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Effect of Transplanting Dates on the Paddy (*Oryza sativa* L.) Cultivar CR Dhan 307 (Maudamani) in *Terai* Zone of West Bengal, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author MP collected the data. Author PB performed the statistical analysis of data. Author TM wrote the first draft of the manuscript. Author PP idea conceptualization and designed the analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Paddy cultivar, CR Dhan 307 (Maudamani) can enhance paddy productivity due to its heavy panicles and high-density planting adaptability. Date of transplanting is one of the important non-monetary inputs which greatly influence the growth and yield of paddy. The appropriate date of

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transplanting ensures optimum vegetative growth during the period of satisfactory temperature and solar radiation level. In India, maximum rice farmers are unable to transplant their crop timely, which reduces rice yield significantly and increases total cost of cultivation. This research aimed to study the effect of different dates of paddy transplanting on the performance of CR Dhan 307 (Maudamani) and to find out the optimum date of transplanting in *terai* zone of West Bengal.

Study Design: Randomized block design with 4 replications.

Place and Duration of Study: The experiment was conducted in *rabi* season, 2017-18 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal.

Methodology: Five treatments namely transplanting on 2nd January, on 14th January, on 26th January, on 8th February and on 20th February allocated randomly in each replication.

Results: Paddy transplanted on 26th January provided the maximum increment in almost all the growth attributes on all the dates such as no. of tillers m^{-2} at 90 DAT (252.77), dry matter accumulation at 90 DAT (1595.20 g m^{-2}) *etc.* and yield attributes such as no. of panicles m^{-2} (210.64), no. of grains $panicle^{-1}$ (280.46), no. of filled grains $panicle^{-1}$ (233.34) *etc. vis-à-vis* grain productivity (7.59 t ha^{-1}) and harvest index (44.20%). Highest gross return (Rs. 132825.00 ha^{-1}), net return (Rs. 83336.00 ha^{-1}) and benefit-cost ratio (2.68:1) as well as the incremental benefit-cost ratio (1.68:1) were obtained from the same treatment.

Conclusion: Paddy transplanting on 26th January can be recommended for the cultivar, CR Dhan 307 (Maudamani) for achieving highest productivity and profitability.

Keywords: Benefit-cost ratio; growth; paddy; transplanting; yield.

1. INTRODUCTION

Paddy (*Oryza sativa* L.) is the leading cereal crop and supports more than 50% of human population in the world [1]. Paddy contributes 1/5th of the dietary energy of the world's population [2]. This crop holds the second position next to wheat in the list of widely consumed cereals. The energy rich compounds such as carbohydrates, fats, proteins are presented in considerable percentages along with some minerals such as iron, calcium and vitamins such as thiamine, riboflavin and niacin in this crop [3]. India is 2nd in ranking among the top ten countries of the world in terms of their rice production [4]. According to the recent data [5], paddy is cultivated in an area of about 45 million hectares with an annual production of about 178.31 million tonnes. However, the average productivity is only about 3.96 t ha^{-1} against the global average productivity of 4.61 t ha^{-1} [5]. Considering the current human population of India, the supply projection falls short of the expected demand. West Bengal, Uttar Pradesh and Punjab are the three leading states in the production of paddy [6].

Paddy is the most important crop in West Bengal in all the three seasons *viz.* aus or pre-*kharif* paddy (March-April to August-September), aman or *kharif* paddy (June-July to October-November) and *boro* or *rabi* paddy (December-January to April-May). The yearly mean grain yield of *boro* paddy in Coochbehar is lower than the annual average yield of the state and the country. In this situation, inclusion of some new high yielding potential varieties can enhance the productivity. CR Dhan 307 (Maudamani) is a one such variety which may give positive results due to its heavy panicles and high-density planting adaptability.

Appropriate agronomic management practices are the basic requirement for using the full potential of any variety. Among the various available technologies, selection of appropriate planting window as per the location and region plays a very critical role in boosting the crop productivity. Time of transplanting is a major factor in paddy cultivation and indirectly measures soil temperature and weather conditions to which young paddy plants are exposed during various stages of development [7]. Change in date of transplanting can preserve the yield of paddy [8]. But very early or very late transplanting shows reduction in grain yield because of panicle sterility and fewer number of productive tillers [9]. The appropriate date of transplanting has much importance for three major reasons. Firstly, it ensures the optimum vegetative growth during the period of satisfactory day and night temperatures. Secondly, the appropriate date of transplanting ensures that the cold sensitive stage occurs at a time when the lowest night temperatures are historically the warmest. Thirdly, transplanting on time guarantees good grain filling under mild temperatures, hence the quality of the grains is also improved [10]. Ultimately, timely transplanting of paddy seedlings helps to attain the optimal productivity [11]. Under field condition, the impact of temperature on phenological development and crop productivity can be examined by accumulated heat unit system since plants require a definite temperature before reaching the certain physiological stage [12]. In winter season, temperature is very low in *terai* zone which leads to 10-15 more days for the seedlings to be ready for transplanting. In such a situation, an appropriate date of transplanting is the only measure that can be adopted to minimize the extra 10-15 days required before transplanting of paddy.

2. MATERIALS AND METHODS

The experiment was conducted in *rabi* season of 2017-18 at the instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal. The experimentation site was situated at an elevation of 43 meter above the mean sea level at 26°19'86" N latitude and 89°23'53" E longitude. This area lies under the *terai* agro-ecological zone of West Bengal. This field experiment was laid out in complete randomized block design with 4 replications and randomly allocated 5 treatments namely transplanting on 2nd January; transplanting on 14th January; transplanting on 26th January, transplanting on 8th February and transplanting on 20th February. The soil was sandy loam textured with initial pH of 6.15, available N, P_2O_5 and K_2O were 126.35 kg ha^{-1}, 29.67 kg ha^{-1} and 101.69 kg ha^{-1}, respectively. The rice cultivar used in this experiment was CR Dhan 307 (Maudamani) which requires long time span (135-145 days) to mature. The seed rate was 40 kg ha^{-1} maintained in nursery and transplanting was done in the main field at exact 1 month after sowing with 2 healthy seedlings $hill^{-1}$. The recommendation for fertilizers in transplanted paddy in West Bengal during *boro* season *viz*.120 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1}, 60 kg K_2O ha^{-1}, 25 kg $ZnSO_4$ ha^{-1} were applied in the form of Urea, Single Super Phosphate (SSP), Muriate of potash (MOP) and Zinc sulphate mono hydrate, respectively. In the main field, one third N, full amount of P_2O_5, K_2O and $ZnSO_4$ were applied as basal. Rest 2/3rd N was applied in two equal top-dressings *i.e.*, 1/3rd N at 25 days after transplanting (DAT) and the rest 1/3rd N at 45 DAT. The crop growth rate was calculated by using the following formula [13]:

Crop growth rate (CGR) = $(W_2 - W_1) / (t_2 - t_1)$ g $m^{-2}day^{-1}$

where,

W_1 and W_2 are plant dry weight per unit area (g m^{-2}) at time t_1 and t_2, respectively.

The relative growth rate was calculated by using the following formula [14]:

Relative growth rate (RGR) = $(\ln W_2 - \ln W_1) / (t_2 - t_1)$ g g^{-1} day^{-1}

where,

W_1 and W_2 are plant dry weight (g) at time t_1 and t_2, respectively

'ln' is Natural logarithm (ln = $\log_e$ Y = 2.303 × $\log_{10}$ Y)

Harvest index (%) is calculated by using the following formula [15]:

Harvest Index (HI) = [Grain yield / (Grain yield + Straw yield)] / × 100

The benefit-cost ratio was calculated using the formula:

Benefit-Cost Ratio (BCR) = Gross return / Cost of cultivation

The incremental benefit-cost ratio was calculated using the formula:

Incremental Benefit-Cost Ratio (IBCR) = Net return / Cost of cultivation

Effect of the treatments was compared statistically by Fisher's least significant difference method at 5% level of significance [16]. All statistical analysis were made using SPSS 24.0 software package developed by IBM corp. (2016).

3. RESULTS AND DISCUSSION

3.1 Growth Attributing Parameters

At 30 DAT, 26th January transplanting treatment recorded the maximum plant height (52.44 cm) which was statistically *at par* with 14th January transplanting treatment (46.30 cm) but differed significantly from all the other treatments (Table 1). Among the various treatments, the maximum plant height was recorded at 60 and 90 DAT in the treatment, 20th February transplanting (89.99 cm at 60 DAT and 123.66 cm at 90 DAT) followed by 26th January transplanting treatment (81.40 cm at 60 DAT and 123.05 cm at 90 DAT). The lowest plant height at 60 DAT was recorded from the treatment, 2nd January transplanting (67.80 cm at 60 DAT and 110.70 cm at 90 DAT). Similar results regarding plant height of paddy as influenced by different dates of transplanting were also reported [17] and [18]. Among all the treatments, transplanting on 26th January treatment registered the maximum number of tillers m^{-2} (185.98, 300.64 and 252.77 at 30, 60 and 90 DAT, respectively) which was statistically *at par* with the treatment 14th January transplanting (167.98) at 30 DAT but differed significantly from all the treatments at 60 and 90 DAT. The lowest number of tillers m^{-2} (107.93, 231.31 and 191.08 at 30, 60 and 90 DAT, respectively) was recorded under the 20th February transplanting treatment at all the dates (Table 1). Decrease in the number of tillers m^{-2} in transplanted paddy during 1st and 2nd week of January may be attributed to prevailing temperature which was lower than the critical level. Similar trend of number of tillers m^{-2} in paddy as influenced by different dates of transplanting was also reported previously [17-19]. Similarly, transplanting on 26th January treatment resulted in the highest dry matter accumulation (452.47, 903.92 and 1595.20 g m^{-2} at 30, 60 and 90 DAT) at all the dates of observation. Transplanting on 26th January treatment differed significantly from all other treatments. The lowest dry matter accumulation at all the dates was recorded with transplanting on 20th February treatment (328.96, 592.37, 1144.61 g m^{-2} at 30, 60 and 90 DAT). The maximum crop growth rates (CGRs) at 30-60 and 60-90 DAT were recorded with transplanting on 26th January treatment (15.05 and 23.04 g m^{-2} day^{-1} at 30-60 DAT and 60-90 DAT, respectively) which differed significantly from all other treatments at 30-60 DAT and being statistically *at par* with transplanting on 14th January treatment (22.93 g m^{-2} day^{-1}) and transplanting on 2nd January treatment (22.63 g m^{-2} day^{-1}) at 60-90 DAT (Table 1). The lowest CGRs at 30-60 and 60-90 DAT were recorded under transplanting on 20th February treatment (8.78 and 18.41 g m^{-2} day^{-1} at 30-60 and 60-90 DAT, respectively) being *at par* with transplanting on 8th February treatment (9.49 and 20.03 g m^{-2} day^{-1}). The relative growth rate (RGR) was not significantly influenced by different dates of transplanting at 30-60 and 60-90 DAT, both. The maximum RGR (0.023 g g^{-1} day^{-1}) during 30-60 DAT was recorded in the treatment, transplanting on 26th January, transplanting on 14th January treatment and transplanting on 2nd January treatment (Table 1). At 60-90 DAT, the maximum RGR (0.023 g g^{-1} day^{-1}) was recorded from the treatment, transplanting on 2nd January, transplanting on 14th January treatment and transplanting on 8th February treatment. The lowest RGR was recorded from the treatment, transplanting on 20th February (0.020 g g^{-1} day^{-1}) at 30-60 DAT and transplanting on 26th January treatment (0.019 g g^{-1} day^{-1}) at 60-90 DAT.

3.2 Yield Attributing Parameters

The longest panicle was recorded in the treatment, transplanting on 26th January (23.99 cm) which was statistically *at par* with the treatments, transplanting on 14th January (23.95 cm), transplanting on 2nd January (23.43 cm) and transplanting on 8th February (23.40 cm). The maximum number of panicles m^{-2} (210.64) was also recorded in 26th January transplanted paddy. The shortest panicle (21.89 cm) and lowest number of panicles m^{-2} (159.23) were found in the treatment, transplanting on 20th February. Researchers [20,18] also reported almost similar panicle length in paddy as influenced by different dates of transplanting. The panicle length in paddy reduced with delaying in transplanting from January to February [21]. Reduction in the number of panicles m^{-2} under delayed transplanting was noticed [15]. The number of grains $panicle^{-1}$ and the number of filled grains $panicle^{-1}$ were recorded highest in the 26th January transplanted crop (280.46 and 233.34) which was significantly higher from all other treatments. Similarly, the lowest number of grains $panicle^{-1}$ (217.97) and the number of filled grains $panicle^{-1}$ (160.64) were recorded in 20th February transplanted crop (Table 2). Earlier report [18] corroborated the result regarding the number of grains $panicle^{-1}$. Scientists [15] found that number of filled grains $panicle^{-1}$ reduced under delayed transplanting. 1000-grain weight was also recorded highest in 26th January transplanted crop (22.50 g). Almost similar 1000-grain weight was previously noticed [22]. Transplanting on 26th January treatment did not vary significantly with other treatments. Earlier finding [18] was in line with this result.

Table 1. Growth attributing parameters of paddy as influenced by various dates of transplanting

Treatments	Plant height (cm)			Number of tillers m^{-2}			Dry matter accumulation ($g\ m^{-2}$)			Crop growth rate ($g\ m^{-2}\ day^{-1}$)		Relative growth rate ($g\ g^{-1}\ day^{-1}$)	
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30-60 DAT	60-90 DAT	30-60 DAT	60-90 DAT
Transplanting on 2nd January	35.72	67.80	110.70	149.32	267.31	217.35	348.58	692.76	1371.52	11.48	22.63	0.023	0.023
Transplanting on 14th January	46.30	77.74	110.89	167.98	280.64	224.27	357.09	709.43	1397.21	11.75	22.93	0.023	0.023
Transplanting on 26th January	52.44	81.40	123.05	185.98	300.64	252.77	452.47	903.92	1595.20	15.05	23.04	0.023	0.019
Transplanting on 8th February	43.13	81.38	115.80	126.66	257.31	204.10	336.22	621.03	1230.09	9.49	20.03	0.021	0.023
Transplanting on 20th February	41.00	89.99	123.66	107.93	231.31	191.08	328.96	592.37	1144.61	8.78	18.41	0.020	0.022
S.Em. (±)	2.051	1.975	2.178	6.046	3.388	5.770	17.300	13.612	14.252	0.860	0.692	0.002	0.001
C.D. (*P*=.05)	6.39	6.15	6.78	18.84	10.55	17.98	53.90	42.41	44.40	2.68	2.16	NS	0.002

Table 2. Yield attributing parameters, yields and harvest index of paddy as influenced by various dates of transplanting

Treatments	Yield attributing parameters					Yield ($t\ ha^{-1}$)			Harvest index (%)
	Panicle length (cm)	No. of Panicles m^{-2}	No. of grains $Panicle^{-1}$	No. of filled grains $panicle^{-1}$	1000-grain weight (g)	Grain yield	Straw yield	Total biomass yield	
Transplanting on 2nd January	23.43	181.12	240.21	190.50	23.43	6.87	8.79	15.66	43.88
Transplanting on 14th January	23.95	186.89	248.33	198.14	23.95	6.92	8.88	15.80	43.82
Transplanting on 26th January	23.99	210.64	280.46	233.34	23.99	7.59	9.58	17.17	44.20
Transplanting on 8th February	23.40	170.08	234.05	184.12	23.40	6.10	8.09	14.20	42.99
Transplanting on 20th February	21.89	159.23	217.97	160.64	21.89	5.21	7.31	12.51	41.58
S.Em. (±)	0.271	4.808	3.885	4.748	0.257	0.324	0.374	0.604	-
C.D. (*P*=.05)	0.84	14.98	12.10	14.79	NS	1.01	1.16	1.88	-

Table 3. Economics of paddy cultivation as influenced by various dates of transplanting

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit:Cost	IBCR
Transplanting on 2nd January	49489	120225	70736	2.43:1	1.43:1
Transplanting on 14th January	49489	121100	71611	2.45:1	1.45:1
Transplanting on 26th January	49489	132825	83336	2.68:1	1.68:1
Transplanting on 8th February	49489	106750	57261	2.16:1	1.16:1
Transplanting on 20th February	49489	91175	41686	1.84:1	0.84:1

3.3 Grain Yield, Straw Yield, Total Biomass Yield and Harvest Index

Among all the treatments, the highest grain yield was obtained from the treatment T_3 *i.e.*, transplanting on 26th January (7.59 t ha^{-1}) which was statistically *at par* with 14th January transplanted crop (6.92 t ha^{-1}) and 2nd January transplanted crop (6.87 t ha^{-1}). The grain yield was recorded minimum with the treatment, transplanting on 20th February (5.21 t ha^{-1}). The highest straw yield was obtained from the treatment, transplanting on 26th January (9.58 t ha^{-1}) which was statistically *at par* with 14th January transplanted crop (8.88 t ha^{-1}) and 2nd January transplanted crop (8.79 t ha^{-1}). The grain and straw yield, both were recorded minimum with the treatment, transplanting on 20th February (5.21 and 7.31 t ha^{-1} grain and straw yield, respectively). The reduction in grain and straw yield of paddy occurred with the delayed planting dates [17]. The reason behind lower grain yield of paddy with delayed planting dates was explained [23] as lower absorbance and hence the light appeared to be the limiting factor. Total biomass yield followed the similar trend to grain and straw yield. Highest result was noted down from the treatment, transplanting on 26th January (17.17 t ha^{-1}) being statistically similar with transplanting on 14th January (15.80 t ha^{-1}) and transplanting on 2nd January treatment (15.66 t ha^{-1}). The lowest total biomass yield was obtained from the treatment, transplanting on 20th February (12.51 t ha^{-1}). The highest total biomass yield was achieved when transplanting was done on 16th January and the lowest was recorded when transplanted on 17th December [24]. The maximum harvest index was recorded with the paddy transplanted on 26th January (44.20%) which was closely followed by the 2nd January transplanted paddy (43.88%). The lowest harvest index was recorded with 20th February transplanted crop (41.58%). Researchers [25] also reported that the harvest index of paddy varieties had a decreasing trend with delay in transplanting. The harvest index of paddy was gradually reduced when transplanting was done 1st January onwards [21].

3.4 Economic Performance of Paddy

The cost of production (Rs.49489 ha^{-1}) was same in case of all the dates of transplanting. The highest gross return (Rs. 132825 ha^{-1}) and net return (Rs. 83336 ha^{-1}) were obtained from the treatment where crop transplanted on 26th January (Table 3) which were followed by the treatment where crop transplanted on 14th January in both cases (gross and net return were Rs. 121100 ha^{-1} and Rs. 71611 ha^{-1}, respectively). The lowest gross return (Rs. 91175 ha^{-1}) and net return (Rs. 41686 ha^{-1}) were obtained from 20th February transplanted crop. Singh et al. (2005) also found almost similar results with respect to the net return from paddy as influenced by different dates of transplanting. Researchers found that the net return was decreased 1st January onwards irrespective of cultivars [21]. The highest benefit-cost ratio (1:2.68) and incremental benefit-cost ratio (1:1.68) were obtained from the crop transplanted on 26th January followed by the crop transplanted on 14th January (2.45:1 and 1.45:1 were benefit-cost ratio and incremental benefit-cost ratio, respectively). The lowest benefit-cost ratio (1:1.84) and incremental benefit-cost ratio (1:0.84) were obtained from the crop transplanted on 20th February. Scientists [26] also found almost similar results with respect to benefit-cost ratio in paddy as influenced by different dates of transplanting. The benefit-cost ratio was decreased 1st January onwards irrespective of cultivars as per the previous report [21].

4. CONCLUSION

Growth and yield of *boro* rice was reduced to an appreciable extent in *terai* zone of West Bengal when paddy transplanted after last week of January. It can be also concluded that transplanting on 26th January can be recommended for paddy variety CR Dhan 307

(Maudamani) for reaping maximum yield and profit.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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