). The effective weed management in direct seeded rice can give similar yields to that of puddled transplanted rice (Malik and Yadav, 2008). Direct seeded rice appears to have the greatest potential in irrigated agriculture, because it helps in saving both labour and water.

In Haryana for instance, on about 1.20 M ha, the rice is cultivated. Out of which fine grain varieties *i.e.* Pusa-1121, CSR-30, Sharbati and

Taraori basmati are cultivated on 0.65 M ha. Coarse grain high yielding varieties (HYVs)) such as PR 114, HKR 127, HKR 47 and hybrids such as PA 6444, PA 6129, Hybrid 40, Hybrid 3325 and RH 257 etc are cultivated on 0.55 M ha. Ambala is the North-Western district of Haryana with 1.55 lakh ha geographical area and 1.35 lakh ha net cultivated area. Moreover, the net irrigated area of Ambala is approximately 1.10 lakh ha, out of which 85 per cent and 15 per cent is being irrigated by tubewells and canals, respectively. The average annual rainfall of the Ambala district is 1076 mm, which is mainly received in monsoon season (July-September). Rice-wheat is the dominant cropping system, while sugarcane is also the major cash crop of Ambala. In Ambala, rice is grown over 0.83 lakh ha area and average productivity is about 38 q/ha.

The fine grain basmati varieties *i.e.* CSR-30 and PUSA-1121 have more cropped area than coarse grain varieties in Ambala-1 block of Ambala district. The basmati varieties, because of their long duration, consume a lot of water and more susceptible to the attack of diseases and Bakanae (foot rot) in particular. Direct seeded rice technology can save more water as compared to TPR and similarly labor requirements can also be reduced. Direct seeded rice also helps in improving soil physical properties, which is beneficial for the wheat and other crops grown before or after rice. Therefore, not only the net income but also the higher system productivity can be achieved through DSR. Keeping in view the above benefits of direct seeded rice, the Krishi Vigyan Kendra (KVK), Tepla-Ambala initiated the adoption of technology since 2009. As DSR provides a major opportunity to change production practices to attain optimum plant density and high water productivity specially in groundwater scarce areas. Therefore, from 2009 to 2012, we have studied the different aspects of direct seeded rice by having some trials, demonstrations, its production technology and experiences are recounted here as under.

RESOURCES AND METHODS

Establishment :

In this innovative technology, the productivity of rice is dependent mainly on crop emergence (germination) and weed control. Laser land leveling, seed treatment, depth of sowing and irrigation management are the major role playing factors on which fate of crop emergence is dependent. Laser leveling is popular for water saving, but in case of DSR, the laser leveling allow planter/drills to place seed at a uniform distance and depth and enable uniform application of irrigation water across the field, resulting in uniform crop stand.

Direct seeding of rice refers to the sowing/putting seeds in line, where they have to grow. There are three different methods of direct seeding depending on varying conditions; dry direct seeding (dry seeding on prepared seedbed), wet seeding (sowing pre-germinated seeds on wet puddled soils) and water seeding (seeds sown into standing water). Dry-Seeding has been the principal method of rice establishment, prior to 1950s in developing countries (Pandey and Velasco, 2005). In this method the seed bed condition is dry, unpuddled and either soaked or dry seeds are sown in rows 20 cm apart using drill.

It was found that Dry-DSR is effective on heavy soils, where infiltration rate is less and seed depth is also less. This requires 2-3 frequent irrigations after sowing for better germination and crop emergence. But in case of light soils, when this practice, is followed the field requires 4-5 irrigations with less irrigation interval as compared to heavy soil. The weeds also grow at the faster rate and are difficult to control. So to overcome such problems, wattar sowing (A moisture situation after pre-sowing irrigation) was found effective in direct seeding on light soils. In this practice, a pre-sowing irrigation is done after field preparation. The sowing is started, when tractor can run on the field without any physical disturbance to the seed bed. The higher seed depth (2.5-4.0 cm) is kept to ensure that seed are placed in moistened soil layer. The post-emergence irrigation is applied on a situation that upper soil layer should not be hardened. The period may vary from 4 to 10 days. In this, it is important to note that during 2012 front line demonstration on DSR, the farmers sown the seed on wattar position on 09.06.12 and the first post-emergence irrigation was applied on 22.06.12. Despite the late monsoon and erratic electricity supply, the crop emergence was good enough and found no decrease in the yield. On heavy soils (daakar, localized name), Dry-DSR was found better with 2-3 frequent irrigations needed just after the sowing. In Dry-DSR seed depth should be within 2.5 cm.

OBSERVATIONS AND ANALYSIS

The experimental findings obtained from the present study have been discussed in following heads:

Rice varieties and their sowing time :

Existing varieties which are used in traditional puddled rice, some of them *i.e.* hybrids and basmati can also be used

Table 1: Rice crop varieties for direct seeded rice

Sr. No.	Rice group	Varieties/Hybrids
1.	Fine grain (Basmati)	Pusa-1121(Sugandha 4), Pusa Basmati-1 and CSR-30
2.	Medium grain (Coarse rice)	Hybrids: PRH-10, Arize-6129, RH-257, Arize-6444 and PHB-71 Inbreds: PR-114 and HKR-47

(Kamboj *et al.*, 2012)

in direct seeded rice (Table 1). To date no specific varieties have been developed for this new production technology of rice. Ambala district has 25-30 per cent area under basmati rice production, of the total rice production area. Pusa-1121 and CSR-30 are popular varieties grown by the farmers. During year 2010-11. On farm trials were conducted on the comparative performance of these varieties under DSR and TPR. The average yield of Pusa-1121 was 30.75 q/ha in DSR, and 32.50 q/ha under TPR. While the average yield of CSR-30 was 25.70 q/ha and 27.10 under DSR and TPR, respectively (Table 2). Front line demonstration of direct seeded rice (Pusa-1121) was conducted. In front line demonstrations, we provided the seed as input and training on the steps involved in DSR. Nine demonstrations were conducted on five farmers field in different villages. The yield varied from 20 q/ha to 42.50 q/ha with average yield of 29.50 q/ ha. Heavy rains and flood in Ambala were main reason for less yield under both the systems. In continuation to the previous year, during year 2011-12, The FLDs were conducted on 3.6 ha in seven different villages of different 3 blocks of Ambala (Pusa-1121). During this year the yield varied from 37.25 q/ha to 43.00 q/ha with average yield of 40.10 q/ha (Table 3a). The yield of the same variety (Pusa-1121) was 41.00 q/ha under TPR (Table 3b). Due to less cost of cultivation in DSR the gross income and B:C ratio was higher in DSR

Haryana comes under North Indo Gangetic plains, where rice is grown during *Kharif* season. The KVK has the only machine in district and the farmers sow the crop on different dates through front line demonstrations. The crop sown on 27th June gave the lowest yield (34.50 q/ha), while the crop sown on 17.6.11 gave the highest yield (43.00 q/ha). The yield showed deceasing trend when crop sown after 17.6.11 to 27.6.11. The maximum net income of Rs 50540 was recorded when rice was sown on 17th June. High net income was due to high paddy yield and reduced cost of cultivation as compared to early sown crop. The minimum net income of Rs. 37450 was observed when rice was sown on 27th June (Table 4). It means, in this technique, the germination has to be completed 10-15 days before the onset of monsoon. Early

Table 2 : Cost of cultivation and benefit cost ratio during 2010-11 (OFT)

Sr. No.	Variety	Sowing method	Cost of cultivation Rs./ha	Yield (q/ha)	Gross income (Rs./ha)	B:C Ratio
1.	Pusa-1121	DSR	20700	30.75	64575	3.11
2.			25100	32.50	68250	2.71
3.	CSR-30	DSR	21800	25.70	69390	3.18
4.			26500	27.10	73170	2.76

Table 3 a: Yield of pusa-1121in FLD during 2011-12

Sr. No.	Village	Block	Yield (q/ha)
1.	Khudda	Saha	41.25
2.	Khudda	Saha	40.00
3.	Tepla	Saha	37.25
4.	Mullana	Barara	39.00
5.	Tharva	Barara	43.00
6.	Nakatpur	Ambala-I	39.50
7.	Mallur	Ambala-I	40.75
	Average yield		40.10

Table 3 b : Cost of cultivation and benefit cost ratio during 2011-12 (FLD)

Sr. No.	Variety	Sowing method	Cost of cultivation Rs./ha	Yield (q/ha)	Gross income (Rs./ha)	B:C ratio
1.	Pusa-1121	DSR	22560	40.10	68170	3.02
2.			25150	41.00	69700	2.77

Table 4 : Effect of date of sowing on yield and profit in direct seeded rice

Sowing date	Cost of cultivation (Rs./ha)	Yield (q/ha)	Gross income (Rs./ha)	Net income (Rs./ha)
4th June	24930	37.25	63325	38395
10th June	23770	39.50	67150	43380
14th June	23200	41.25	70125	46925
17th June	22560	43.00	73100	50540
21st June	21950	39.50	66300	44350
27th June	21200	34.50	58650	37450

sowing may put extra financial load of providing necessary irrigation requirements.

Seed treatment and seed rate :

In DSR, the seeds come in direct contact with soil, therefore, it is necessary to eliminate or reduce certain soil and seed borne diseases (Gopal *et al.*, 2010). Seed soaking/ priming and its treatment is the part of seed treatment. Seed priming accelerates the seed germination and facilitates crop emergence earlier than weed germination. Generally, the seeds are soaked for 15 to 20 hours for their treatment/ priming. For proper functioning of the seed metering mechanism of seed drill, before sowing, the seed should be dried in shade for 2 hours, which decreases the moisture content of seed and reduces the chances of entangling in the seed drill. To avoid deterioration the seed should be sown shortly after priming. Foot rot (Bakanae) is a common disease in TPR on Pusa-1121 variety, which is subjected to sow the seeds for nursery without any seed treatment. But this disease was not seen in DSR, because, the farmers treated the seed with fungicides and bactericide along with seed priming. The seeds can be treated with fungicide (Bavastin or Emisan) 1 g/kg of seed and bactericide (Streptocycline) 1 g/10 kg of seed is needed.

In general, the farmers perception is that the high seed rate means higher yield. But in case of direct seeded rice if the seed rate is high, then attack of disease will also be higher consequently with reduced yields. If the weeds are controlled effectively, then the seed rate may be reduced without affecting the yield. For medium to fine grain varieties, the seed rate of 15-20 kg/ha has been found optimum in direct seeded rice (Gopal *et al.*, 2010 and Kamboj *et al.*, 2012).

Different seed rates (15, 17.5 and 20 kg/ha) were assessed and their effect on yield specially in Pusa-1121 variety was assessed. It was found that the seed rate of 17.5 gave the highest yield followed by 20 kg and 15 kg/ha. The yield was 45.10 q/ha for 17.5 kg/ha, 43.60 q/ha for 20 kg/ha and 37.00 q/ha for 15 kg/ha seed rate. The highest plants per square meter were noticed with highest seed rate and then followed by 17.5 kg/ha and 15 kg/ha seed rate. While the plant height (142 cm) was highest in 15.00 kg/ha and subsequently 140 cm in 17.5 kg/ha and lowest (135 cm) in 20.00 kg/ha. It was observed that the less number of effective tillers per plant in highest seed rate with same number on medium and minimum seed rates (Table 5.).

Nutrient management :

In general, the recommendation of NPK fertilizers dose is similar to that of fertilizer applied in traditional puddled rice. However, in DSR, the higher dose of nitrogen (22.5-30 kg/ha) is suggested (Gathala *et al.*, 2011). At the time of sowing the full dose of phosphorus (P) and potash (K) and one third nitrogen (N) as basal should be applied. To minimize nitrification/denitrification, volatilization and infiltration losses, which are likely to be higher due to unpuddled condition of soil, the split application of nitrogen fertilizer would be beneficial. At active tillering and panicle initiation stage, the remaining dose (two-third) of N should be applied in two split applications as topdressing. The micronutrient deficiency of zinc (Zn) in general and iron (Fe) in particular was observed. Taking into consideration the facts of aerobic conditions of direct seeded rice, the farmers are advised to apply zinc@25 kg/ha and slightly higher dose of N (22.5 to 30 kg per ha) and foliar application of iron sulphate if needed. The recommended dose of fertilizer in DSR is given in Table 6.

Weed management :

Weed management in the direct seeded rice is the key for its success. When it was shifted from anaerobic rice (TPR) to aerobic rice (DSR), accordingly the weed flora also changed dramatically. Puddling followed by flooding control weeds in TPR, unlike in DSR, TPR seedlings have a

Table 5 : Observations in different seed rate in Pusa-1121

Sr. No.	Observations	Seed rate (kg/ha)		
		15	17.5	20
1.	Number of plant/m^2	28	35	37
2.	No of effective tiller/plant	13-15	12-15	11-13
3.	Plant height (cm)	141	140	136
4.	Yield (q/ha)	37.00	45.10	43.60

Table 6 : Recommended fertilizer dose for DSR

Sr. No.	Rice group	Fertilizer (kg/ha)			
		Nitrogen (N)	Phosphorus (P_2O_5)	Potash (K_2O)	Zinc sulphate ($ZnSO_4$, 21%)
1.	Coarse	150-165	60	60	25
2.	Basmati	60-75	30	-	25

(Kamboj, *et al.*, 2012)

competitive benefit over newly emerged weeds compared with emerging DSR seedlings (Rao *et al*., 2007). Densities of barnyard grasses, climbing dayflower (*Commelina diffusa* L.) and purple net sedge (*Cyperus rotundus* L.) increased in DSR compared with TPR during field experiment from 2000 to 2004 in India (Singh *et al.*, 2005). The rapid shift in weed flora with an increased population of *Echinochloa crus gulli*, *E. colona, Ischaemum rugosum* and *Leptochloa chinensis*, *Cyper rotundus*. was also observed during the 2012-13, both weak monsoon *i.e.* 70-80 per cent less rainfall and interrupted electricity supply resulted in poor irrigation. Grasses such as *Echinochloa colona*, *E. cruss-gulli* infestation occurred repeatedly, *Dactyloctenium aegyptium, Leptochloa chinensis* and *Eragrostis japonica*, broadleaves; *Commelina diffusaand* and sedges; *Cyperus difformis* and *C. rotudus* were dominant due to frequent and long dry spells.

As per the mandates of the KVK to demonstrate the front line technology developed by the research institutes/ SAUs. Pendimethalin (Stomp) @ 1 kg a.i./ha in case of wattar sowing and oxadiargyl (Top star) @ 0.09 kg a.i. /ha in dry-DSR were observed, effective as pre-emergence application. After 15-25 DAS, bispyribac alone or bispyribac plus pyrazusulfuron (Saathi) are generally suggested to control weeds. It was found that with the application of these post emergence herbicide, grasses such as *Echinochloa* excluding *leptochloa* and sedges *cyperus eria* and *C. rotundus* were controlled effectively.

Irrigation application :

In wattar sowing first irrigation can be avoided up to 3-10 days till the germination has taken place. But in dry sowing frequent 2-3 light irrigations were applied for not allowing the surface to be white (absolute dry). Avoid standing of water after first irrigation in Dry-DSR, because it may cause seed rotting. To ensure uniform application of irrigation water, the land should be laser leveled. Gopal *et al.,* 2010 recommended avoiding water stress and keeping the soil wet at the tillering, panicle initiation and grain filling stages, because these are the critical stages for rice.

Economics :

At present 23 per cent of the rice is cultivated through the direct seeded technology globally. Direct seeded rice has received much attention, because of low input demand including labor and water and both of them are going to be scarce in the coming years (Farooq *et al.*, 2011). High weed infestation and poor crop stand in DSR lead to lesser yield as compared to TPR (Singh *et al.*, 2005). Moreover, cost of production is less in DSR, while weed control is usually cheaper in TPR. The yield of DSR during 2010-11, however, low as compared to TPR, due to poor weed control as well as flood during the season. But, better crop establishment and weed control, the yield of DSR was at par with TPR and so far the returns during 2011-12 (Table 2 and Table 3 b). The DSR method resulted in higher economic returns than traditional puddle rice, which is subjected to lower cost of cultivation.

Impact :

Earlier, the farmers were not convinced, but through the extension activities such as: OFTs (on farm trial), FLDs (front line demonstrations), trainings, traveling seminars, method demonstrations, printing material and media, this technology was disseminated among the farmers of Ambala gradually they started believing this technology. This technology was started with 0.4 ha in 2009, which increased to about 25 ha in 2011 and 1000 ha in 2012. As the horizontal expansion area (Table 7) shows, the area under DSR is expanding year by year and momentum is likely to be caught in the coming years. In 2012, various other government bodies *i.e.* Department of Agriculture, Ambala; Assistant Agricultural Engineering deptt., Ambala and private seed companies have accelerated the movement and now more than 10 direct seeding drills are available in Ambala.

Table 7: Year wise area under DSR (ha)

Sr. No.	Year/ season	Area under DSR (ha)
1.	2009 *Kharif*	0.40
2.	2010 *Kharif*	8.00
3.	2011 *Kharif*	25.00
4.	2012 *Kharif*	1000.00

Scope :

Ambala is facing the problem of groundwater depletion and low productivity of wheat. The state department of Agriculture has already categorized it under black-zone. It was well aware of the adverse effects of puddling on physical properties of soil and on succeeding non-rice crop mainly wheat, whose productivity has been stagnant over the past few years. Gangwar *et al.*, 2010 reported increase in productivity of wheat, which is attributed to reduced compaction (bulk density) and high infiltration rate *i.e.* better soil physical environment in DSR. The DSR technology, however, requires 5 person-days ha^{-1} to TPR which in comparison needs 25-50 person-days ha^{-1} (Balasubramanian and Hill, 2002; Dawe, 2005) means lesser labour input in DSR.

It was also observed similar results of increase in wheat productivity at KVK. During 2011-12 *Rabi* season, the same variety of wheat (HD-2733) was sown on the two parallel plots of rice. During previous year, one field was of direct seeded and other was traditional puddled rice field and same variety of rice (PUSA-1121) was grown on both the plots. The yield of direct seeded rice was at par with TPR with average yield of 41.50 q/ha against 42.00 q/ha of TPR. The yield of wheat was increased by 10-15 per cent on direct seeded plot (55.75q/ha) as compared with the average yield of wheat on the TPR field (51.00 q/ha). Hence, on the front of water scarcity and escalating labor rates, stagnant wheat productivity, direct seeded rice offers better alternative of traditional puddled rice.

Needs :

Weeds, if not managed timely, may reduce yield. Therefore, apply suitable herbicides timely to ensure the control over weeds. Sustainable integrated weed management technologies/strategies need to be developed, because weeds are the major threats to the direct seeded rice. Improved varieties suitable for aerobic conditions with early vigor, short duration and disease resistant must be developed for its wide scale adoption.

Authors' affiliations :

AFZAL AHMAD, UPASANA SINGH AND RAMESH KUMAR, Krishi Vigyan Kendra, AMBALA (HARYANA) INDIA

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