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Research Article

IMPACT OF DIRECT SEEDED RICE ON ECONOMICS OF PADDY CROP IN HARYANA

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Abstract- A study concerned about an assessment of the resource and environmental constraints and cost analysis of transplanted rice (TPR) and direct seeded rice (DSR) is made in agri-economics context to suggest options for promotion of DSR in India. Results showed that net return was higher in DSR (Rs. 60105) as compared to TPR (Rs. 57532.5) and B:C ratio was found 2.13 in DSR while it was only 1.94 in TPR. Thus, net returns were 4 % higher in DSR than TPR method as cost of cultivation was 15% less in DSR. Moreover, technical efficiency of DSR was found to be 92% whereas it was 87% in case of TPR. In case of DSR system, economic efficiency measure was 0.52 as compare to 0.32 in TPR system. It was observed that farmers could save 55% human labour, 10% machine labour and 33% irrigation water in DSR as compared to transplanted rice. The results showed that DSR method of paddy cultivation was more economically efficient compared to TPR system.

Keywords- DSR, Economics, Rice, TPR

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Introduction

India is the second largest producer of rice in the world with an average annual production of 94 million tonnes (Government of India, 2011) and fulfils 43 percent of calories requirement of more than 70 percent of the Indian population. This signifies the contribution of rice in meeting food requirements of the hungry mouth of country. But now day crop yield stagnation as well as no further increment in crop yield is emerging challenge for researchers [1]. It accounts for approximately 21% of world's rice production [2]. Haryana produces 3.5 million tonnes of rice and contributes approximately 3.7% to India's total rice production with per hectare productivity of 3.03 tonnes [3]. In Haryana, rice is grown by transplanting during wet season from June to October. The demand of cereals to meet the food necessity is rising of increasing population, while on the other hand most important inputs (water, labour) of agriculture are decreasing in the area. The traditional system of rice production (conventional tilled-transplanted rice) in this region is basically water, labour and energy intensive, adversely affecting the environment. Therefore, to sustain the long-term production of rice, more efficient alternative methods of rice productions are needed [4]. In recent years, water table is running down at a very rapid rate throughout the globe, thus, poses alarming threats and limiting the scope for cultivation of high water requiring crops very seriously. Therefore, there is an immense need of searching alternate method of rice cultivation [5] and direct seeding of rice is one of the appropriate methods. Direct seeding of rice refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery. In Asia, rice is commonly grown by transplanting one month-old seedlings into puddled and continuously flooded soil (land preparation with wet tillage). The TPR system leads to more losses of water through puddling, surface evaporation and percolation [6].

DSR is a feasible alternative to conventional puddle transplanted rice with good potential to save water, reduce labour requirement, and mitigate green house gas (GHS) emission. However, the DSR suffers from some constraints particularly high weed infestation. The system has been proved cost–effective but it requires further improvement in technological approach to realize greater benefits. Therefore, keeping in view the above concerns an assessment of the resource and environmental constraints and cost analysis of TPR and DSR is made in agro-economics context to suggest options for promotion of DSR in India. Similarly, direct seeding is becoming an attractive alternative to transplanting of rice and spreading rapidly in Haryana due to labour shortage and escalating cost of production.

Materials and Methods

Data Sources

Both secondary and primary data were collected for the study. Secondary data were collected from government statistical agencies.

Selection of district

Kaithal districts of Haryana were selected purposively on account of a large area under DSR of rice cultivation.

Selection of blocks and villages

Pundri, Kaithal and Rajound blocks were selected randomly from Kaithal district. Further from each block, two villages were selected randomly i.e. Sirsaland and Pabnawa were selected from Pundri block; Chandana and Guhna were selected from Kaithal block and Kukarkanda and Jakholi were selected from Rajound block.

Selection of farmers

Twenty farmers from each village were also selected randomly i. e. half of them adopted conservation agricultural practices (DSR) and half adopted conventional agricultural practices (TPR). Thus 120 farmers were selected. The primary data were collected on various aspects of conservation and conventional practices in wheat.

Analytical Tools
Keeping in view the stated specific objectives of the study, different statistical models (both tabular and functional analysis) were applied for the analysis of related data.

Cost Concepts
The total costs were divided into two broad categories.

(a) Variable costs
(b) Fixed costs

Returns measures
Gross returns: Gross returns were obtained by multiplying the total product with the price realized. Net returns over operational cost: Net returns were obtained by deducting the total costs incurred from the gross returns obtained. Benefit: cost ratio over operational cost: Returns per rupee of cost were obtained by dividing the gross returns with cost of cultivation.
Resource productivity in crop production
The specific Cobb-Douglas type of production function used for the study was:

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5^{b_5}X_6^{b_6}U \quad \text{......[1]}$$

Where,
Y = Gross returns (Rs./ha)
α = Intercept, a scale parameter
X1 = Human labour (Rs./ha)
X2 = Machine labour (Rs./ha)
X3 = Seed (Rs./ha)
X4 = Chemical fertilizers (Rs./ha)
X5 = Plant protection chemicals (Rs./ha)
U = Error term
bi = Output elasticities of respective inputs. The summation of these gave returns to scale.
The [Eq-1], upon logarithmic transformation took the linear form; the parameters were estimated using the Ordinary Least Square (OLS) method.
lny = lna + b1 ln X1+b2 ln X2+b3 ln X3 + b4 ln X4 + b5 ln X5+ b6ln X6+U ...[2]

Economic efficiency of conventional and conservational practices in wheat systems

Frontier production function analysis
To capture the ability of farmers to achieve the maximum realizable crop outputs with minimum level of inputs under the existing situation and given technologies, a careful examination of farm specific technical efficiency of the farmers was necessary.
The function in log form will be:

$$\sum_{i=1}^{n} \beta i\ In\ xi + U \text{ ln Y = A + U} \leq 0 \quad \text{........... [3]}$$

The above model was estimated using Corrected Ordinary Least Squares (COLS) regression. As a first step, Ordinary Least Squares (OLS) was applied to the regression equation to yield best linear unbiased estimates of βi coefficient. The function estimated was in the form below:

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5^{b_5}X_6^{b_6}U \quad \text{... [4]}$$

Where,
Y = Gross returns (Rs./ha)
α = Intercept, a scale parameter
X1 = Human labour (Rs./ha)
X3 = Seed (Rs./ha)
X4 = Chemical fertilizers (Rs./ha)
X5 = Plant protection chemicals (Rs./ha)
X6 = Irrigation (Rs./ha)
U = Error term
bi = Output elasticities of respective inputs.
The summation of these gave returns to scale.
[Eq-4] was estimated in log form using Ordinary Least Square test. The above equation was chosen in place of [Eq-2 and 3] to nullify the scale effect in assessing the technical efficiency. The frontier production function was derived from the Cobb-Douglas type production function fitted to the gross returns from crop cultivation. The technical efficiency was worked out using potential output that can be realized from a set of inputs. The potential gross returns are given by the following method:

Y* = Y + em ..... [5]

Where,
Y* = Potential gross returns that could be derived from crop cultivation
Y = Estimated gross returns from crop cultivation
em = Highest positive error term
The intercept estimate 'α' was then corrected by shifting the function until no residual was positive and one became zero. This was done by adding the largest error term of the fitted model to the intercept. The new production function with shift in the intercept in the frontier production function and it gave the maximum gross returns obtainable for given level of input and it would be of the form.

$$\sum_{i=1}^{n} \beta i\ In\ Xi + U \text{ ln Y* = A + U} \leq 0 \quad \text{........ [6]}$$

If the value of βi was negative, then the geometric mean of ithinput Xi was taken instead of βi ln Xi. The frontier production functions were estimated separately for canal irrigated and well irrigated farms.

Timmer's measure of technical efficiency
It was the ratio of actual gross returns to the potential gross returns on the production function given the level of input use on the ith farm.
Technical efficiency of ith farm = Yi / Yi*

Where,

Yi = Actual gross returns from crop cultivation on ith farm
Yi* = The potential gross returns attainable from crop cultivation on ith farm
(a) Allocative efficiency
(b)

$$\text{Allocative efficiency} = \frac{\text{VMP Xi}}{\text{MFCXi}}$$

$$\text{VMPXi} = \frac{\beta i\overline{Yi}}{\overline{Xi}} \quad \text{...... [7]}$$

Where,
VMPXi= Value marginal product of ith input
βi = Input coefficient of ith input
$\overline{Y}$ I = Geometric mean of gross returns of ith input
$\overline{X}$ I = Geometric mean of input of ith input
(d) Economic efficiency

Economic efficiency (EE) is the product of technical efficiency (TE) and allocative efficiency (AE)

EE = TE × AE ......[8]

Results and Discussion
Cost of Cultivation of Rice in Haryana among Different Practices
It was revealed from the data presented in [Table-1] that gross returns in DSR and TPR were Rs. 113155 and Rs. 118720/ha, respectively. Similarly, net returns

accounted for Rs. 60105 in DSR and Rs. 57532/ha in TPR. The net income was higher in DSR due to lower cost of cultivation. The total cost of cultivation amounted to Rs. 53050/ha in DSR method and Rs. 61187/ha in TPR method. The lower cost of cultivation was mainly due to lower expenses on human labour (55%), machine use (10%) and irrigation (33%) as shown in [Table-1]. The benefit: cost ratio of 2.13 was observed in DSR as against 1.94 in TPR (Trans Planted Rice) method. Similar findings were reported by [7] who reported that DSR lowers the cost of cultivation than TPR method of rice cultivation.

Table-1 *Cost and return in rice production under DSR and TPR methods in Haryana (Rs./ha)*

Particular	DSR	Per cent share	TPR	Per cent share
Labour	11250	21.20	17500	28.60
Machine	8000	15.08	8750	14.30
Seed	1300	2.45	812.5	1.32
Fertilizer	7625	14.37	6000	9.80
PPC	11375	21.44	10125	16.54
Irrigation	13500	25.44	18000	29.41
Operational cost (Rs)	53050		61187.5	
Gross income (Rs)	113155		118720	
Net income (Rs)	60105		57532.5	
B : C ratio	2.13		1.94	

Benefits of DSR over TPR in Input Use, Yield, Cost and Return

It was observed that through the DSR farmers could save 55% human labour, 10% machine labour and 33% irrigation water in DSR as compared to transplanted rice as mentioned in [Table-2]. The rice yield with DSR technology was lower by 5% than TPR method [Table-3]. Most of the farmers opined that weed management was a challenging task in DSR. In a similar study [8] reported that lower yield was obtained in DSR as compared to the TPR due to high weed manifestation. Therefore, the major challenge for farmers in direct seeded rice was effective weed management and as the failure to eliminate weeds may result in very low yield [9]. While [10, 11] in their studies have indicated that direct seeded rice has potential as a replacement of transplanted rice, if weeds are controlled effectively. The gross returns were higher in TPR by 5%. But higher net returns were obtained in DSR by 4% than TPR method. This was mainly due to reduction in the cost of cultivation (operational cost) by 15% in DSR method. The cost incurred to produce one kg of rice was Rs. 12.42 and Rs. 13.36 in DSR and TPR, respectively. The cost of production (Rs./kg) was lower by 10% in DSR as compared to TPR method. [12] in his study also revealed that profitability was higher in DSR than TPR due to considerable reduction in the cost of tillage operations.

Table-2 *Benefits of DSR over TPR in input use (Rs./ha)*

Particular	DSR	TPR	Gain (%)	Loss (%)
Labour	11250	17500	55	-
Machine	8000	8750	10	-
Seed	1300	812.5	-	37
Fertilizer	7625	6000	-	21
PPC	11375	10125	-	11
Irrigation	13500	18000	33	-

Table-3 *Gain and loss of DSR over TPR in paddy (Yield, cost and return)*

Particular	DSR	TPR	Gain (%)	Loss (%)
Yield (t/ha)	4.27	4.48	-	5
Operational cost (Rs./ha)	53050	61187.5	15	-
Gross returns (Rs./ha)	113155	118720	-	5
Net returns (Rs./ha)	60105	57532.5	4	-
Cost of production (Rs./kg)	12.42	13.66	10	-
B : C ratio	2.13	1.94	9	-

Resource Productivity in Rice Cultivation System

The regression coefficient which shows change in dependent variable due to unit change in input was worked out. The results showed that the regression coefficients under DSR for labour (0.266) and irrigation (0.278) were significant at 5% level of significance, respectively. The regression coefficients for machine (0.123) and seed (0.204) were positive but not significant. The coefficient pertaining to fertilizer (-0.250) was negative and significant at 1% level of significance. Whereas PPC (-0.250) was negative but non-significant as shown in [Table-4]. Adjusted R2 was 0.85. It reduced total variation associated with independent. In this model, variation reduced up to 85%. The regression estimates under TPR are presented in [Table-5]. The intercept, which represents the contribution of the factors that are not included in the model, was found to be 7.595. The adjusted coefficient of multiple determination was 0.814, indicating adequacy of fit for the model. The regression coefficients of irrigation (0.242) and fertilizer (0.106) were significant at 10 and 5%. The coefficient pertaining to labour (0.017), machine (0.078) and PPC (0.077) was positive but not significant, whereas seed (-0.306) was negative but non-significant.

Table-4 *Regression coefficient under DSR*

S. No.	Particular	Coefficient	Std. error	t- value
1.	Intercept	6.256	0.632	9.89
2.	Labour	0.266**	0.153	1.738
3.	Machine	0.123	0.141	0.879
4.	Seed	0.204	0.244	0.833
5.	Fertilizer	-0.250***	0.094	2.636
6.	PPC	-0.250	0.140	0.223
7.	Irrigation	0.278**	0.136	2.049
	Adjusted R^2	0.85		

***, ** and * Indicate significance at 1, 5 and 10% levels, respectively.

Table-5 *Regression coefficient under TPR*

S. No.	Particular	Coefficient	Std. error	t- value
1.	Intercept	7.595	1.332	5.701
2.	Labour	0.017	0.034	0.507
3	Machine	0.078	0.074	1.057
4.	Seed	-0.306	0.207	-1.475
5.	Fertilizer	0.106**	0.042	2.543
6.	PPC	0.077	0.052	1.465
7.	Irrigation	0.242***	0.063	3.828
	Adjusted R^2	0.814		

***, ** Indicate significance at 1 and 5% levels, respectively.

Technical Efficiency of DSR and TPR System of Rice Cultivation

The mean technical efficiency [Table-6] of rice cultivation under DSR cultivation system was 92%. Majority of the farmers using DSR cultivation system of rice (56.43%) had high efficiency (91% and above technical efficiency) and 25.71% farmers had medium efficiency (80-90% technical efficiency) among the different categories of farmers. Only 17.86% farmers were under the low efficiency. The mean technical efficiency [Table-7] of rice cultivation under TPR cultivation system was 87%. Majority of the farmers using TPR cultivation system of rice (41.46%) had high efficiency (91% and above technical efficiency) and 36.67% farmers had medium efficiency (80-90% technical efficiency) among the different categories of farmers. Only 21.87% farmers were under the low efficiency. In a similar study reported that higher efficiency was obtained in DSR as compared to the TPR due to high lower cost of cultivation and higher saving and B:C ratio. Therefore, the major challenge for farmers in direct seeded rice was its adoption on long term basis.

Table-6 *Technical efficiency of DSR*

S. No.	Particulars	Per cent
1.	High efficiency group (91% and above)	56.43
2.	Medium efficiency group (80-90%)	25.71
3.	Low efficiency group (less than 80%)	17.86
4.	Average efficiency	92

Table-7 *Technical efficiency of TPR system of rice cultivation*

S. No.	Particulars	TPR
1.	High efficiency group (91% and above)	41.46
2.	Medium efficiency group (80%-90%)	36.67
3.	Low efficiency group (less than 80%)	21.87
4.	Average efficiency	87.00

Allocative Efficiency of DSR and TRP System of Rice Cultivation

The allocative efficiency of rice cultivation under DSR is presented in [Table-8]. The allocative efficiency (MVP) for labour (0.75) and irrigation (0.68) was less than unity which indicates over use of these resources implying additional investment in these inputs was not economical, since the additional revenue obtained will not be adequate to cover the additional cost incurred. However, the allocative efficiency measure of fertilizer (-0.76) was negative indicating that its use was in the irrational region (III region) of the production function. Other inputs like seed, machine and PPC did not show significant regression coefficient, hence avoided from interpretation of results. [Table-4]. 22 shows that for TPR cultivation of rice, the allocative efficiency (MVP) for machine labour (-0.54) and seed (-1.12) was less than unity indicating over use of these resources. Additional one rupee invested in these inputs will not be economical. Other inputs like labour, seed and PPC showed non-significant regression coefficient.

Table-8 *Allocative efficiency of DSR and TPR system of rice cultivation*

S. No.	Inputs	DSR			TPR		
		MVP	MFC	MVP/MFC	MVP	MFC	MVP/MFC
1.	Human labour (Rs.)	0.75	1	0.75	0.62	1	0.62
2.	Machine labour (Rs.)	0.78	1	0.78	-0.54	1	-0.54
3.	Seeds (Rs.)	0.64	1	0.64	-1.12	1	-1.12
4.	Fertilizers (Rs.)	-0.76	1	-0.76	0.58	1	0.58
5.	PPC (Rs.)	0.78	1	0.78	0.44	1	0.44
6.	Irrigation (Rs.)	0.68	1	0.68	0.10	1	0.10

Economic Efficiency of Different Cultivation Systems of Rice Cultivation

The economic efficiency for different practices of rice cultivation was calculated as product of the technical efficiency of particular cultivation system with their respective allocative efficiency and the results are presented in [Table-9]. In case of DSR system, economic efficiency measure was 0.52 indicating that there was scope to increase the returns by 48% with optimum allocation of resources. It was 0.32 with TPR; this indicated that there was scope to increase the returns by 68% with optimum allocation of resources. The results showed that DSR cultivation of wheat cultivation system was more economically efficient compared to TPR system of rice cultivation.

Table-9 *Economic efficiency of different cultivation systems of rice cultivation*

Particular	Technical efficiency	Allocative efficiency	Economic efficiency
DSR	0.92	0.56	0.52
TPR	0.87	0.37	0.32

Conclusion

The results indicated that DSR technology had potential to increase farmer's income and save scarce resources. Hence, DSR technology is a viable alternative to overcome the problems of rising cost of cultivation, labour and water shortages for sustainable rice production. However, problems of seed drill availability and weed infestation need to be addressed to accelerate wider adoption of DSR technology.

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Umesh Kumar Sharma= Major Advisor
Ved Parkash Luhach = Co- Major Advisor
Saroj Kumari = help in statical tools and coding

Abbreviations:
DSR = Direct Seeded Rice,
TPR= Trans Planted Rice

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