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Performance evaluation of Direct-Seeded Rice (DSR) conventional transplanted rice in Bihar

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ABSTRACT

An experiment was conducted during *kharif* 2018 at the experimental farm of Dr. Rajendra Prasad Central Agricultural University, Pusa and Bihar Agricultural University, Sabour with popular varieties of paddy to study growth, yield and economic assessment under three paddy production systems as treatments T_1, T_2 and T_3 i.e Dry-DSR by rice-wheat seeder equipment, Dry-DSRB by broadcasting of seeds and TPR: manual transplanting of seedling in puddled soil, respectively. The cultivars, viz. Rajendra Bhagwati, Rajendra Saraswati and Rajendra Sweta, recorded maximum yield 5.59 t/ha, 5.16 t/ha and 4.16 t/ha in treatment T_1, followed by treatment T_3 (5.23 t/ha, 4.92 t/ha and 3.75 t/ha), respectively. The yield of Rajendra Bagwati and Rajendra Saraswati in treatment T_2 was 4.75 t/ha and 4.86 t/ha, respectively. Benefit-cost ratio of Rajendra Bhagwati in treatments T_1, T_2 & T_3 were found 4.38 : 1, 3.74 : 1 & 3.19 : 1, respectively followed by Rajendra Saraswati and Rajendra Sweta with values in ratios 3.97:1, 3.85:1 & 2.97:1 as well as 2.97:1, 2.84:1 and 1.99:1, respectively. Obviously, the Dry-DSR of by rice wheat seeder equipment has been found economical viable technology for growing rice in respect of yield and net benefit.

Keyword: Benefit cost ratio, Direct seeded rice, Economics, Puddling, Transplanting, Yield

Rice is the staple food of India and is cultivated about 32.0 lakh ha in Bihar. Transplanting of seedlings in puddled field is in practice, which is very cumbersome, labour intensive and energy consumptive as it requires 30 man-days/ha (Prasad *et al.* 2001). Un-availability of labour for timely transplanting of seedlings, increased wages and depletion of ground water are intricately linked with present rice production system. The conventional method is observed as a major source of greenhouse gas (GHG) emission, particularly methane causing global warming and climate change. The inter-Governmental panel on climate change (IPCC 2007) had projected a temperature increase between 1.1°C and 6.4°C by the end of 21st century. The productivity and sustainability of rice-based systems are threatened because of (1) the inefficient use of inputs; (2) increasing scarcity of resources, especially water and labor; (3) changing climate; (4) the emerging energy crisis and rising fuel prices; (5) the rising cost of cultivation; and (6) emerging socioeconomic changes (Ladha *et al.* 2009). In the Indo-Gangetic Plains (IGP) the yield stagnation/decline has been observed in recent decades (Ladha *et al.* 2003, Pathak *et al*. 2003). However, increase in rice production and productivity is need of hour for increasing population and expected diet change (Joshi *et al.* 2009). Advantages of potential saving water 35–55% (Lav *et al*. 2007), reduction drudgery to farmer and man power reduction 11-66% (Isvilanonda 2002, Kumar *et al.* 2009, Rashid *et al.* 2009) of Direct Seeded Rice (DSR) over the conventional rice transplanting, thereby found promising the DSR (Gupta *et al.* 2006).

Dry DSR with reduced tillage using tractor is limiting in fragmentated small land holding and taking slow pace. In light of facts, the Rice-Wheat Seeder, light in weight, easy in operation and efficient in seeding of rice in inter and intra- rows at definite spacing has been developed by Dr. Rajendra Prasad Central Agricultural University, Pusa (ICAR 2020). The present study was undertaken to study the direct seeded rice with Rice-Wheat Seeder in comparison with conventional transplanting of rice as well as broadcasting of dry rice seed in Bihar condition.

MATERIALS AND METHODS

An Experiment was conducted during *kharif* 2018 at the experimental farm of Dr. Rajendra Prasad Central Agricultural University, Pusa (Latitude 25.9^{0}N, Longitude 85.7^0 E) of calcareous sandy loam soil and the K.V.K, Sabour of the Bihar Agricultural University, Sabour (Latitude 25.23^0 N, Longitude 87.07^0 E) of sandy loam soil, located in the state of Bihar. The popular cultivars of rice of Bihar (Rajendra-Bhagwati, Rajendra-Saraswati and Rajendra-Sweta) were undertaken for the study.

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The three rice establishment techniques were: Direct seeding of dry paddy seeds in pulverized soil by manually operated Rice-wheat seeder equipment (T_1); Direct seeding of dry paddy seeds in pulverized soil by broadcasting (T_2); and manual transplanting in puddled soil (T3). These establishment methods, viz. T_1, T_2 and T_3 falls under category of Dry-DSR, Dry-DSRB and puddling & transplanting rice seedlings: TPR., respectively. Three replications for each treatments of each plot measuring 54 m × 64 m were randomized. The experimental plots were prepared with cultivator and rotavator after harvesting of preceding crop. The plots for T_1: Dry-DSR were pulverized by one pass of cultivator followed by two passes of rotavator. For treatment T_2: Dry-DSRB primarily field was prepared by operating cultivator followed by rotavator in one pass followed by another one pass after broadcasting of seeds, second pass of rotavator was done to cover seeds with soil. However, the plots of T_3: TPR were puddled by using Rotavator at the time of transplanting, as an additional operation to achieve puddling index in the range of 85–90%.

Seed rate treatment T_1 (Dry-DSR by rice- wheat seeder) was adjusted for 24–26 kg/ha. The seed rate could not be fixed in using Rice-Wheat Seeder due to its seed metering and delivery system. The seed rate was maintained at the rate 30.0 kg/ha for treatment T_2 (Dry-DSRB). Sowing of dry rice seed for treatment T_1 and T_2 was done 25 days advanced than date of transplanting to maintain uniformity among the treatment. The nursery for transplanting was done about 25 days in advance of date of transplanting for treatment: T_3 (TPR). The T_1 and T_2 plots were irrigated within 24 hr of seeding. Water levels were maintained in the plots of T_3 as conventional practice. In all treatments N, P, K were applied in the ratio of 100: 60: 40 in split doses in the ratio of 50: 25: 25. Weeds were controlled by two weeding for treatments T_1 and $T_{2,}$ in which first weeding was done by Cono-weeder at 20 days after seeding (DAS) and the second weeding was performed by manual labour at 45 DAS. In treatment, T_3 single weeding was done at 45 DAS with Cono-weeder.

The cost of operation of all the three treatments was computed by standard economic analysis method using fixed cost and variable cost. The fixed cost was reckoned by using the Straight-line method for computation of depreciation value. The cost of Rice-Wheat Seeder was taken ₹12000 and considering field capacity: 0.18 ha/h, field efficiency: 84%, annual use: 100 h and service life: 8 years. The seeder (T_1) required 5 man-days/ha for seeding rice seed. However, the treatment T_2 and T_3 required 2 man-days/ha and 25 man-days/ha for broadcasting and transplanting, respectively. The prevailing labour rate ₹300/day was considered for the study. Different economic indicators, viz. cost of cultivation, gross return, net returns and benefit: cost ratio were calculated based on the existing price of the inputs and outputs. Grain and straw cost were worked out considering @ ₹15000/ton and @ ₹15000/ton the prevailing market price of grain and straw, respectively. The plant height was measured with the help of steel scale. The height of rice plants in direct seeded experimental (T_1 and T_2) plots was initially measured at 20 days after seeding. The subsequent measurements were done at interval of 15 days up to the last measurement conducted at 65 days after seeding. In treatment (T_3) with transplanted rice, plant height was started measuring after 10 days transplanting (35 DAS days after seeding) and continued up to 65 days after seeding at an interval of 15 days.

After the harvest maturity, five randomly selected each of 1 square meter area crop from each experimental plot crop was harvested. Yield attributing parameters, viz. number of effective tillers, grains per tiller and weight of 1000 grains were recorded. The yield per square meter area was computed and converted to hectare basis for each plot thereby average value was reported for respective treatment.

RESULTS AND DISCUSSION

Plant growth parameter measured in terms of plant height at different stages (20, 35, 50 and 65 DAS) of plant growth was found expressively higher under direct seeding condition: T_1 (Table 1) than Dry-DSRB: T_2 irrespective of cultivars under the study. It might be due to field plant geometry attained by rice-wheat seeder equipment designed characteristic i.e. row-row distance about 23 cm and plant to plant distance in range of 15-20 cm. The planting geometry might help the crop in receipting optimum quantity of essential inputs e.g. sun-light, air, nutrients etc., responsible for better plant growth. On contrary, plant matrix in Dry-DSRB: T_2 plots were found such as that it was intercepting plant growth essential inputs and thereby affecting plant growth adversely. However, plant height in treatment T_3 for Rajendra Bhagwati was found at par with treatment T_1 at all stages of growth measurement. Transplanted rice (T3) of Rajendra Saraswati had registered better growth as compared to the treatment T_1 and T_2. The outspreading bending leaf of the above two varieties may be responsible for better growth on account of larger canopy area responsible of receiving of higher amount of sunlight. The Rajendra Sweta

Table 1 Effect of seeding or transplanting on plant growth

Variety	Treatment	Plant height at different intervals in days after seeding: cm			
		20 DAS*	35 DAS	50 DAS	65 DAS
Rajendra Bhagwati	T_1	15.6	25.3	39.7	61.4
	T_2	13.8	23.2	36.8	58.6
	T_3	----	25.0	40.5	61.3
Rajendra Saraswati	T_1	17.2	25.8	41.3	64.5
	T_2	15.9	24.1	39.5	61.9
	T_3	------	26.3	41.8	63.8
Rajendra Sweta	T_1	13.7	24.5	35.3	55.7
	T_2	12.5	22.7	34.0	53.6
	T_3	-----	24.3	33.6	54.4

*DAS: days after seeding

variety had plants with erect leaf and this might have been a factor behind its lower height in treatment T_3 besides the disadvantage and advantage of transplanted paddy that it takes around a week time for root establishment after transplanting and registers almost no weed emergence at early stage of growth, respectively**.**

Perusal of data on yield indicates (Table 2) that T_1 was superior among all three cultivars under study in terms of yield over other two treatments T_2 and T_3. Rajendra Bhagwati had recorded maximum yield, 5.59 t/ha, in treatment T_1 followed by 5.23 t/ha in treatment T_3. However, treatment T_2 plots yielded minimum of 4.75 t/ha. A similar trend was followed in Rajendra Saraswati, maximum yield was found in treatment T_1 (5.16 t/ha) followed by treatment T_3 (4.92 t/ha) and treatment T_2 (4.86 t/ha). In case of Rajendra Sweta, yield was maximum in treatment T_1 (5.23 t/ha), followed by treatment T_2 (4.92 t/ha) and treatment T_3 (3.75 t/ha). Dry-Dsr: T_1 demonstrated better in terms of number of grains per panicle and of higher test weight among all the treatments under study. However, number of panicle per square meter was found highest in case of TPR: T_3 followed by Dry DSR: T_1 and Dry DSRB: T_2. The yield of paddy in direct seeding by rice-wheat seeder for all the varieties may be highest because of better root establishment, higher effective tillers and uniform plant geometry. These results are in close conformity with finding of Bohra and Kumar (2015), Sharma *et al.* (2006), Gill *et al.* 2006 and Singh *et al.* (2005). In two varieties, viz. Rajendra Bhgwati and Rajendra Saraswati, yield of transplanted paddy was better than DSR by broadcasting and this may be because of characteristics of out spreading bending leaf of these varieties as well as on account of delayed weed infestation and growth after puddling operation.

In respect of third variety Rajendra Sweta, treatment T_2 had been yielded 3.87 t/ha higher than that of in treatment T_3:3.75 t/ha. It may be on account of higher amount of seed rate and higher number of seeds used in Dry-DSRB (broadcasting method). It has been also supported from the data of 1000 grain weight for this variety: 22.37 g, which is lowest from other varieties, i.e. Rajendra Bhagwati and Rajendra Saraswati. Scanning of data (Table 2) clearly illustrated that the cost of cultivation was maximum ₹26900.00 for TPR; T_3, followed ₹ 22050.00 in Dry-DSR; T_1 (₹). However, Dry-DSRB T_2 registered the minimum cost of cultivation ₹ 21400.00. However, the Dry-DSR: T_1 had been found highly profitable, followed by treatment T_2 and T_3, irrespective of cultivars under study as evident from the computed data of benefit-cost ratio (Table 2). In addition to direct immediate economic benefit of Dry-DSR: T_1 also effective in averting adverse effect of the growth and yield of subsequent crops induced by puddling operation in conventional rice system, on soil physical properties e.g. poor soil structure, sub-optimal permeability in the lower layers and soil compaction (Gathala *et al.* 2001). In case of Rajendra Bhagwati, B-C ratio for treatment T_1 was found to be 4.38: 1, followed by 3.97: 1 in treatment T_2 and 2.97: 1 in treatment T_3. The B-C ratio for Rajendra

Table 2 Effect of direct seeding and transplanting on rice yield and economic attributes

Treatment	Yield attributing parameter	Variety		
		Rajendra Bhagwati	Rajendra Saraswati	Rajendra Sweta
T_1: Dry-DSR	No. of panicles m^2	108.00	101.00	88.00
	Grains/panicle	206.00	211.00	207.00
	1000 grain wt.: g	25.13	24.22	22.82
	Yield: t/ha	5.59	5.16	4.16
	Cost of cultivation: ₹/ha	22050.00	22050.00	22050.00
	Gross-return: ₹/ha	118710.00	109620.00	87600.00
	Net-return: ₹/ha	96660.00	87570.00	65550.00
	B-C ratio	4.38: 1	3.97: 1	2.97: 1
T_2: Dry-DSRB	No. of panicles/ m^2	97.00	101.00	94.00
	Grains/panicle	201.00	198.00	181.00
	1000 grain wt.: g	24.34	24.30	22.75
	Yield : t/ha	4.75	4.86	3.87
	Cost of cultivation: ₹/ha	21400.00	21400.00	21400.00
	Gross-return: ₹/ha	101490.00	103860.00	82170.00
	Net-return: ₹/ha	80090.00	82460.00	60770.00
	B-C ratio	3.74: 1	3.85: 1	2.84: 1
T_3: TPR	No. of panicles/ m^2	112.00	104.00	91.00
	Grains/panicle	186.00	200.00	184.00
	1000 grain wt: g	25.09	23.65	22.37
	Yield: t/ha	5.23	4.92	3.75
	Cost of cultivation: ₹/ha	26900.00	26900.00	26900.00
	Gross-return: ₹/ha	112830.00	106860.00	80550.00
	Net-return: ₹/ha	85930.00	79960.00	53650.00
	B-C ratio	3.19: 1	2.97: 1	1.99: 1

Sweta in treatment T_1, T_2 & T_3 were 2.97: 1, 2.84: 1 & 1.99: 1 respectively. Rajendra Saraswati had registered B-C ratio 3.97:1 for treatment T_1, 3.85:1 for T_2 and 2.97:1 for treatment T_3 respectively.

Reasons behind highest B-C ratio for all selected paddy varieties in treatment T_1 is quite obvious and definitely it is on account of enhancement of yield of crop as well as due to reduction in cost of cultivation. Although for two varieties, Rajendra Bhagwati and Rajendra Saraswati, yield of crop in treatment T_3 was marginally high as compared to treatment T_2, the lowest cost of cultivation in treatment T_2 had affected the economics of production. In third variety Rajendra Sweta, yield of crop twined with the reduction in cost of cultivation had effect on economics of production. Direct seeding of dry seeds of paddy by Rice-wheat seeder equipment was found superior for paddy cultivation as compared to farmer's practice of growing transplanted paddy as well as the direct seeding of dry seeds by broadcasting method, in respect of plant height, grain yield and the economics of production as expressed in terms of Benefit-Cost ratio. For varieties with outspreading bending leaf, transplanting of seedlings was found to be better to achieve more yield than the DSR by broadcasting. For variety with erect leaf, DSR by broadcasting was superior in grain yield. However, due to diminished cost of cultivation, economics of production of DSR by broadcasting was better than transplanted paddy.

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