

Original Research Article

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## Yield and Economics of Rice (*Oryza sativa* L.) as Influenced by Establishment Methods and Varieties under Mollisols of Pantnagar

D.K. Singh\*, P.C. Pandey, Shanker Dutt Thapliyal and Gangadhar Nanda

Department of Agronomy, G. B. Pant University of Agriculture and Technology,  
Pantnagar, Uttarakhand- 263 145, India

\*Corresponding author

### ABSTRACT

#### Keywords

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The present investigation was carried out during kharif season of 2015 and 2016 in split-plot design with four establishment methods namely wet-direct seeded (Wet DSR), direct seeded aerobic (DSR-aerobic), direct seeded on furrow irrigated raised bed (DSR on FIRB) and transplanted (TP) in main plots and eight rice cultivars (Pant Dhan 23, Pant Dhan 24, Pant Shankar Dhan 1, Pant Shankar Dhan 3, Pusa Basmati 1, Pusa 1121, Govind and Pant Dhan 26) in sub-plots taking 3 replications. Result revealed that highest grain and straw yield was recorded under TP in both years. The increment in grain yields over wet DSR and DSR-aerobic were 7.63 and 11.29 % and 10.75 and 15.64 % in 2015 and 2016, respectively. The maximum gross return (Rs. 83972 and 84552 ha<sup>-1</sup>) and net return (Rs. 50636 and 51216 ha<sup>-1</sup>) was obtained in TP while the benefit cost ratio (1.80 and 1.71) was found maximum with DSR-aerobic during 2015 and 2016. Highest grain and straw yield was obtained with hybrid variety Pant Shankar Dhan 3 for both years except 2015 where Pant Dhan 24 recorded maximum straw yield. The maximum gross return (Rs. 85218 and 90685 ha<sup>-1</sup>) and net return (Rs. 55108 and 60575 ha<sup>-1</sup>) was recorded in variety Pant Shankar Dhan 3 in 2015 and 2016. Growing rice hybrid Pant Shankar Dhan 3 under conventional transplanting can give higher grain yield.

### Introduction

Rice is the staple food crop for more than 50% of world population (Fageria, 2007) and is the most important cereal crop of India covering an area of 43.9 mha with production and productivity of 106.5 million tonnes and 2424 kg ha<sup>-1</sup>, respectively (Anonymous, 2014). Cultivation of rice with conventional transplanting requires huge amount of irrigation water ranging from 1,500 and 3,000 mm (Sharma *et al.*, 2002; Singh *et al.*, 2002). With declining water resources and increasing

demand for other competitive users of water like for domestic and industrial use, there will be water crisis in near future. So, alternative rice production technology with low water input is needed. In wet-direct seeded rice, seeds are either broadcasted or sown in line using drum seeder. To feed the ever increasing population we have to constantly increase the food grain production of which rice constitutes a major role. In this regard role of varieties has profound influence on the

productivity and thereby meeting the rice production demand. There are different types of rice cultivars like hybrids, high yielding varieties and basmati rice of various durations suitable to particular area and consumers demand. Moreover, high yielding varieties have multiple resistances to the biotic (insects and diseases) and abiotic stresses like drought, salinity/alkalinity tolerance etc. Among several types of rice, basmati rice is regarded as the king of rice and it fetches higher price due to better organoleptic quality characteristics. The demand of this type of rice is also high in other countries (Singh *et al.*, 2017). The availability of short-duration rice cultivars has led to large increases in cropping intensity, greater on-farm employment, increased food supplies and higher food security in many major rice-producing countries (Khush, 2001). Different varieties viz. hybrid, high yielding, basmati and short duration varieties show different behaviour under different establishment methods which needs to be experimented.

## Materials and Methods

The experiment was conducted during kharif season of 2015 and 2016 in A2 block at N. E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Geographically, it is located at 29° N latitude and 79.29° E longitudes and an altitude of 243.84 metre above mean sea level. Soil of the experimental field was silty loam in texture and is of alluvial origin and classified as Aquic Hapludoll (Deshpande *et al.*, 1971). The chemical analysis of upper 20 cm soil showed that it was high in organic carbon, low in available N, medium in available phosphorus and potassium and slightly alkaline in soil reaction (Table 1). The experiment was laid out in split-plot design with four establishment methods namely wet-direct seeded (Wet DSR), direct seeded

aerobic (DSR-aerobic), direct seeded on furrow irrigated raised bed (DSR on FIRB) and transplanted (TP) in main plots and eight rice cultivars including two high yielding varieties (Pant Dhan 23 and Pant Dhan 24), two hybrids (Pant Shankar Dhan 1 and Pant Shankar Dhan 3), two Basmati varieties (Pusa Basmati 1 and Pusa 1121) and two high yield short duration varieties (Govind and Pant Dhan 26) in sub-plots taking 3 replications.

The experimental field was prepared by ploughing once by disc plough followed by cross disc harrowing twice, after that the field was levelled. Certified seeds of variety Pant Dhan 23, Pant Dhan 24, Pant Shankar Dhan 1, Pant Shankar Dhan 3, Pusa Basmati 1, Pusa 1121, Govind and Pant Dhan 23 with different seed rates were sown as per table 2 in different establishment methods. Furrows were opened manually at 20 cm distance in direct seeded aerobic, direct seeded on FIRB plots and in wet direct seeded puddle plots, pre-germinated seeds were broadcasted as per treatment. After seeding, furrows in direct seeded plots were covered properly (manually) with soil. Twenty four days old seedlings were transplanted in puddled field using two seedlings hill<sup>-1</sup> at a spacing of 20 cm x 20 cm. After 10 days of sowing the missing plants in the rows as per treatment were replanted (gap filling) with the seedling uprooted for the same plot where it had high density. Recommended dose of fertilizer i.e. 120-60-40 N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O was applied in the experimental plots. Before seeding, 25% N (30 kg N ha<sup>-1</sup>), full dose of phosphorus (60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) and potassium (40 kg K<sub>2</sub>O ha<sup>-1</sup>) was applied through urea (46% N), NPK mixture (12: 32: 16) and muriate of potash (60% K<sub>2</sub>O), respectively and incorporated into soil. The remaining quantity of nitrogen (90 kg N ha<sup>-1</sup>) was top dressed in two splits: at tillering (60 kg N ha<sup>-1</sup>) and panicle initiation (30 kg N ha<sup>-1</sup>) stages in wet direct seeded, direct seeded-aerobic and direct

seeded on furrow irrigated raised bed rice and in transplanted rice, 50% N ( $60 \text{ kg N ha}^{-1}$ ) applied as basal, remaining quantity of nitrogen ( $60 \text{ kg N ha}^{-1}$ ) was top dressed in two splits: at tillering ( $30 \text{ kg N ha}^{-1}$ ) and panicle initiation ( $30 \text{ kg N ha}^{-1}$ ) stages. Irrigation was given by flooding method, pre-sowing irrigation was given into the field for preparation of seed bed and water was given as per need to maintain condition of the soil, rest excess water was drained out from the field time to time during crop season in direct seeded-aerobic, direct seeded on FIRB and wet-direct seeded rice and soil moisture was maintained near about saturation at sowing to milk stage. While in transplanted rice, a thin film of water (2-3 cm) was maintained during initial stage up to seedling establishment, thereafter, plots were kept continuously flooded and irrigated whenever required in order to maintain a ponded layer of 5-6 cm depth during the vegetative stage and after panicle initiation, 2-3 cm depth of water was maintained in bed and plots were drained 15 days before harvest. Pendimethalin @  $1 \text{ kg a.i.}$  was mixed in 750 litre water and was sprayed next day of sowing as pre-emergence and bispyribac sodium @  $0.25 \text{ kg a.i. ha}^{-1}$  in 750 to 1000 litre of water was sprayed at 15-20 days after sowing (DAS) as pre-emergence in DSR-aerobic and DSR on FIRB methods and pretilachlor @  $0.75 \text{ kg a.i. ha}^{-1}$  in 750 to 1000 litre of water was sprayed at 6 DAS as pre-emergence in wet direct seeded method and 1-3 days after transplanting (DAT) in transplanted plots to control the weeds. Two weedings were done at 20 and 40 days after sowing by removing weeds manually using a khurpi. To control Khaira (Zn deficiency), two sprays of zinc ( $5 \text{ kg zinc sulphate}$  with  $2.5 \text{ kg slaked lime}$  dissolved in 1000 litre water/ha) were done at 15 and 25 days after emergence. For iron deficiency especially in DSR plots,  $\text{FeSO}_4$  was applied @ 0.5% at 20 days after emergence. There was no serious problem of insect-pest except mild incidence

of stem borer which was controlled timely by applying Cartap hydrochloride (Calden-G) @  $20 \text{ kg ha}^{-1}$ . Crop from the net plot area were harvested with sickle when more than 90% grains of the panicles were matured. These were left on the field for sun drying for 2-3 days. After proper sun drying, threshing was done by pullman thresher individually for each net plot ( $6.4 \text{ m}^2$ ). The total weight of grain harvested from the net plot of  $6.4 \text{ m}^2$  was recorded and was converted into  $\text{kg ha}^{-1}$  at 14 per cent moisture. The data recorded were analyzed following standard statistical analysis of variance procedure as suggested by Gomez and Gomez (1984). Wherever the interaction between establishment methods and rice varieties found significant were presented in separate two way tables.

## Results and Discussion

### Yield attributes, yield and harvest index

Establishment methods caused significant variation in yield attributes, yield and harvest index during both the years of experiment except 1000-grain weight and harvest index for 2015 (Tables 3 and 4). Maximum number of panicles  $\text{m}^{-2}$  was obtained under wet DSR in 2015 which was significantly higher than rest of the establishment methods. However during 2016, DSR-aerobic recorded highest number of panicles  $\text{m}^{-2}$  which was comparable with DSR only. Higher number of panicle  $\text{m}^{-2}$  in wet DSR and DSR-aerobic method might be due to more number of seedlings  $\text{m}^{-2}$  which may lead to more number of shoots resulting in higher number of panicles  $\text{m}^{-2}$ . This is consistent with the observation of Tao *et al.*, (2016) who reported that wet direct seeded rice recorded highest panicle number per square meter among the three rice establishment methods they studied (wet direct seeded rice, dry direct seeded rice and transplanted rice). Significantly highest panicle weight was obtained under TP during

2015 and 2016. TP resulted in higher panicle weight could be attributed to better partitioning of photosynthates from vegetative to reproductive parts. Thousand grain weight of rice did not vary significantly among four establishment methods. Dou *et al.*, (2016) showed that water regimes like continuous flooding, saturated and aerobic could not influence 500 grain weight of rice. Akhgari and Kaviani (2011) found that planting methods like transplanting and direct seeding failed to influence 1000 grain weight. These results signify that 1000 grain weight is genetic character. TP recorded highest grain (5271 and 5124 kg ha<sup>-1</sup>), straw (5508 and 5349 kg ha<sup>-1</sup>) and total biological yield (10779 and 10473 kg ha<sup>-1</sup>) during both the years which was significantly higher than all other establishment methods except for grain yield during 2015 where it was statistically at par with wet DSR (5525 kg ha<sup>-1</sup>) and straw yield during the same year where wet DSR (5304 kg ha<sup>-1</sup>) and DSR-aerobic (5169 kg ha<sup>-1</sup>) were comparable with it. Similar results were obtained by Rana *et al.*, (2014). Singh *et al.*, (2001) noticed significantly higher grain and straw yields in transplanted rice than direct seeded rice both on puddled and unpuddled seedbed. Saharawat *et al.*, (2010) observed that the yield of both dry and wet direct seeded were 0.45-0.61 t/ha lesser than transplanted rice. Chauhan *et al.*, (2015) also found higher grain yield under transplanted rice than direct seeded rice. Harvest index was not influenced by establishment methods during 2015 but during 2016 did differ significantly and significantly higher harvest index was registered by both DSR on FIRB and TP (48.9) than rest of the establishment methods.

Perusal of data revealed that different varieties had significant effect on number of panicles m<sup>-2</sup>, panicle weight, 1000-grain weight, yield and harvest index during both the years of experiment (Tables 3 and 4).

Variety Pant Dhan 23 and Pant Shankar Dhan 3 recorded highest number of panicles m<sup>-2</sup> during 2015 and 2016, respectively. During 2015, Pant Dhan 23 was comparable to Pusa Basmati 1, Pant Shankar Dhan3 and Pusa 1121. During 2016, Pant Shankar Dhan 3 was statistically at par with Pant Dhan 24 and Pant Dhan 23. During 2015, Pant Shankar Dhan 1 recorded maximum panicle weight which was at par with Pant Dhan 24, Pant Shankar Dhan 3, Pant Dhan 23 and Pant Dhan 26. During 2016, highest panicle weight was observed in Pant Shankar Dhan 3 which was at par with Pant Dhan 24, Pant Dhan 23 and Pant Shankar Dhan 1. The variety Pant Shankar Dhan 1 recorded significantly higher 1000-grain weight than that of all other varieties during both years except varieties Pant Dhan 23, Pant Dhan 24 and Pant Shankar Dhan 3 which were at par with each other. Highest grain yield (5627 and 5473 kg ha<sup>-1</sup>) was obtained with variety Pant Shankar Dhan 3 during both years which was significantly greater than rest of the varieties tested except for Pant Dhan 24 which was comparable with it in 2015. The interaction between establishment methods and varieties with respect to grain yield was found significant during both the years of experimentation (Table 4). Highest grain yield (6458 and 6590 kg ha<sup>-1</sup>) was obtained in Pant Shankar Dhan 3 variety under TP during both the years which was significantly superior over all other combinations of establishment methods and varieties for both years except for Pant Dhan 24 in TP (6198 kg ha<sup>-1</sup>) in 2015 which was comparable with it. Highest straw yield was obtained in variety Pant Dhan 24 (5894 kg ha<sup>-1</sup>) and Pant Shankar Dhan 3 (5736 kg ha<sup>-1</sup>) during 2015 and 2016, respectively. The varieties Pant Shankar Dhan 3, Pant Dhan 24 and Pant Dhan 23 produced comparable straw yields during both the years. Pant Shankar Dhan 3 hybrid was significantly superior over others in terms of biological yield (11506 and 11208 kg ha<sup>-1</sup>) during both the years except

Pant Dhan 24 and Pant Dhan 23 which produced comparable biological yields during 2015. During both the years maximum harvest index was recorded with variety Pant Shankar Dhan 1 (49.7 and 49.4) which was at par with variety Pant Shankar Dhan 3, Govind, Pant Dhan 24 and Pant Dhan 23 during both the years. Differential

performance of varieties may be attributed to their genetic makeup. Higher values of yield attributes and yield were recorded in hybrid and high yielding varieties than remaining cultivar. This might be due to ability of high yielding and hybrid varieties for better growth and better partitioning of photosynthates to reproductive parts.

**Table.1** Initial soil chemical properties of upper 20 cm layer of the experimental field

Particulars	Value	Method employed
Soil pH	7.7	Glass electrode pH meter method (Jackson, 1973)
Organic carbon (%)	0.92	Modified Walkley and Black method (Walkley and Black, 1934)
Available N (Kg ha <sup>-1</sup> )	232	Alkaline KMnO <sub>4</sub> method (Subbiah and Asija, 1956)
Available P (Kg ha <sup>-1</sup> )	21	Olsen's method (Olsen <i>et al.</i> , 1954)
Available K (Kg ha <sup>-1</sup> )	212	Flame photometry (Jackson, 1973)

**Table.2** Details of seed rates of varieties under different establishment methods

Varieties	Seed rate (kg ha <sup>-1</sup> )			
	Wet DSR	DSR-aerobic	DSR on FIRB	TP
Pant Dhan 23	40	40	25	30
Pant Dhan 24	40	40	25	30
Pant Shankar Dhan 1	30	30	20	20
Pant Shankar Dhan 3	30	30	20	20
Pusa Basmati 1	35	35	20	25
Pusa 1121	35	35	20	25
Govind	40	40	25	30
Pant Dhan 26	40	40	25	30

**Table.3** Effect of establishment methods and varieties on yield attributes, straw and biological yield and Harvest index of rice during 2015 and 2016

Treatment	Panicles m <sup>-2</sup>		Panicle weight (g)		1000-grain weight (g)		Straw yield (kg ha <sup>-1</sup> )		Biological yield (kg ha <sup>-1</sup> )		Harvest index (%)	
	2015	2016	2015 5	2016 6	2015	2016	2015	2016	2015	2016	2015	2016
Establishment methods												
Wet DSR	278	324	2.23	1.72	24.3	24.5	5304	4988	10201	9592	48.0	48.0
DSR-aerobic	261	329	2.09	1.58	24.3	24.2	5169	4811	9928	9242	48.3	48.0
DSR on FIRB	195	205	2.29	2.23	24.1	24.5	3981	4059	7803	7947	49.5	48.9
TP	213	231	2.75	2.56	24.5	24.3	5508	5349	10779	10473	49.1	48.9
CD (P=0.05)	11.2	12.1	0.09	0.21	NS	NS	340.0	211	468	341	NS	0.6
Varieties												
Pant Dhan 23	253	280	2.48	2.19	25.0	25.0	5570	5275	10876	10290	49.0	48.8
Pant Dhan 24	239	285	2.65	2.20	25.0	24.9	5894	5513	11419	10691	49.0	48.5
Pant Shankar Dhan 1	224	271	2.67	2.15	25.2	25.3	4841	4812	9554	9508	49.7	49.4
Pant Shankar Dhan 3	250	287	2.55	2.29	25.0	25.0	5880	5736	11506	11208	49.2	48.8
PB 1	251	260	1.73	1.66	22.7	22.7	4214	4073	7953	7683	47.3	47.0
Pusa 1121	249	268	1.86	1.80	22.8	23.0	4448	4360	8524	8356	48.0	47.8
Govind	226	258	2.03	1.87	24.2	24.4	4448	3957	7832	7732	49.2	48.8
Pant Dhan 26	222	267	2.46	2.00	24.6	24.4	5060	4687	9762	9041	48.2	48.2
CD (P=0.05)	19.3	14.3	0.21	0.16	0.2	0.6	486	267	723	428	0.9	0.8



**Table.4** Interaction between different establishment methods and varieties on rice grain yield during 2015 and 2016

	Grain yield (kg ha <sup>-1</sup> ) under establishment methods									
	2015					2016				
	Wet DSR	DSR-aerobic	DSR on FIRB	TP	Mean	Wet DSR	DSR-aerobic	DSR on FIRB	TP	Mean
Varieties										
Pant Dhan 23	5486	5364	4462	5892	5301	5304	5133	4191	5431	5015
Pant Dhan 24	5936	5590	4375	6198	5525	5479	5220	4382	5629	5178
Pant Shankar										
Dhan 1	5086	4878	3524	5364	4713	5058	4247	4072	5403	4695
Pant Shankar										
Dhan 3	5826	5538	4684	6458	5627	5463	5300	4537	6590	5473
Pusa Basmati1	3854	3871	3177	4052	3739	3586	3652	3134	4069	3610
Pusa 1121	4357	4270	3229	4444	4075	3950	4089	3596	4347	3996
Govind	3750	3664	3507	4342	3816	3644	3724	3477	4252	3774
Pant Dhan 26	4878	4895	3618	5416	4702	4347	4081	3715	5272	4354
Mean	4897	4759	3822	5271		4604	4431	3888	5124	
CD (P=0.05) value				2015	2016					
Establishment methods				161	148					
Varieties				270	178					
Two varieties at same establishment method				540	365					
Two establishment methods at same variety				529	363					

**Table.5** Effect of establishment methods and varieties on economics of rice during 2015 and 2016

Treatment	Gross return (Rs./ha)		Cost of cultivation (Rs./ha)		Net return (Rs./ha)		B:C ratio	
	2014	2015	2014	2015	2014	2015	2014	2015
Establishment method								
Wet DSR	78355	76657	28936	28936	49419	47721	1.71	1.65
DSR-aerobic	76243	73796	27248	27248	48995	46549	1.80	1.71
DSR on FIRB	60997	64461	27077	27077	33920	37384	1.25	1.38
TP	83972	84552	33336	33336	50636	51216	1.52	1.53
Varieties								
Pant Dhan 23	80317	83114	28791	28791	51526	54323	1.79	1.89
Pant Dhan 24	83793	85965	28791	28791	55002	57174	1.91	1.99
Pant Shankar Dhan 1	71301	77714	30110	30110	41191	47604	1.36	1.58
Pant Shankar Dhan 3	85218	90685	30110	30110	55108	60575	1.83	2.00
Pusa Basmati 1	71512	60200	28904	28904	42608	31296	1.48	1.09
Pusa 1121	77807	66451	28904	28904	48904	37548	1.70	1.31
Govind	57822	62527	28791	28791	29030	33736	1.01	1.18
Pant Dhan 26	71363	72277	28791	28791	42572	43486	1.48	1.50



## Economics

The data pertaining to economics of different establishment methods and rice varieties for both years are presented in table 5. The maximum gross return (Rs. 83972 and 84552 ha<sup>-1</sup>), cost of cultivation (Rs. 33336 ha<sup>-1</sup> for both years) and net return (Rs. 50636 and 51216 ha<sup>-1</sup>) was obtained in TP while B:C ratio (1.80 and 1.71) was found maximum with DSR-aerobic establishment method in 2015 and 2016. Highest benefit: cost ratio under DSR-aerobic was attributed to reduced investment in field operations like land preparation and planting, irrigation water and labour than other establishment methods. Singh *et al.*, (2001) noticed higher net returns under transplanted rice than direct seeded rice both on puddled and unpuddled seedbed in a rice-wheat cropping system. Rana *et al.*, (2014) reported higher B: C cost ratio under direct seeding of sprouted seed than transplanting methods due to saving of irrigation water and labour.

With regard to economics of different varieties, cost of cultivation was found maximum with variety Pant Shankar Dhan 1 and Pant Shankar Dhan 3 (Rs. 30110 ha<sup>-1</sup> in both years. The maximum gross return (Rs. 85218 and 90685 ha<sup>-1</sup>) and net return (Rs. 55108 and 60575 ha<sup>-1</sup>) was recorded in variety Pant Shankar Dhan 3 in 2015 and 2016 while maximum benefit cost ratio (1.91) was recorded in Pant Dhan 24 during 2015 but during 2016, Pant Shankar Dhan 3 produced maximum B:C ratio (2.00).

It can be concluded based on the result of two year experiment, it can be concluded that transplanted rice produces more grain and straw yield as well as gross and net return. In a situation of water scarcity and labour crunch, direct seeded-aerobic establishment method can be viable alternate method of establishment with Pant Shankar Dhan 3 and

Pant Dhan 24 because it gave greater B: C ratio. Rice hybrid Pant Shankar Dhan 3 performed better than others in terms of grain yield and gross and net return.

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