Current Journal of Applied Science and Technology

37(6): 1-7, 2019; Article no.CJAST.52049
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Direct Seeded Rice: An Emerging Resource Saving Production Technology of Rice in Bhagalpur District (Bihar)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2019/v37i630323
Reviewers and Editors: This manuscript was reviewed and approved by ICCRM-2019* Organising committee.

Original Research Article

Received 23 September 2019
Accepted 02 October 2019
Published 15 October 2019

ABSTRACT

The study was carried out at the farmer fields during *Kharif* season (2015-16 to 2017-18) in seven villages of four blocks of district Bhagalpur, Bihar. All 54 demonstrations on rice crop were demonstrated in 29 ha area by the active participation of farmers with the objective to show and popularize the improved technologies of rice production (Direct Seeded Rice-DSR) potential developed at Bihar Agricultural University Sabour, Bhagalpur (Bihar). Specifically it examines the changes in farmers' inputs (labour and materials) and level of productivity and incomes between direct-seeded rice (DSR) and traditionally transplanted rice (TPR) and finally measures the economic return on investment in direct seeding. Analyses included comparison of means of all inputs, cost and return and economic surplus framework. Results revealed that the average yield of all farmers under DSR was 2.60% lower than TPR. However, on comparing the cost of cultivation of DSR farmers with TPR farmers, it was observed that the DSR farmer had (a) higher expenditures on herbicides; (b) lower expenses on fertilizer, fuel, and rent cost for land preparation and (c) lower labour costs for seedbed preparation and care, crop establishment and fertilizer application. In this way the sum of the total cost of cultivation in DSR was reduced by Rs. 8941 /ha than TPR. DSR also recorded the maximum net return (Rs. 42857/ha) and benefit: Cost ratio (2.95).

On the basis of above findings it may be concluded that the DSR method of rice cultivation is more economical than TPR as it reduced the cost of cultivation by 37.9% and gave maximum net return as well as benefit cost ratio.

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** Note: This paper was presented in International Conference on Crop Residue Management (ICCRM-2019), October 14-15, 2019, Patna, Organised by Bihar Agricultural University, Sabour, Bhagalpur - 813210 (Bihar), India. Conference organising committee completed peer-review of this manuscript.*

Keywords: Economics; Direct Seeded Rice (DSR); transplanted rice (TDR); yields.

1. INTRODUCTION

Rice *(Oryza sativa* L.) is one of the most important and extensively grown crops in tropical and subtropical regions of the world and a staple food for more than 70% of the world population. Rice–wheat cropping system is the dominating cropping system in Indo-Gangetic Plain (IGP), which covers an area of 10.5 m ha in India [1]. India ranks first in acreage (43.86 m ha), second in production (104.80 m t) after China, contributing about 20% of the world rice production [2,3] with average productivity of 23.90 q/ha. The demand for food grains in India is increasing day by day and the requirement by the year 2025 is estimated to be increased by 40 per cent as compared to 2003-04. According to Food and Agriculture Organization (FAO), food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Dev and Sharma, 2010). To sustain present food self-sufficiency and to meet future food requirements, there is need to increase rice productivity by 3 per cent per annum. The productivity and sustainability of rice based systems are threatened due to shrinking resources, especially land, labour and water, under changing climate scenario. In addition, emerging socio-economic changes such as urbanization, migration of labour, preference for nonagricultural activities etc increases the cost of cultivation. TPR is a traditional method of cultivation of rice which influences soil health owing to dispersion of soil particles and consequent compaction of the soil. In addition, it is not much relevant in the changing climatic scenarioas it has a substantial contribution to the greenhouse gases emission, particularly methane (CH4) [4]. The efficient agronomic management and technological innovations are needed to address these issues. Direct-seeded rice (DSR) is becoming more popular establishment method over traditionally transplanted rice [5]. The area under direct-seeded rice (DSR) systems is now expected to increase in the future because of labour and water shortages. Keeping the view in consideration the field demonstrations were conducted to explore the impact of DSR technology over TPR with respect to net return per rupee investment.

2. MATERIALS AND METHOD

The front line demonstration was conducted in *Kharif* season of three consecutive years 2015-16 to 2017-2018 by the Krishi Vigyan Kendra Sabour, Bhagalpur district of Bihar in 29 ha at 54 farmer's field of seven villages of four blocks of Bhagalpur district for resource conservation in rice by introducing direct seeded rice (DSR). The soils of the experimental fields was sandy clay loam to clay loamy in texture, with average pH 7.6, organic carbon 0.45%, available N 213.1 kg/ha, P_2O_5 20.7 kg/ha, K_2O 197 kg/ha. Krishi Vigyan Kendra, Sabour is located in the Eastern part of Bihar and lies between 24°30"and 25°30" at North latitude and 86°30" and 87°30" East longitude at an elevation of around 55 Meter above the mean sea level. Interested large, medium and small holding farmers were purposely selected for Direct Seeded Rice (DSR). A group of co-operative farmers were identified based on their participation and feedback received during the preliminary survey and interactive meeting. Land labeling was completed after harvest of rabi crops through laser land leveler for uniform irrigation water standing, seed germination, weed control. After Land labeling, soil was pulverized conventionally with the help of 2-3 harrowing followed by planking for DSR. Direct seeded rice was sown in lines giving row-to-row spacing of 20 cm using a seed rate of 30 kg/ha at 2.5-3.0 cm depth with the help of multi crops planter machine. Whereas, traditionally transplanted rice fields were conventionally-tilled as DSR and puddled for smooth transplanting of rice seedlings. Sowing of rice seed in main field for DSR and sowing rice seed in nursery for TPR was done on same date. Whereas, 2-3 healthy seedling of 20-25 days old were transplanted/hill at a spacing of 20 cm × 15 cm in TPR. Rajendra Sweta variety was used for both DSR and TPR in all experimental years. Sowing of seeds in nursery for TPR as well as for DSR was done in first fortnight of June before onset of moonson. Seeds were treated with Carbendazim @ 2.5 g/kg seed, Chloropyriphos (20%) @ 8.0 ml/kg seed, *Azotobacter* culture @ 20 g/kg seed, PSB culture @20 g/kg seed before sowing of seed in main fields/nursery plots. The recommended dose of fertilizer (100 kg N, 40 kg P_2O_5 and 20 kg K_2O) was applied through urea, diammonium phosphate (DAP) and muriate of potash (MOP). Half dose of N and full dose of P_2O_5 & K_2O were applied as basal and remaining half dose of N

Table 1. Technology demonstrated in traditionally transplanted rice (TPR) and direct seeded rice (DSR)

S. No.	Technological intervention	Transplanted rice (TPR)	Direct seeded rice (DSR)
1.	Land labeling in summer	Not used	Through laser land leveler
2.	Soil condition	Upland to low land	Upland to medium land
3.	Variety	Rajendra Sweta	Rajendra Sweta
4.	Seed rate	30 kg/ha	30 kg/ha
5.	Seed treatment	Carbendazim @ 2.5 g/kg seed, Chloropyriphos (20%) @ 8.0 ml/kg seed, *Azotobacter* culture @ 20g/kg seed, PSB culture @20 g/kg seed	Carbendazim @ 2.5 g/kg seed, Chloropyriphos (20%) @ 8.0 ml/kg seed, *Azotobacter* culture @ 20 g/kg seed, PSB culture @20 g/kg seed
	Sowing time	First fortnight of June	First fortnight of June
6.	Sowing /establishment method	21-25 days old seedling transplanted at 20x15 cm in puddled condition	Seed sowing at 20 cm and 2.5-3.0 cm depth by multi crops planter machine in pulverized dry condition
7.	Gap filling	Not used	15-20 days after sowing
8.	Fertilizer application	100:40:20 kg NPK/ha	100:40:20 kg NPK/ha
9.	Weed management	Bispyribac Sodium 25 g a.i./ha +Pyrazosulfuron ethyl @ 25 g a.i./ha as post emergence	Pendamethalin @ 1.0 kg a.i./ha followed by Bispyribac Sodium 25 g a.i./ha +Pyrazosulfuron ethyl @ 25 g a.i./ha as post emergence
10.	Irrigation	Water stagnation	Light irrigation at 30 DAS like wheat
11.	Drainage	Not practice	Good drainage facility essential

was applied as top dressing in two equal splits at tillering and panicle initiation stages. Weed control in DSR was done by using Pendamethalin @ 1.0 kg a.i./ha as pre-emergence with 600-700 litres of water just after sowing followed by tank mixed Bispyribac Sodium 25 g a.i./ha + Pyrazosulfuron ethyl @ 25 g a.i./ha as post emergence at 18-20 days after sowing using knap-sack sprayer fitted with flat-fan nozzle. While, In TPR only post-emergence herbicide *i.e.* Bispyribac Sodium 25 g a.i./ha +Pyrazosulfuron ethyl @ 25 g a.i./ha was used at 18-20 DAT. Irrigation was given to maintain soil water level at field capacity in DSR, whereas, in TPR 5.0 cm depth of water was applied in each irrigation after complete disappearance of water (Table 1). The crop was raised under irrigated condition under the recommended package of practices. Yield attributes and yields (grain and straw) of crop were recorded at harvest stages. Gross and net returns were calculated based on grain and straw yields and their prevailing market prices, while benefit: cost ratio was calculated by dividing gross returns by total cost of cultivation.

Demonstrated crops were visited regularly by the scientists of KVK during different stages of crop growth and upgraded the skill of beneficiaries during the course of training and visit programme that helped them in performing various field operations like labeling, sowing, irrigation, spraying, weed control, harvesting etc. Finally field day/crop cutting was demonstrated before farmers in the villages and local extension functionaries to show the superiority of the technology for the disseminating the message at large scale. Feedback information were received from the farmers during training, visit field day/crop cutting for further improvement in research and extension programmes.

3. RESULTS AND DISCUSSION

3.1 Weeds Density

Data recorded on weed intensity at 20 days after pre-emergence application of pendimethaline in DSR and 20 days after transplanting of TPR without using any herbicide revealed that the intensity of weed flora *Echinochloa colona, Echinochloa crus-galli, Dactyloctenium aegyptium*, *Leptochloa chinensis, Cyperus rotundus, Cynodon dactylon, Digitaria sanguinalis, Elusine indica, Commelina benghalensis, Eclipta alba* etc., in DSR before post emergence was comparatively higher than the TPR (Table 2). However, the weed intensity of all categories at 30 DAS and DAT after using of Bispyribac Sodium 25 g a.i./ha +Pyrazosulfuron ethyl @ 25 g a.i./ha as post emergence at 18-20 DAS/DAT was counted almost similar with little bit differences It is clear from the Table 2 that the grassy weeds were pre-dominant than broad-leaf and sedge weeds in both DSR and TPR at 20 days after sowing/transplanting. Similar findings have also been made by Singh et al. [6] and Baghel et al. [7]. They reported the effective weed control in DSR by using the pre-emergence pendimethalin and post-emergence bispyribac Sodium + Pyrazosulfuron ethyl. Lower weed intensity at initial stage in TPR was mainly due to destruction of weeds through puddling. Mishra and Singh [8] also confirmed the present finding. Buhler et al. [9] reported that, reduced tillage in DSR caused heavy weed infestations, which subsequently increased dry matter of weed.

3.2 Yield and Yield Attributing Characters

The yield attributing characters viz. plant height, number of panicles/m^2, panicle length, filled grains/panicle and 1000-grains weight in TPR was slightly higher than DSR in all the experimental years (Table 3). Higher numbers of panicles/hill and grains/panicle in TPR method was reported in Wahlang et al. [10]; while significantly lower spikelets/panicle in DSR compared to TPR was also mentioned Mallareddy and Padmaja [11]. Unfilled grains showed almost similar in both TPR than DSR. Similar result has also been made by Shahane et al. [12].

Table 2. Weed density at before and after herbicide application in DSR and TPR (three years mean)

Treatment	No of grassy weeds/m^2		No of broad-leaf weeds/m^2		No of sedges weeds /m^2	
	BHA* at 20 DAT/DAS	AHA** at 30 DAT/DAS	BHA* at 20 DAT/DAS	AHA** at 30 DAT/DAS	BHA* at 20 DAT/DAS	AHA** at 30 DAT/DAS
TPR	6.4	1.3	1.9	0.5	0.6	0.2
DSR	11.7	1.1	3.7	0.7	3.1	0.2

Note: BHA- Before post-emergence herbicide, AHA**- After post-emergence herbicide*

Table 3. Effect of establishment methods on yield and yield attributes of rice

Year	No. of farmer	Area (ha)	Yield attributes										Yield (q/ha)		% Increase to DSR
			Plant height (cm)		Panicles/m^2		Panicle length (cm)		Filled grain/panicle		1000-grain wt. (g)				
			DSR	TPR	DSR	TPR	DSR	TPR	DSR	TPR	DSR	TPR	DSR	TPR	
2015-16	15	12	112.9	116.5	339	345	21.7	22.4	205	213	13.9	14.3	36.5	37.2	-1.90
2016-17	20	10	116.4	119.2	371	386	25.1	26.0	232	227	14.5	14.9	42.4	43.8	-3.19
2017-18	19	07	120.7	124.6	356	364	23.7	24.4	218	237	14.1	14.9	39.7	40.8	-2.70
Total/mean	54	29	116.7	120.1	355.3	365.0	23.5	24.3	218.3	225.7	14.2	14.7	39.5	40.6	-2.60

Table 4. Effect of establishment methods on economics of rice

Year	Direct seeded rice (Rs./ha)				Transplanted rice (Rs./ha)			
	Gross Cost	Gross Return	Net Return	B:R	Gross Cost	Gross Return	Net Return	B:C
2015-16	20400	49900	29500	2.45	26650	50670	24020	1.90
2016-17	21798	67680	45882	3.10	32350	69910	37560	2.16
2017-18	23101	76289	53188	3.30	33122	78415	45293	2.37
Total/mean	21766	64623	42857	2.95	30707	66332	35624	2.14

Data on account of yield performance of transplanted rice (TPR) and direct seeded rice (DSR) for three years presented in Table 3 obviously indicated that the DSR method produced slightly lower grain yield of 39.5 q/ha as compared to 40.6 q/ha under traditionally transplanted rice (TPR). Slightly higher yield (2.60%) in TPR produced than direct seeded rice (DSR) was mainly due to lower weed intensity that increased the yield attributes and ultimately the yield. Chapagain et al. [13] also reported similar results from SRI and TPR, while in another study Hugar et al. [14] found higher grain yield in TPR than DSR.

3.3 Economics

Data presented in Table 4 clearly indicated that the DSR method incurred the maximum net returns of Rs. 42857 /ha with minimum total cost of cultivation of Rs. 21766 /ha. Maximum cost of cultivation (Rs. 30707/ha) was involved in TPR. The reduction in cost of cultivation in DSR to the tune of Rs, 8941/ha as compared to TPR was mainly due to increase in farm labours in various field operations like nursery preparation, transplanting, field preparation and irrigation water etc. The highest benefit: cost ratio (2.95) was also incurred in DSR method, which accounted 37.9% higher over traditionally transplanted rice (TPR).

4. CONCLUSION

Present study demonstrates the newly released crop production and protection technologies and management practices at the farmer's field under real farming situation. It can be inferred from the data that the direct seeded rice (DSR) method is more economical and beneficial for the rice growers as it reduced the cost of cultivation to the tune of Rs 8941/ha and increased the benefit :cost ratio by the margin of 37.9% over traditional transplanted rice method (TPR).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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