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Impact of Sowing Dates on the Growth and Yield of Rice (*Oryza sativa* L.) Varieties under Wet Seeded Condition in North-Eastern Ghats Zone of Odisha

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ABSTRACT

An experiment was conducted to reveal the effect of sowing dates on rice varieties under wet seeded condition during *Kharif* at Post Graduate Research Farm, MSSSoA, CUTM. The experiment was designed in split plot design with three replications. Three sowing dates (11th July, 21st July and 31st July) and three rice varieties (Swarna, Naveen and RNR 15048) were taken as mainplot and subplot treatments, respectively. As per the results, 11th July sown crop performed significantly superior in terms of almost all the growth attributes such as tiller density at 90 DAS (238.11 m^{-2}), LAI at 90 DAS (3.10) and DMA at harvest (1123.53 g m^{-2}), yield attributes such as no. of panicles m^{-2} (216.78), no. of filled grains $panicle^{-1}$ (115.33) and grain yield (4.67 t ha^{-1}) as compared to other sowing dates. The grain yield of rice varieties was reduced @50.22 kg ha^{-1} day^{-1} due to the delayed sowing from 11th July - 21st July and @45.61 kg ha^{-1} day^{-1} till the end of July. In the other hand, the rice variety, Naveen provided significantly higher results of almost all growth attributes such as plant height at harvest (104.0 cm), yield attributes and grain yield (4.71 t ha^{-1}). GDD, PTU and HTU showed significant positive correlation with grain yield at 50% flowering to harvest for the variety, Swarna and RNR 15048 whereas, significant negative correlation was obtained at sowing to PI for the variety, Naveen. In conclusion, the rice variety, Naveen sown on 11th July performed superior in respect to growth and yield attributes and yield with optimum duration of phenophases and provided higher economic returns.

Key words: Growth, rice, sowing dates, variety, yield

INTRODUCTION

Climate imposes a venerable impact on the agricultural productivity. Growth and yield of any crop depends upon seasonal weather conditions (Sastry et al., 2000). Crop like rice is very much dependable on different weather indices (Sindhu et al., 2022). Rice is one of the major cereals which is grown all over the world and it is used as a primary food for greater than 50% of world population. After China, India is known as second largest rice producer. Rice has wide range of nutritional benefits. It has 6-7% protein and ample quantity of carbohydrate. In India, rice is being cultivated in *Kharif* season as a rainfed or restricted irrigated crop in different types of soil and climatic conditions. Temperature requirement during its life cycle is 21°C to 37°C for satisfactory growth and development.

Wet seeded rice requires less water input (20%), less cost and less labour and tend to mature faster than transplanted crop (Banik et al., 2020). But early or delayed sowing leads to decreased production of wet seeded rice (Singh et al., 2019). Sowing dates ensure the satisfactory temperature for optimum vegetative and reproductive growth of rice. Thus, optimum sowing time should be standardized for all ago-ecological situation for achieving higher grain yield. The rice crop in every location is subjected to various sets of environmental condition (Laenoi et al., 2018). Thus, three widely cultivated high-yielding rice varieties of Odisha and Andhra Pradesh were taken for this experiment. A particular thermal energy is essential for the occurrence of different phenological stages of rice (Sindhu et al., 2022). For yield prediction of rice, some agrometeorological indices like as growing degree day (GDD), Heliothermal unit (HTU), Photothermal unit (PTU) can be impactful. The concept of GDD is developed on the basis of actual time required to attain a phenological stage, linearly related to a range of temperature between base temperature and optimum temperature (Monteith, 1981). The requirement of thermal energy in the form of agro-meteorological indices at different growth stages of rice in association with the grain yield can be understandable by the relation between crop and weather (Bhagat et al*.,* 2023).

MATERIALS AND METHODS

The field experiment was conducted in *Kharif* season of 2023 at Post-Graduate Research Farm of M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha. The experimental soil was sandy loam textured with slightly acidic in nature had initial pH of 6.1. The soil was low in organic carbon (0.42%), mineralizable nitrogen (253 kg ha^{-1}) and available phosphorus (12.70 kg ha^{-1}) and medium in available potassium (127.20 kg ha^{-1}). The experiment was carried out in split plot design with three replications and nine treatments combinations. The mainplot treatments were three sowing dates *i.e.*, D_1-11th July, D_2-21st July and D_3-31st July and the sub-plot treatments were three rice varieties *i.e.*, V_1-Swarna, V_2-Naveen, V_3-RNR 15048.

Sowing dates were decided based on the mean total daily rainfall occurred in July at Paralakhemundi during the last 15 years *i.e.*, 2008-2022 (ORMS, 2023) (Figure 1). Similar rainfall pattern was observed in 28th, 29th and 31st standard meteorological week of 2023 when sowing operation was done (Figure 2). The maximum and minimum temperature were varied between 32.5-28.4°C and 26.4-14.4°C, respectively during the period of experimentation (Figure 2). Sowing was done at a depth of 3 cm in line sowing method by maintaining 20 cm row wise and 15 cm plant wise spacing. The herbicide, pyrazosulfuron ethyl was applied @20 g ha^{-1} as pre-emergence at 2 days after sowing (DAS). Hand weeding was done two times at 25 and 40 DAS, respectively. Recommended fertilizer dose (RDF) was 80-40-40 kg ha^{-1} N-P_2O_5-K_2O and irrigation was given during the later stages of crop growth when no rainfall occurred.

All the recorded observations analysed statistically with the help of ANOVA and C.D. value was calculated at 5 per cent level of significance (Gomez and Gomez, 1984).

Crop growth rate (CGR) was calculated at 30-60 DAS, 60-90 DAS and 90 DAS-harvest in the experiment. CGR is the gain in dry matter production by one unit area of rice per unit time expressed as g m^{-2} day^{-1} (Watson, 1952).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \text{ g m}^{-2} \text{ day}^{-1}$$

where, W_1 = Dry weight of the above-ground plant parts per unit area at time t_1; W_2 = Dry weight of the above-ground plant parts per unit area at time t_2; t_1 = Time of 1st sampling and t_2 = Time of 2nd sampling

GDD was calculated by using the following formula as per Nuttonson (1955):

Growing degree days (GDD) (°C day hrs.) = $\Sigma kj(T_{max.}-T_{min.})/2] - T_{base}$

where, T_{max} = Daily maximum temperature (°C); T_{min} = Daily minimum temperature (°C); T_{base} = Base temperature of rice which was taken as 10°C (Sandhu et al., 2013); j is initial date of phenological phase of interest; k is last date of phenological phase of interest and Σ is accumulated of starting to ending date of particular phenological phases.

HTU was measured by using the following formula given by Chakravarty and Sastry (1983):

Heliothermal units (HTU) (°C day hrs.) = GDD × Bright sunshine hours

PTU was determined by using the following formula as per Reddy and Reddy (2016):

Photothermal units (PTU) (°C day hrs.) = GDD × Day length

HUE of rice was measured following Shamim et al. (2013), for which biological yield of the crop and the GDD from sowing to maturity were used.

Heat use efficiency (HUE) (kg ha^{-1} °C day hr.$^{-1}$) = Biological yield/GDD

HTUE of rice was measured by following the formula as per Sreenivas et al. (2010), for which biomass of the crop and the HTU from sowing to maturity were used.

Heliothermal unit use efficiency (HTUE) (kg ha^{-1} °C day hr.$^{-1}$) = Biological yield/HTU

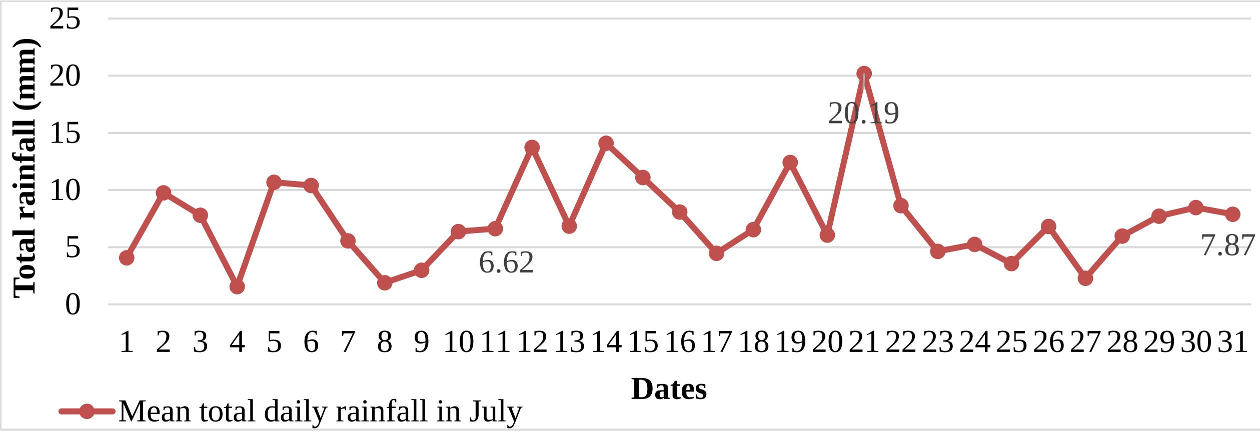

Fig. 1. Mean total daily rainfall during July in Paralakhemundi, Odisha in the period of 2008-2022.

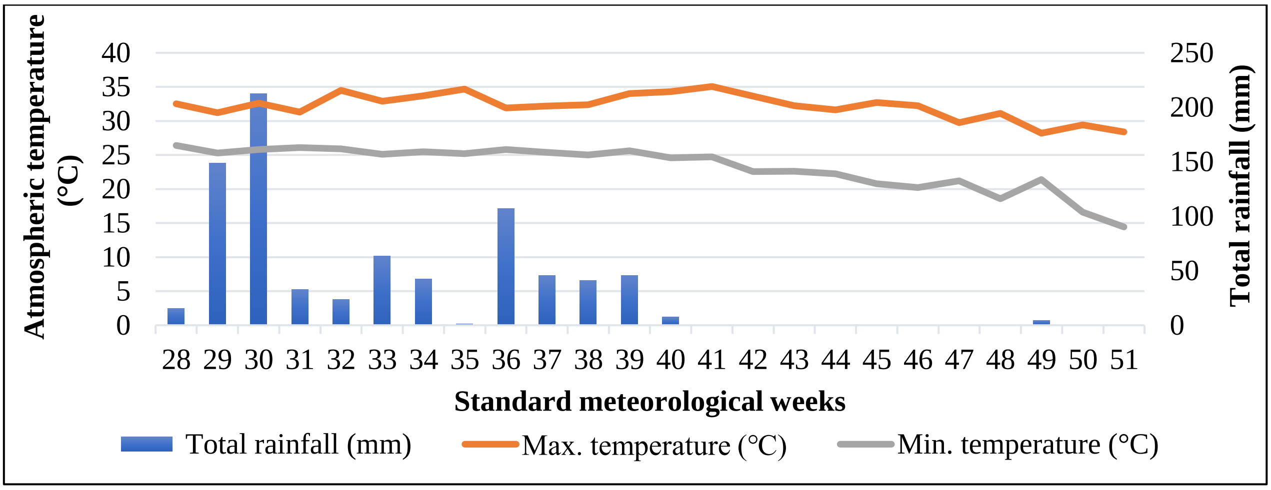

Fig. 2. Maximum and minimum temperature and total rainfall in the cropping period.

RESULTS AND DISCUSSION

The findings stated that there was a significant variation in plant height of rice at harvest with varying the sowing dates (Table 1). Among the sowing dates, 11th July recorded significantly taller plants (96.6 cm) at harvest than the plant height (89.8 cm) at harvest under the sowing at 31st July but statistically *at par* with the plant height (92.1 cm) obtained at harvest when sowing was done at 21st July. Similar trend was reported earlier by Akram et al. (2007), Bashir et al. (2010) and Osman et al. (2015). It is obvious that the dwarfness in plants was observed due to the fact that delayed planting had smaller crop growing period as a result of photoperiodic response (Bashir et al., 2010). No. of tillers m^{-2} and leaf area index (LAI) at 60 and 90 DAS was significant differed in different sowing dates (Table 1). Significant difference in no. of tillers m^{-2} at 90 DAS was also reported earlier by Pandey et al. (2023) under transplanted *Rabi* crop of rice. Rice sown on 11th July observed maximum number of tillers m^{-2} and LAI at 60 DAS (179.00 and 2.90, respectively) and 90 DAS (238.11 and 3.10, respectively) which was significantly higher than tiller density and LAI at 60 and 90 DAS under all other sowing dates. Mandal et al. (2011) and Tolma et al. (2023) reported likewise. Longer period of vegetative phase coupled with favourable weather situation during the critical crop growth periods showed higher tiller density with earlier sowing and the reduction in no. of tillers per unit area on later sowing dates might be because of lower temperatures during later period of growth, which causes tiller mortality (Mir et al., 2023). As per the result, there was significant difference in dry matter accumulation (DMA) on all the dates when the sowing was done in various dates (Table 1) and DMA was recorded significantly higher under the rice sowing on 11th July (188.41, 654.33, 1025.35 and 1123.53 g m^{-2}, at 30, 60 and 90 DAS and at harvest, respectively). The matching trend of DMA at harvest was observed earlier (Mandal et al., 2011; Mir et al., 2023). Longer period of vegetative phase integrated with favourable weather situation at the critical crop growing periods provided taller plants and higher tiller density, which finally enhanced

DMA in earlier sowing (Mir et al., 2023). In case of relative growth rate (RGR), the crop sown on 31st July contributed significantly higher RGR at 30-60 DAS (0.0437 g g^{-1} day^{-1}) than all other dates. But the CGR obtained in the crop sown on 31st July (15.07 g m^{-2} day^{-1}) was significantly lower than CGR obtained at 30-60 DAS under the sowing on 11th July (15.53 g m^{-2} day^{-1}). The crop sown on 11th July recorded significantly higher RGR (0.0151 g g^{-1} day^{-1}) and CGR (12.37 g m^{-2} day^{-1}) than the crop sown on 31st July which recorded minimum RGR (0.0076 g g^{-1} day^{-1}) and CGR (5.29 g m^{-2} day^{-1}) at 60-90 DAS. This was probably because of the availability of favourable temperature at certain crop growth phase under the rice sowing on 11th July. At 90 DAS-harvest, RGR (0.0054 g g^{-1} day^{-1}) was recorded significantly higher than all other dates when crop was sown on 31st July but significant variation in CGR was not observed with varying the sowing dates. This was might be due to earlier maturity of rice varieties sown on 11th July than rice varieties sown on 31st July.

Table 1. Plant height at harvest, no. of tillers m^{-2} at 60 and 90 DAS, LAI at 60 and 90 DAS and DMA at 30, 60 and 90 DAS and at harvest of rice as affected by the sowing dates combined with different varieties.

Treatments	Plant height at harvest (cm)	No. of tillers m^{-2} 60 DAS	No. of tillers m^{-2} 90 DAS	LAI 60 DAS	LAI 90 DAS	DMA (g m^{-2}) 30 DAS	DMA (g m^{-2}) 60 DAS	DMA (g m^{-2}) 90 DAS	DMA (g m^{-2}) harvest
Dates of sowing									
11th July (D_1)	96.6	179.00	238.11	2.90	3.10	188.41	654.33	1025.35	1123.53
21st July (D_2)	92.1	168.89	226.00	2.71	3.02	177.05	624.25	937.16	1048.16
31st July (D_3)	89.8	154.33	216.22	2.52	2.90	170.42	622.59	781.06	957.43
S.Em. (±)	1.20	1.39	0.97	0.04	0.02	1.13	3.40	9.19	8.33
C.D. (P = 0.05)	4.70	5.45	3.83	0.15	0.08	4.45	13.37	36.07	32.69
Varieties									
Swarna (V_1)	82.2	122.78	181.11	2.29	3.13	139.78	550.28	811.97	951.86
Naveen (V_2)	104.0	198.44	297.22	3.41	2.30	226.98	724.03	1023.41	1137.27
RNR 15048 (V_3)	92.2	181.00	202.00	2.43	3.58	169.13	626.86	908.20	1040.00
S.Em. (±)	0.74	0.89	1.07	0.05	0.03	1.00	4.27	10.17	13.82
C.D. (P = 0.05)	2.29	2.74	3.30	0.14	0.08	3.07	13.16	31.33	42.47
Dates of sowing × Varieties									
S.Em. (±)	1.29	1.54	1.85	0.08	0.05	1.73	7.40	17.61	23.93
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Among the rice varieties, Naveen (104.0 cm) showed the tallest plants at harvest than all other rice varieties. Similar plant height of the rice variety, Naveen at harvest was reported previously by (Dileep et al., 2018). Plant height of Naveen at harvest was significantly higher than the plant height of Swarna (82.2 cm) at harvest. Previous report of Patra et al. (2018) corroborated this result. Significantly higher tiller density was obtained with the rice variety Naveen at 60 and 90 DAS (198.44 and 297.22 m^{-2}, respectively) than others. Similar findings on tiller density of Naveen at 90 DAS was reported earlier by Dileep et al. (2018). The rice variety, Naveen recorded significantly higher LAI at 60 DAS as compared to other varieties. Similar result was noted down earlier by Das et al. (2015). But the rice variety, RNR 15048 provided significantly higher LAI than all other rice varieties at 90 DAS (Table 1). The rice variety, Naveen showed significantly higher dry matter production at all dates (226.98, 724.03, 1023.41 and 1137.27 g m^{-2} at 30, 60 and 90 DAS and at harvest, respectively) in comparison to other rice varieties (Table 1). The rice variety, RNR 15048 showed significantly higher dry matter production at all dates (169.13, 626.86, 908.20 and 1040.00 g m^{-2} at 30, 60 and 90 DAS and at harvest, respectively) than the rice variety, Swarna (139.78, 550.28, 811.97 and 951.86 g m^{-2} at 30, 60 and 90 DAS and at harvest, respectively). Earlier report of Chandrika et al. (2015) under transplanted condition supported this result. RGR of the rice variety, Swarna (0.0457 and 0.0127 g g^{-1} day^{-1} at 30-60 DAS and 60-90 DAS, respectively) was found significantly higher than rice variety, Naveen at 30-60 DAS and 60-90 DAS (0.0387 and 0.0114 g g^{-1} day^{-1} at 30-60 DAS and 60-90 DAS, respectively). But the rice variety, Swarna recorded significantly lower RGR (0.0033 g g^{-1} day^{-1}) than the rice variety, Naveen (0.0049 g g^{-1} day^{-1}) at 90 DAS to harvest. The rice variety, Naveen recorded significantly higher CGR at 30-60 DAS (16.57 g m^{-2} day^{-1}), 60-90 DAS (9.98 g m^{-2} day^{-1}) and 90 DAS-harvest (5.19 g m^{-2} day^{-1}) than Swarna (13.68, 8.72 and 2.81 g m^{-2} day^{-1} at 30-60 DAS, 60-90 DAS and 90 DAS-harvest, respectively).

However, there was no significance difference was noted down between the interaction of sowing dates and varieties for plant height at harvest, no. of tillers m^{-2} and LAI at 60 and 90

DAS and DMA at 30, 60 and 90 DAS and at harvest (Table 1). There was no significant variation noticed between the interaction of sowing dates and varieties for CGR and RGR at 30-60 DAS, 60-90 DAS and 90 DAS-harvest (Figure 3).

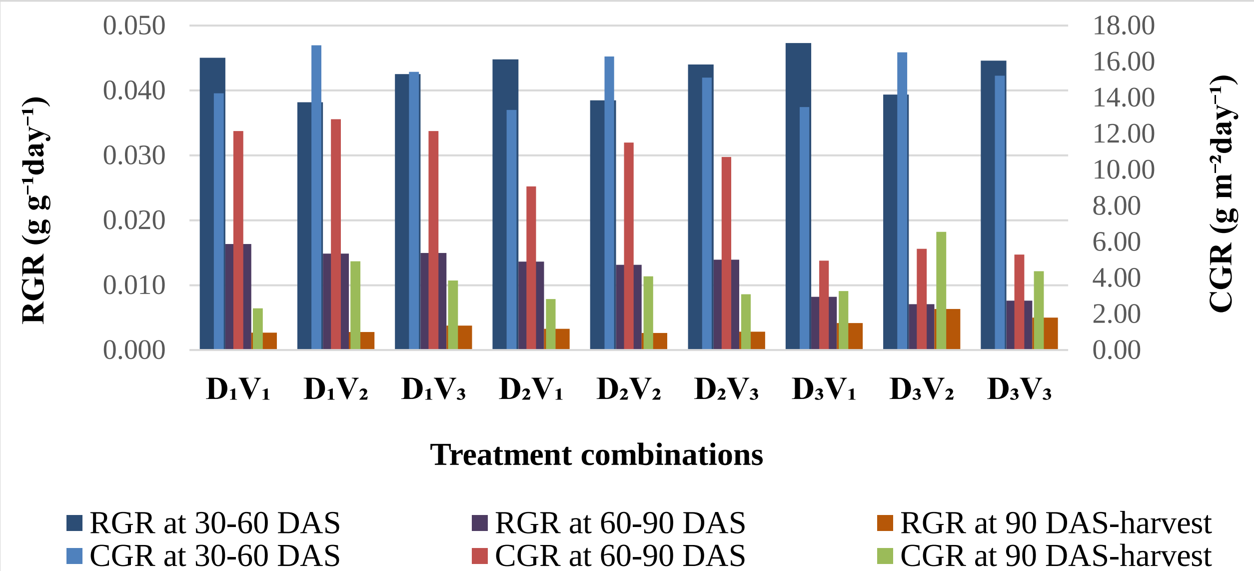

Fig. 3. Relative growth rate (RGR) and crop growth rate (CGR) of rice as affected by the sowing dates combined with rice varieties.

Rice crop sown on 31st July had maximum GDD, HTU and PTU at sowing to PI stage (1240, 11531 and 15385 °C day hours, respectively). But at PI to 50% flowering stage, highest results of GDD and HTU were obtained only (445 and 4080 °C day hours, respectively) when the crop sown on 31st July and maximum PTU (5134 °C day hours) had accumulated under the sowing on 21st July during the period of PI to 50% flowering. Rice crop sown on 11st July had accumulated maximum GDD, HTU and PTU during the period of 50% flowering to harvest (744, 6602 and 8516 °C day hours, respectively). The previous finding of Sindhu et al. (2022) related to PTU at 50% flowering to harvest under transplanted condition was in line with the result obtained. The date of sowing influences the total temperature of wet seeded rice during various phenological phases. The optimum time of sowing can help the crop to utilize the temperature efficiently and offer the potential grain yield (Mir et al., 2023).

Long duration rice variety, Swarna had accumulated maximum GDD, HTU and PTU during the period of sowing to PI (1409, 12513 and 17650 °C day hours, respectively) and PI to 50% flowering (447, 4104 and 5145 °C day hours, respectively), both. But the short duration rice variety, Naveen had accumulated maximum GDD, HTU and PTU during the period of 50% flowering to harvest (753, 6636 and 8526 °C day hours, respectively).

Interaction of the dates of sowing with rice varieties, crop sown on 31st July combined with the rice variety, Swarna had accumulated maximum GDD, HTU and PTU (1455, 13557 and 17909 °C day hours, respectively) at sowing to PI stage among all the treatment combinations whereas, the combination of the sowing date, 21st July and the rice variety, Swarna had accumulated maximum GDD, HTU and PTU (458, 4311 and 5274 °C day hours, respectively) at PI to 50% flowering stage among all. At 50% flowering to harvest, the sowing date of 11th July combined with the rice variety, Naveen showed the highest GDD, HTU and PTU (791, 7111 and 9051 °C day hours, respectively) among the treatment combinations (Table 2). The earlier findings of Sreenivas et al. (2010) regarding GDD and HTU corroborated these results.

Table 2. Agrometeorological indices accumulated in phenological phases by rice varieties in combination with different sowing dates.

Treatments	Sowing to PI				PI to 50% flowering				50% flowering to harvest			
	Days	GDD	HTU	PTU	Days	GDD	HTU	PTU	Days	GDD	HTU	PTU
Dates of sowing												
11th July (D_1)	59	1129	8912	14488	20	399	3571	4802	40	744	6602	8516
21st July (D_2)	62	1183	10482	14946	22	436	4009	5134	41	702	5901	7832
31st July (D_3)	64	1240	11531	15385	24	445	4080	5117	42	666	5137	7273
Varieties												
Swarna (V_1)	73	1409	12513	17650	24	447	4104	5145	42	447	4104	5145
Naveen (V_2)	49	941	8338	12014	21	412	3688	4956	41	753	6636	8526
RNR 15048 (V_3)	63	1200	10075	15154	22	421	3868	4951	40	690	5781	7706
Dates of sowing × Varieties												
D_1V_1	72	1369	11543	17437	22	444	4153	5225	41	699	5955	8000
D_2V_1	73	1404	12440	17605	24	458	4311	5274	42	670	5080	7303
D_3V_1	75	1455	13557	17909	25	439	3848	4937	44	639	4634	6864
D_1V_2	47	892	7386	11568	19	365	3189	4512	40	791	7111	9051
D_2V_2	49	940	8401	12012	21	407	3543	4911	41	757	6847	8640
D_3V_2	52	992	9226	12463	23	463	4332	5446	42	710	5949	7887
D_1V_3	59	1125	7807	14460	20	387	3371	4670	40	743	6741	8496
D_2V_3	63	1204	10606	15220	22	444	4172	5216	40	679	5775	7554
D_3V_3	66	1272	11811	15783	23	433	4060	4967	41	649	4827	7067

*GDD: Growing degree days (°C day hours); PTU: Photothermal units (°C day hours); HTU: Heliothermal units (°C day hours).

The result presented in Table 3 indicated that there was a significant negative correlation between the grain productivity of rice variety, Swarna and HTU (r = -0.9901*) and highly significant negative correlation between the grain productivity of rice variety, Naveen and HTU during the period of sowing to PI (r = -0.9977*). This result also indicated that GDD and PTU had significantly negative correlation with the grain productivity of rice variety, Naveen (r = -0.9888* and -0.9914*) and very strong negative correlation with the grain productivity of rice variety, RNR 15048 (r = -0.9997*** and -0.9998***) during the period of sowing to PI. There was no significant correlation found for the grain productivity of rice varieties versus GDD, grain productivity of rice varieties versus PTU and grain productivity of rice varieties versus HTU during the period of PI to 50% flowering. In the period of 50% flowering to harvest, significant positive correlation was achieved between the grain productivity of rice variety, Swarna and GDD (r = 0.9952*) and the grain productivity of rice variety, RNR 15048 and GDD (r = 0.9903*). Similarly, there was significant positive correlation for the grain yield of rice variety, Swarna versus HTU (r = 0.9942*) and a strong positive correlation for the grain yield of rice variety, RNR 15048 versus HTU (r = 0.9981**) during this time period. Similar results had been noticed by Sindhu et al. (2022). But the grain productivity of rice variety, Swarna and PTU were strongly correlated (r = 0.9986**) and grain productivity of rice variety, RNR 15048 and PTU were just significantly correlated (r = 0.9933*) during the period of 50% flowering to harvest.

Table 3. Correlation coefficients of grain yield vs. GDD, grain yield vs. HTU and grain yield vs. PTU as affected by the sowing dates combined with rice varieties.

Swarna (V_1)			
Phenological phases	GDD	HTU	PTU
Sowing to PI	-0.9829	-0.9901*	-0.9706
PI to 50% flowering	0.1778	0.5867	0.7408
50% flowering to harvest	0.9952*	0.9942*	0.9986**
Naveen (V_2)			
Phenological phases	GDD	HTU	PTU
Sowing to PI	-0.9888*	-0.9977**	-0.9914*
PI to 50% flowering	-0.9782	-0.9418	-0.9779
50% flowering to harvest	0.9761	0.9082	0.9569
RNR 15048 (V_3)			
Phenological phases	GDD	HTU	PTU
Sowing to PI	-0.9997***	-0.9873	-0.9998***
PI to 50% flowering	-0.8023	-0.8330	-0.5981
50% flowering to harvest	0.9903*	0.9981**	0.9933*

* when $p < 0.05$, ** when $p < 0.01$ and *** when $p < 0.001$.

Among the yield components, panicle density, panicle length, no. of filled grains panicle^{-1}, no. of spikelets panicle^{-1} and 1000-seed wt. differed significantly among the sowing dates (Table 4). Rice crop sown on 11th July provided significantly larger no. of panicles m^{-2} (216.78), panicle length (22.2 cm), no. of filled grains panicle^{-1} (115.33), no. of spikelets panicle^{-1} (131.78) and 1000-seed weight (20.97 g) than other sowing dates of rice. Similar findings on no. of filled grains panicle^{-1} and 1000-seed wt. were reported previously by Bashir et al. (2010). Tolma et al. (2023) also presented earlier that the change in sowing date significantly changed the no. of panicles m^{-2} and 1000-seed weight of rice. Earlier sowing provided favourable weather conditions in *kharif* season which helped the plant to enhance its growth and phasic change in comparison to later dates of sowing (Bashir et al., 2010). As a result of late sowing, emergence of seedlings was below par and panicle emergence was decreased, resulting in lower length of panicles, panicle weight, filled grains panicle^{-1} and 1000-seed weight (Mir et al., 2023).

Significant varietal impact on the yield components of rice was found in this study (Table 4). The rice variety, Naveen produced significantly higher no. of panicles m^{-2} (249.11), panicle length (22.9 cm), no. of filled grains panicle^{-1} (116.44), no. of spikelets panicle^{-1} (136.00) and 1000-seed weight (22.47 g) than all other rice varieties. Significant variation in no. of panicles m^{-2} and 1000-seed weight between two different rice varieties and panicle length and 1000-seed weight among three rice varieties were also reported previously by Satapathy et al. (2016) and Barla and Kumar (2011), respectively.

Panicle length was significantly affected due to the interaction between the sowing dates and rice varieties (Table 5). Here, the crop sown on 11th July combined with rice variety, Naveen recorded significantly superior panicle length (73.0 cm). However, there was no significant difference in the interaction effect of sowing dates and rice varieties on other yield components of rice.

Table 4. Yield attributes of rice as influenced by the sowing dates combined with different varieties.

Treatments	No. of panicles m^{-2}	Panicle length (cm)	No. of filled grains panicle^{-1}	No. of spikelets panicle^{-1}	1000-seed weight (g)
Dates of sowing					
11th July (D_1)	216.78	22.2	115.33	131.78	20.97
21st July (D_2)	201.56	20.9	108.00	123.89	20.67
31st July (D_3)	181.78	20.0	101.00	119.67	20.39
S.Em. (±)	1.32	0.08	0.93	0.64	0.03
C.D. (P=0.05)	5.20	0.32	3.66	2.53	0.12
Varieties					
Swarna (V_1)	158.56	19.8	98.56	116.22	20.10
Naveen (V_2)	249.11	22.9	116.44	136.00	22.47
RNR 15048 (V_3)	192.44	20.4	109.33	123.11	19.46
S.Em. (±)	1.33	0.08	0.69	0.45	0.03
C.D. (P=0.05)	4.11	0.25	2.12	1.40	0.09
Dates of sowing × Varieties					
S.Em. (±)	2.31	0.14	1.19	0.79	0.05
C.D. (P=0.05)	NS	0.44	NS	NS	NS

Table 5. Interaction effect between sowing dates and different varieties on panicle length (cm) of rice.

Date of sowing × Variety interaction table				
	V_1	V_2	V_3	Mean
D_1	62.0	73.0	64.8	66.6
D_2	59.4	68.3	60.5	62.8
D_3	57.0	64.8	58.5	60.1
Mean	59.5	68.7	61.3	

Yield of rice was significantly influenced by the performance of yield attributing characters (Table 6). Rice crop sown on 11th July showed significantly higher grain productivity (4.67 t ha^{-1}), straw productivity (8.52 t ha^{-1}) as well as biological productivity (13.20 t ha^{-1}) as compared to other sowing dates. Similar type of result related to grain productivity of rice was reported by Dahiya et al. (2017). Sowing on 21st July showed significantly higher grain yield, straw yield and biological yield (4.17, 7.84 and 12.01 t ha^{-1}, respectively) than sowing on 31st July (3.76, 7.27, 11.03 t ha^{-1}, respectively). Delayed sowing provided a shorter vegetative phase resulted in low carbohydrate and mineral accumulation in the different plant parts which in turn translated into panicle. Therefore, low yields were achieved. Similar conclusion was drawn earlier by Nahar et al. (2009). Harvest index varied non-significantly due to variation in sowing dates.

Here the rice variety, Naveen recorded significantly higher yield of grain (4.71 t ha^{-1}) and straw (8.62 t ha^{-1}) and biological yield (13.33 t ha^{-1}) than other two rice varieties. Similar results related to grain and straw yield were reported earlier by Barla and Kumar (2011). Rice variety, Naveen produced significantly larger yield of grain and straw than others because of higher tiller density, LAI and DMA during the crop growing period. Harvest index did non-significantly due to use of different rice varieties.

The interaction of sowing dates with varieties remained insignificant in grain, straw and biological yield and harvest index.

Table 6. Yield of rice as affected by the sowing dates combined with different varieties.

Treatments	Grain yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Dates of sowing				
11th July (D_1)	4.67	8.52	13.20	35.42
21st July (D_2)	4.17	7.84	12.01	34.68
31st July (D_3)	3.76	7.27	11.03	34.07
S.Em. (±)	0.02	0.14	0.15	0.37
C.D. (P=0.05)	0.09	0.55	0.60	NS
Varieties				
Swarna (V_1)	3.73	7.24	10.98	33.96
Naveen (V_2)	4.71	8.62	13.33	35.29
RNR 15048 (V_3)	4.17	7.77	11.93	34.91
S.Em. (±)	0.05	0.12	0.12	0.46
C.D. (P=0.05)	0.15	0.36	0.37	NS
Dates of sowing × Varieties				
S.Em. (±)	0.08	0.20	0.21	0.80
C.D. (P=0.05)	NS	NS	NS	NS

HUE and HTUE were influenced by growing degree days and heliothermal units, respectively (Figure 4). Hence, rice variety, Naveen recorded highest heat use efficiency when crop was sown on 11th July (6.82 kg ha^{-1} °C day hr.$^{-1}$). However, heliothermal unit use efficiency was found maximum when the sowing of rice variety, Naveen was done on 11th July (0.79 kg ha^{-1} °C day hr.$^{-1}$) as compared to others combinations. The matching trend was reported earlier by Sreenivas et al. (2010). These findings supported the fact that early sowing of short duration rice variety had higher HUE and HTUE than late sown medium and long during varieties.

In Table 7, the result showed that the sowing on 11th July obtained maximum gross return (Rs. 96806 ha^{-1}), net return (Rs. 51604 ha^{-1}) and B:C ratio (1.14) among all other sowing dates. The gross return, net return and B:C ratio is higher because of more grain yield and straw yield under early sowing in *kharif* season. The rice variety, Naveen recorded highest gross return (Rs. 96000 ha^{-1}), net return (Rs. 50799 ha^{-1}) and B:C ratio (1.12) as compared to other varieties. The gross return, net return and B:C ratio is higher because of more grain yield and straw yield with rice variety, Naveen than other varieties.

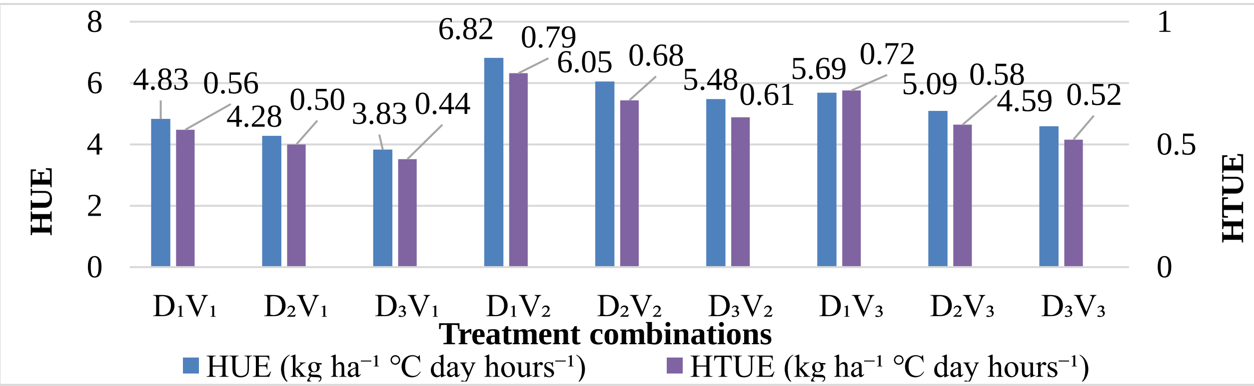

Fig. 4. Heat use efficiency and heliothermal unit use efficiency of rice as affected by the sowing dates combined with different varieties.

Table 7. Economics of rice as influenced by the sowing dates combined with different varieties.

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit-cost ratio
		Dates of sowing		
11th July (D_1)	45202	96806	51604	1.14
21st July (D_2)	45202	85687	40486	0.90
31st July (D_3)	45202	77546	32344	0.72
		Varieties		
Swarna (V_1)	45112	71060	25949	0.58
Naveen (V_2)	45202	96000	50799	1.12
RNR 15048 (V_3)	45292	92978	47687	1.05

CONCLUSION

Delay in sowing of rice beyond 11th July reduced the grain yield @50.22 kg ha^{-1}day^{-1} till 21st July and @45.61 kg ha^{-1} day^{-1} till the end of July. The rice variety, Naveen was performed better than other two varieties in respect of growth and yield attributing parameters and grain yield as well as economics under all the three sowing dates in north-eastern ghats zone of Odisha.

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