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Effect of Delayed Time of Planting on Grain Yield and Agro-morphological Traits of Elite Rice (*Oryza sativa* L.) Varieties

Santrupta Manmath Satapathy[1*], V. K. Srivastava[1], Prasanta Kumar Majhi[2] and Suraj Gond[1]

[1]Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, India.
[2]Department of Plant Breeding and Genetics, Odisha University of Agriculture and Technology, Regional Research and Technology Transfer Station (RRTTS), Keonjhar-758002, Odisha, India.

Authors' contributions

This work was carried out in collaboration among all authors. 'All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present investigation entitled "Effect of delayed time of planting on Yield and Agro-morphological traits of different Rice (*Oryza sativa* L.) Varieties" was conducted to estimate the grain yield performance of different rice varieties under delayed planting conditions in Varanasi region of Uttar Pradesh, India.
Study Design: The experiment was laid in a Split plot design with three replications, consists of four elite rice varieties (HUR-3022, DRR-44, HUR-4-3, and HUR-105) as sub plot factor and three dates of planting (05/09/2018, 13/08/2018 and 20/08/2018) as main plot factor. Hence a total number of 12 treatments were allotted in the whole design.
Place and Duration of Study: The field trial was conducted during *Kharif*-2018 at Agricultural research farm under Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh.

**Corresponding author: E-mail: pintumanmath@gmail.com;*

Methodology: Materials for the studies consist of four elite rice varieties (V1- HUR-3022, V2- DRR-44, V3- HUR-4-3, and V4- HUR-105) as sub plot factor and three dates of planting (D1- 05/09/2018, D2- 13/08/2018 and D3- 20/08/2018) as main plot factor. The biometric observations were taken from the field at a regular interval of 30, 60 and 90 days after planting (DAP) and during crop harvest. The yield attributes were recorded before, during and after harvest of the crop as per the need.

Results: The variety DRR-44 was found to be a best performer on planting date 06.08.2018 and recorded significantly higher yield of 3.8 t/ha followed by HUR-3022 (2.4 t/ha) and HUR-105 (1.64 t/ha).

Conclusion: Rice varieties sown in the field showed highest grain yield when sown on 6th August as compared to 13th and 20th August. As the dates of planting delayed crop yield subsequently decreased. Higher yield level in rice can be confirmed by adjusting the planting dates with the proper climatic conditions. So that the crop phenology can coincide with the suitable weather condition to boost the photosynthetic efficiency and ultimately increase the grain yield.

Keywords: Rice; delayed planting; yield; agro-morphological traits; crop phenology.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the primary source of energy for over half of the world's population. In Asia, rice is consumed by 3.5 billion people as staple food [1]. Therefore, increase in population will require 70 per cent more rice in 2025 than is consumed today [1]. It contains decent amounts of protein, fibre, vitamin B, iron and manganese and it is an essential component of Food Security Mission of Government of India as it plays a vital role against malnutrition in the country. The country grows rice in about 43 million ha area with a production of about 118.43 million tons for an average productivity of 2.75 tha^{-1} [2]. Rice farmers face serious challenges of low income due to degradation of natural resources, climate change related magnification of both biotic and abiotic stresses [2]. India's rice production target for 2025 is 140 million tons which can be accomplished only by increasing rice production by 2 million tons per year over the existing in the coming decade [3].

The optimum time period for sowing and transplanting of rice is critical for achieving high grain yield, even though the optimum time of planting in rice varies with respect to variety, regional, and location basis [4]. Planting time is indirectly responsible for soil temperature and weather conditions to which young rice seedlings and growing rice plants are exposed during different phenological stages [5]. Rice crop require a particular temperature for its phenological development such as panicle initiation, flowering, panicle exertions from flag leaf sheath and maturity. Seedling at the optimum time is an important factor of transplanting for uniform stand establishment of rice. Among the crop production practices, optimum time and method of sowing are the important agronomic tools that allow the crop to complete its growth timely and successfully under specific agro-ecological conditions [6]. Because seedling sown with the delayed time produces fewer tillers due to the reduction of the vegetative period and hence results in poor yield. An optimum date of planting in a particular ecological setting provides an accumulation of desired heat units necessary for proper growth and development of rice crop [7]. Time of planting in rice crop is very important to be optimized because of the variation in the growth duration, thermo-sensitivity, photo-sensitivity and vegetative lag period of different varieties. The sowing time of the rice crop is important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperatures and high levels of solar radiation. Secondly, the optimum sowing time for each cultivar ensures the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved [8]. Optimum date of sowing is the best time of sowing for important properties such as maximum tillering, panicle initiation, chlorophyll content, high leaf area index, more sink capacity, large panicle length, more number of panicles m^{-2}, and higher grain yield [9]. At a specific location, maximum grain yield can be achieved by planting the crop at the optimum time, which may vary from variety to variety [10]. Early dates of planting increase the physiological parameter and grain yield of rice as compared to late planting due to higher dry matter accumulation in plants [9, 11]. However, late transplanting results in reduced yield promoting parameters and also limits the growth duration which further leads to a reduction in leaf area, productive tillers and test weight [12, 13]. Most of the above studies have confirmed that grain yield was significantly influenced by sowing time and higher productivity can be achieved by adopting an optimum date of planting. Therefore, the present investigation aimed to evaluate the grain yield performance of elite rice varieties under delayed planting conditions to screen out the suitable date of planting for Varanasi region.

2. MATERIALS AND METHODS

2.1 Experimental Materials

The present experiment was conducted during *kharif*-2018 to estimate the performance of different rice varieties under delayed planting conditions. The materials for the studies consist of four elite rice varieties (V1- HUR-3022, V2- DRR-44, V3- HUR-4-3, and V4- HUR-105) as sub plot factor and three dates of planting (D1- 05/09/2018, D2- 13/08/2018 and D3- 20/08/2018) as main plot factor. The ideal features of the research materials are mentioned in the Table 1. All the elite rice varieties chosen for the experiment were of medium duration and suitable for direct sowing condition in Varanasi region.

2.2 Experimental Site and Design

The field experimental was conducted in the Agricultural research farm under Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The experiment was conducted in a split plot design with three replications, which consists of 4 main plots and each main plot with 3 sub-plots. Hence, a total number of 12 treatments are allotted in the whole design. The location is under the sub-tropical region of Indo-Gangetic plains. Geographically it is located on 25º 2´ North latitude, 23º 03´ East longitudes and at an altitude of 75.7 meters above mean sea level. The field is under continuous cropping of rice and wheat. The farm was blessed with assured irrigation facility and homogenous fertility status. All the agronomical practices carried out during the experiment from field preparation to harvesting in proper time to produce a good yield.

Table 1. Desirable features of elite rice varieties used for the experimental studies

Sl. No.	Rice Variety	Yield (t/ha)	Duration (days)	Other Desirable Features
1.	HUR-3022 (V1)	5.0-5.5	105-110	This variety is popularly known as Malviya Dhan 3022 developed by B.H.U and released by SVRC of U.P. for whole Uttar Pradesh in 2004 but occupied a vast area in Western Bihar. This is an early maturing, high yielding variety with long-slender grains and good cooking quality. The variety is resistant to lodging, leaf and neck blast.
2.	DRR-44 (V2)	8.0	120	This variety is developed IIRR, Hyderabad, and released in 2014 for the states like Uttarakhand, Bihar and Haryana. This is resistant to drought, early duration, high yielding, long-slender grain quality and suitable for both irrigated and aerobic direct seeded rice conditions. The variety is resistant to blast and moderately resistant to Bacterial Leaf Blight and plant hopper.
3.	HUR-4-3 (V3)	5.5-5.8	135-140	This variety is developed by B.H.U. and released by SVRC of U.P. for commercial cultivation in irrigated areas of Eastern and Western Uttar Pradesh. The variety is semi-dwarf (90-100cm), grain type-long and slender with resistant to brown planthopper and leaf roller.
4.	HUR-105 (V4)	6.0-7.0	130-135	This variety is developed by B.H.U. and highly tolerant to drought and also tolerant to brown spot, bacterial leaf blight, leaf and neck blast, and stem borer.

2.3 Observations on Yield and Agro-morphological Traits

The biometric observations were taken from the field at a regular interval of 30, 60 and 90 days after planting (DAP) and during crop harvest. Five spots from each plot were randomly selected and tagged with a label. Healthy plants per running meter away from the boarder rows of each plot was selected randomly and taken for estimation of dry matter accumulation at the mentioned interval. The yield and yield attributes were recorded before, during and after harvest of the crop as and when required based on the investigation. The observations included growth parameters [plant height (cm), number of tillers m^{-2}, number of leaves m^{-2}, dry matter accumulation (gm)] and yield parameters [number of panicles m^{-2}, length of panicles (cm), panicle weight (g), test weight (g), grain yield (t/ha) and Straw weight (t/ha)].

2.4 Statistical Analysis

The statistical analysis was conducted by using data analysis software WASP version 1.0 (https://ccari.res.in/waspnew.html). The analysis of variance (ANOVA) was accomplished by using Microsoft Excel-2010 to get the concluding remarks. The standard error of mean and level of significance (at 5%) were estimated via F-test.

3. RESULTS AND DISCUSSION

3.1 Effect of Different Dates of Planting on Growth Attributes

3.1.1 Number of tillers per m^2

At the earlier growth stages, a greater number of tillers was produced as compared to the later stages. It depicts that the crop possesses better tillering ability in its earlier growth period. As the planting date delayed from 06/08/2018 to 20/08/2018, the number of tillers decreases, but no significant variation was observed (Table 2). The highest number of tillers was recorded on planting date 06/08/2018 (278.25) followed by 13/08/2018 (275.2) and 20/08/2018(258.0). There was an inverse relationship between number of tillers and delayed date of planting. In case of varieties, DRR-44 (276) proved to be the superior over other varieties, but was not able to produce significant variation. Next to it, HUR-3022 (265) was found to have better tillering ability. HUR-4-3 (231) produced the minimum number of tillers (Table 3). No significant effect was recorded in number of tillers under the interaction of date of planting and varieties.

3.1.2 Number of leaves per m^2

After analyzing the collected data, it can be expressed that number of leaves produced in the crop increases up to 60 DAP and afterwards decreased at 90 DAP. Crop sown on 06/08/2018 (977) date of planting produced significantly higher number of leaves as compared to 13/08/2018 (851.25) and 20/08/2018 (666.75) (Table 2). As the date of sowing delayed from D1 to D3, the number of leaves decreased. Among the varieties, DRR-44 (849.3) was found to be superior, but at par with the HUR-3022 (848). Variety HUR-4-3 (805) produced the least amount of leaves (Table 3). Interaction of different dates of planting and different varieties proved to be non-significant on number of leaves m^{-2} at each growth stages.

3.1.3 Height of plant (cm)

Pursual of the data showed that plant height increases throughout all the growth stages of the crop. However, it remained more at early growth stage compared to the later. Plant height decreases significantly on delaying planting dates. Crops sown on 06/08/2018 (204.7 cm) proved to be significantly superior followed by 13/08/2018 (173.42 cm) and 20/08/2018 (162.57 cm) (Table 2). Crop sown on D3 (20/08/2018) produced the least height of plants. This trend of response was followed at all the growth stages. In respect of plant height, variety DRR-44 (244.6) showed the highest plant height over other three varieties at all stage of growth (30 DAP, 60 DAP, 90 DAP). The variety HUR-4-3 (156 cm) showed minimum plant height at all the growth stages (Table 3). No significant effect was recorded on plant height due to interaction effect of date of planting and varieties.

3.1.4 Dry matter production (g)

The dry weight of plant increases gradually up to the harvest stage. Perusal of the data revealed significant variation on the dry matter accumulation due to various treatments at all growth stages (30 DAP, 60 DAP and 90 DAP) (Table 2). By delaying the date of planting, dry matter accumulation decreases. A crop sown on 06/08/2018 (178g) was found significantly superior over 13/08/2018 (164.3g) and 20/08/2018 (156g) in terms of dry matter accumulation at all the growth stages. Considering dry weight of plant, DRR-44 (203.29) was found significantly superior followed by HUR-3022 (173.36g), HUR-105 (160.85g) and HUR-4-3 (136.3g) (Table 3). This trend was observed at all growth stages of the crop. Interaction effect was not found significant on dry weight of plant due to different treatments.

3.2 Effect of Sowing Date and Rice Variety on Crop Parameters

Plant growth is considerably governed by the date of planting under different agroclimatic conditions. Different varieties behaved differently to the delayed planting condition. Number of tillers is an important growth attribute of the crop that ultimately leads to its productivity. It was found that planting beyond 06/08/2018 resulted in decrease of number of effective tillers. It supports the findings of Khalifa [14] that stated that number of tillers was higher under early sowing (April 20th) and gradually decreased with delaying sowing. If we consider performance of different varieties, DRR-44 showed its superiority in number of tillers production whereas HUR- 4-3 produced the least number of tillers. The short plants, less tillers, and low dry matter observed in early planted (22nd July) crop and characters increased successive with the advances of planting date until 7-22nd September and again declined thereafter irrespective of growth stages up to 60 DAT [15]. As per the findings, plant height decreases as we move more towards delayed planting beyond 5th August. Higher plant height was observed in the varieties sown on 06/08/2018. Among varieties DRR-44 showed significantly higher plant height as compared to others with HUR-4-3 was with the shortest plant height.

According to Dawadi and Chaudhary [16], late sowing, shortened the growth period of the plant which reduced the leaf area, number of leaves per plant than early sowing. These results were in line with the findings of Bashir *et al.*; Chandini *et al.*; Shah and Bhurer [12,13,17]. The biomass production was higher when the LAI and number of leaves per plant increased. As per our experimental findings, there was decreases in number of leaves when the planting date goes beyond 5th August towards 20th August and a higher number of leaves were recorded with 6th August (dates of sowing). As per the findings, DRR-44 expresses significantly higher number of leaves at all the growth stages as compared to other varieties. Whereas HUR-4-3 produced the minimum number of leaves at all the growth stages. As far as the effect of planting dates with respect to plant dry weight accumulation is concerned, early planting recorded significantly higher dry weight of plants compared to the delayed condition. There is a continuous increase in dry weight of plant as the age of the plant increases towards harvesting. As the date of planting concerned, crop sown on 06/08/2018 recorded higher dry weight of plant beyond which it decreases. Such finding is in the same line with the findings of Sharma *et al*. [18]. Among varieties, DRR-44 was observed as well adapted to delayed planting with maximum plant dry weight at all the growth stages and HUR-4-3 recorded lowest dry weight of rice crop.

3.3 Effect of Different Treatments on Grain Yield Attributes

3.3.1 Panicle weight (g)

The data showed that planting on 06/08/2018 (3.5g) recorded significantly higher panicle weight over 13/08/2018 (3.2g) and 20/08/2018 (2.8g) (Table 4). A decreasing trend of panicle weight was observed while delaying planting from 06/08/2018 towards 20/08/2018. It merely depicts an inverse relationship between panicle weight and delaying of planting. Data further revealed that among the different rice varieties, DRR-44 (4.4g) showed its superiority over other varieties and recorded significantly higher panicle weight, followed by HUR-3022 (3.1g) and HUR-105 (3.0g). Both V1 and V4 were at par with each other for panicle weight. HUR-4-3 (2.3g) was recorded the lowest panicle dry weight (Table 5 and Fig. 1). No significant variation on panicle weight was observed due to interaction of different dates of planting and varieties.

3.3.2 Panicle length (cm)

The data showed that planting on 06/08/2018 (52.71 cm) recorded significantly higher panicle length than 13/08/2018 (52 cm) and 20/08/2018 (51.1 cm) (Table 4). Crop planted on 20/08/2018(D3) recorded the lowest panicle length. It can be observed that panicle length decreases on delaying planting dates from D1 to D3. Among different rice varieties DRR-44 (53.8 cm) showed its superiority over the other varieties and recorded higher panicle length, but at par with HUR-3022 (52.9 cm). HUR-3022 (52.9 cm) and HUR-105 (52.0 cm) were also at par with each other. Variety HUR-4-3 (47 cm) recorded significantly smaller panicle length as compared to other varieties (Table 5 and Fig. 1). No significant variations in panicle length by the interaction of different planting dates and varieties were observed.

Table 2. Analysis of variance for growth parameters of different rice varieties as affected by different planting dates

Sources of Variation	df	Number of tillers m^{-2}			Number of leaves m^{-2}			Plant height (cm)			Dry matter production (g)		
		30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
Replication	2	70.78	75.00	70.08	15781.75	16834.36	10850.78	32.11	32.35	40.38	3.48	59.03	25.22
Sowing Dates (D)	2	3187.53*	3511.08*	3481.08	32746.58*	32468.53*	35210.11*	595.40	622.94*	637.86*	187.33*	153.76*	134.59*
Error D	4	225.03	220.21	191.29	3405.21	3193.61	4036.57	5.00	5.71	5.83	12.01	4.90	4.80
Variety (V)	3	1560.15*	1881.11*	1830.26	642.77^{NS}	439.63^{NS}	2287.74*	1636.12	1643.45*	1879.34*	1418.63*	1088.93*	776.31*
D × V	6	1895.01*	1819.08*	1799.34	12139.21*	11589.16*	8179.07*	67.88	53.54*	39.25^{NS}	246.14*	213.11*	209.50*
Error V	18	135.61	131.06	154.59	3909.31	4195.34	3614.60	15.70	15.13	16.74	25.81	23.41	34.57
SEm (D) ±	-	4.330	4.284	3.993	16.845	16.314	18.341	0.645	0.690	0.697	1.001	0.639	0.632
SEm (V) ±	-	3.882	3.816	4.145	20.842	21.590	20.041	1.321	1.297	1.364	1.693	1.613	1.960
CV (D)	-	19.79	18.24	16.17	22.84	20.38	24.68	3.91	4.04	4.02	6.84	4.21	3.90
CV (V)	-	15.36	14.07	14.54	24.47	23.36	23.35	6.94	6.58	6.81	10.03	9.21	10.47
CD (D) (p=0.05)	-	17.003	16.820	15.677	66.143	64.055	72.014	2.534	2.709	2.738	3.929	2.508	2.483
CD (V) (p=0.05)	-	11.533	11.338	12.314	61.923	64.149	59.543	3.924	3.853	4.052	5.032	4.791	5.823

*Where, * represents significance at 5% probability, 'NS'- represents Non-significant*

Table 3. Growth parameters of different rice varieties as affected by different planting dates

Treatments	Number of tillers m^{-2}			Number of leaves m^{-2}			Plant height (cm)			Dry matter production (g)		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
Planting Date												
D1:06/08/2018	258.75	274.25	278.25	910.5	977	934	195.4	201.38	204.7	165.6	169.7	178
D2:13/08/2018	252.25	273	275.2	788.75	851.25	815.5	162.1	171	173.42	152.1	157	164.3
D3:20/08/2018	244	255	258	599.5	666.75	609	156.25	160	162.57	145.2	149.8	156
SEm ±	4.330	4.284	3.993	16.845	16.314	18.341	0.645	0.690	0.697	1.001	0.639	0.632
CD (p=0.05)	17.003	16.820	15.677	66.143	64.055	72.014	2.534	2.709	2.738	3.929	2.508	2.483
Cultivar												
V1: HUR-3022	249.6	261.2	265	772	848	802	160.5	164.6	166.7	160.1	165	173.36
V2: DRR-44	259	272.3	276	798.3	849.3	824.6	231.1	237.3	244.6	191.39	196.78	203.29
V3: HUR-4-3	216	227	231	738	805	761	144.8	151	156	100.7	117.1	136.3
V4: HUR-105	229.5	240	243.1	756	823.6	775	148	157.4	161	155.3	151	160.85
SEm ±	3.882	3.816	4.145	20.842	21.590	20.041	1.321	1.297	1.364	1.693	1.613	1.960
CD (p=0.05)	11.533	11.338	12.314	61.923	64.149	59.543	3.924	3.853	4.052	5.032	4.791	5.823

Table 4. Analysis of variance (ANOVA) for yield and yield components of different rice varieties as affected by different planting dates

Sources of Variation	df	Panicle dry weight (g)	Panicle length (cm)	Bundle weight (g)	Test weight (g)	Grain yield (kg/ha)
Replication	2	0.02	0.24	0.10	0.47	833.33
Sowing Dates (D)	2	0.18*	5.00*	18.41*	0.18^{NS}	1390439.61*
Error D	4	0.01	0.31	0.60	0.15	5072.01
Variety (V)	3	0.76*	7.14*	6.90*	6.54*	1457944.04*
D × V	6	0.47*	5.32*	1.58^{NS}	1.73^{NS}	61269.88*
Error V	18	0.03	0.84	0.98	1.49	19781.62
SEm (D) ±	-	0.033	0.161	0.224	0.112	20.559
SEm (V) ±	-	0.057	0.306	0.330	0.407	46.882
CV (D)	-	10.585	3.235	16.206	1.892	9.495
CV (V)	-	15.929	5.340	20.621	5.962	18.752
CD (D) (p=0.05)	-	0.128	0.631	0.881	0.439	80.724
CD (V) (p=0.05)	-	0.169	0.909	0.980	1.208	139.295

*Where, * represents significance at 5% probability, 'NS'- represents Non-significant*

Table 5. Yield and yield components of different rice varieties as affected by different planting dates

Treatments	Panicle weight (g)	Panicle length (cm)	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Planting Dates (3)					
D1:06/08/2018	3.5	52.71	21.23	3.35	4.04
D2:13/08/2018	3.2	52	21.12	2.04	3.12
D3:20/08/2018	2.8	51.1	20.98	1.34	2.13
SEm ±	0.033	0.161	0.224	0.112	0.259
CD (p=0.05)	0.128	0.631	0.881	0.439	0.984
Cultivars (4)					
V1: HUR-3022	3.1	52.9	21.43	2.4	3.2
V2: DRR-44	4.4	53.8	21.56	3.8	4.76
V3: HUR-4-3	2.3	47	20.71	1.07	2.1
V4: HUR-105	3	52	20.8	1.64	2.67
SEm ±	0.057	0.306	0.330	0.407	46.882
CD (p=0.05)	0.169	0.909	0.980	1.208	139.295

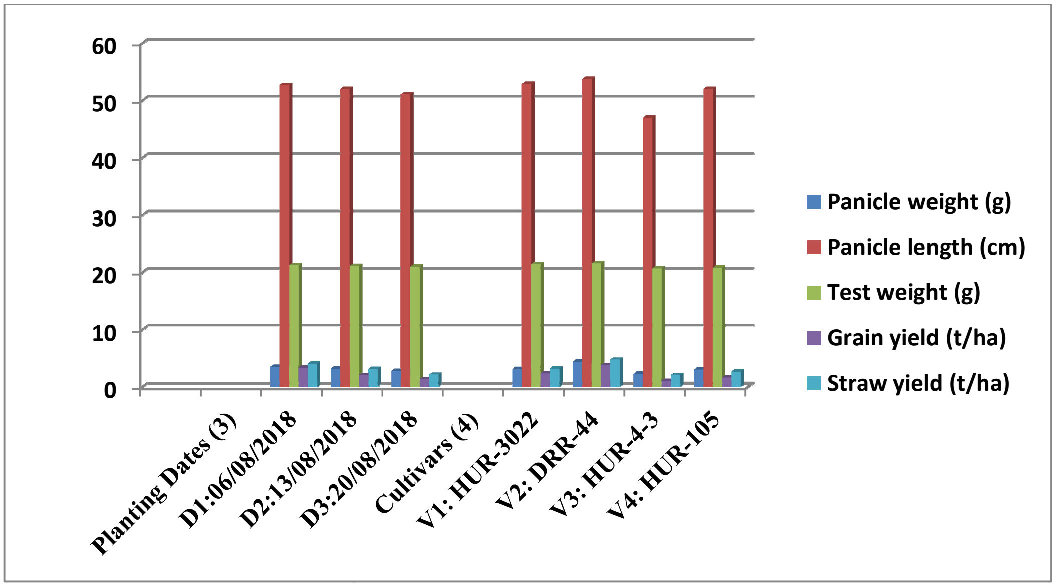

Fig. 1. Yield attributes of different rice varieties as affected by different planting dates

3.3.3 Test weight (g)

A critical analysis of the data indicated no significant variation in test weight due to different dates of planting (Table 4). A decreasing trend of test weight was observed due to delaying planting from 06/08/2018 (21.23g) to 20/08/2018 (20.98g) while crop sown on 06/08/2018. So far as the different varieties are concerned DRR-44 (21.56g) was recorded higher test weight which was at par with HUR-3022 (21.42g). However, both V1 and V4 were at par with each other. HUR-4-3 (20.71g) expresses the lowest test weight which was marginally different from the rest (Table 5 and Fig. 1). Similarly, the interaction effect between the different dates of planting and varieties on the test weight remains non-significant.

3.3.4 Grain yield (t ha^{-1})

Pursual of the data showed that planting on 06/08/2018 (3.35 t/ha) recorded significantly higher yield of 3.35 t/ha over D2: 13/08/2018 (2.04 t/ha) and D3: 20/08/2018 (1.34 t/ha) (Table 4). Planting on 20/08/2018 (D3) showed minimum grain yield. As the date of planting delayed onwards from 06/08/2018, the grain yield decreased significantly at a rate of 134 kg/day. Among the different rice varieties V2 (DRR-44) showed its superiority over other varieties and recorded significantly higher yield of 3.8 t/ha followed by HUR-3022 (2.4 t/ha) and HUR-105 (1.64 t/ha). Variety HUR-4-3 *i.e.*, V3 recorded the lowest grain yield of 1.07 t/ha. Interaction effect of different dates of planting and varieties was significant on grain yield. As per the data, DRR-44 planted on 06/08/2018 recorded the maximum grain yield followed by the same V2 sown on 13/08/2018. HUR-4-3 sown on 20/08/2018 (D3) recorded the lowest grain yield (Table 5 and Fig. 1).

3.3.5 Straw yield (t ha^{-1})

Statistical analysis of the data indicated that no significant variation in straw yield either due to different dates of planting or different varieties (Table 4). Different dates of planting produced mild variation on the straw yield. A decreasing trend of straw yield was viewed with delaying date of planting from 06/08/2018 towards 20/08/2018. The data clearly indicated that DRR-44 (4.76 t/ha) recorded higher straw yield followed by HUR-3022 (3.2 t/ha), but at par with each other. HUR-4-3 (2.1 t/ha) was recorded lowest straw yield (Table 5 and Fig. 1). As obvious from the data, the interaction effect between the different dates of planting and varieties failed to show any marked variation on straw yield.

3.4 Interaction Effect of Planting Date and Variety on Yield and Yield Attributes

Different yield attributes like panicle weight, panicle length, test weight affect the yield of the crop. Such characters were considered for different rice varieties under delayed planting condition. Number of panicles per plant decreased as the planting was delayed. Effective number of tillers per plant was responsible for number of panicles per plant which was more with timely planted. Again, number of panicles is directly correlated with the number of grains per plant [12,18]. As per the experimental finding, crop sown on 06/08/2018 resulted in maximum panicle length as compared to those sown delayed. Careful observation in the experiment was the existence of an inverse relationship observed between the panicle lengths and delaying of planting. DRR-44 sown on 6th August showed larger panicle length whereas; HUR-4-3 sown on 20th August produced shortest panicle length. It can be observed that the same variety performed differently under different dates of planting. Number of florets in the panicle: number of seeds in the panicle is one of the most important components of seed performance in rice. Regardless of the floret physical location on the panicle, their number can be affected by the environmental heat during the maturity period [19]. Planting date had a significant effect on panicle fertility percentage. The largest percentage belonged to the first planting date with an average of 72.5%. Fertility percentage declined due to delayed planting date and can be attributed to higher environmental detrimental conditions during the reproductive stage, panicle emergence time and also the maturation period [13,20]. The obtained results are on the same line of the reported literatures. DRR-44 performed the best when sown on 06th August with higher panicle weight and HUR-4-3 with the lowest panicle weight sown on 20th August. An inverse relationship was found between the late planting with panicle weight.

The thousand grain weight was influenced by both the factors of the experiment *i.e*. sowing dates and varieties. The highest value of the 1000 grain weight belonged to the first and second date of planting. Reduction in the1000 grain weight on the third planting date was due to excessive environmental stress [12,20]. It was also observed that the results of 1000 grain weight took the same trend as that of number of filled grains per panicle under delayed planting condition and it was supported by the findings of Khalid *et al*.; Chandini *et al*. [13,21]. Test weight is such a stable character which is less affected by environment, but delayed planting alters test weight marginally in the varieties. Grain yield is the ultimate requirement from the food crop. It is also observed that highest grain yield was recorded on August planting and which was significantly superior to 1st and 16th September transplanting [13,22]. Some reports published on hybrid rice also showed that rice grain yield decreases with more delayed planting [23]. When the interaction effects between grain yield and different dates of sowing were compared, then higher yield was observed in the variety DRR-44 (1544.44 t/ha) when planted on 6.08.2018 and second highest yield was recorded in the variety HUR-3022 (1133.33 t/ha) (Table 6 and Fig. 2).

3.5 Economics of Different Treatment Combinations

The effect of different treatment combinations on cost of cultivation, gross return (GR), net return (NR) and B:C ratios are presented in the Table 7. The results showed marked variation in grain and straw yield of different rice varieties under delayed planting condition and accordingly different gross return, net return and B:C ratios were worked out. A cursory glance of the data of the different treatment combinations showed a decreasing trend of gross return, net return and B:C ratio with increasing date of planting but were not able to produce any significant variation. The highest GR (62578), NR (21543) and B: C ratio (1.52) was found with the date of planting on 06/08/2018 over others. Data further revealed that DRR-44 was recorded with significantly higher GR (70984), NR (29949), B:C ratio (1.72) over other varieties under observation.

Table 6. Interaction effects of treatments on Grain yield (t ha^{-1}) of different rice varieties

	D1:06/08/2018	D2:13/08/2018	D3:20/08/2018
V1: HUR-3022	1133.33	681.48	600.00
V2: DRR-44	1544.44	1374.07	944.44
V3: HUR-4-3	674.07	288.89	111.11
V4: HUR-105	1125.92	381.48	140.74
SEm ±	81.203		
CD (p=0.05)	241.266		

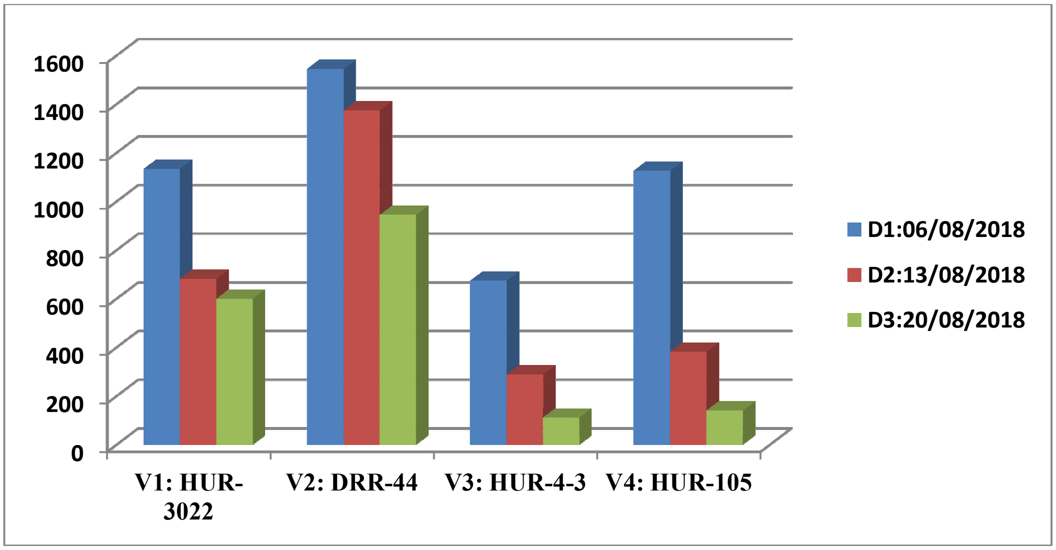

Fig. 2. Interaction effects of sowing dates and variety on grain yield (t ha^{-1}) of different rice varieties

Table 7. Effect of different treatments on cultivation economics of rice

Treatments	Cost of cultivation (□)	Gross return (□)	Net return (□)	B:C ratio
Planting Dates (3)				
D1:06/08/2018	41035	62578	21543	1.52
D2:13/08/2018	41035	56787	15752	1.38
D3:20/08/2018	41035	52358	11323	1.27
SEm±	0.00	2876.35	2669.43	0.07
CD(p=0.05)	0.00	9953.47	9746.42	0.23
Varieties (4)				
V1: HUR-3022	41035	58478	17443	1.42
V2: DRR-44	41035	70984	29949	1.72
V3: HUR-4-3	41035	42387	1352	1.03
V4: HUR-105	41035	45356	4321	1.10
SEm±	0.00	2430.98	2330.98	0.05
CD(p=0.05)	0.00	6832.15	6735.25	0.15

4. CONCLUSION

The experimental findings also showed that initial dates of sowing yield more grain and subsequently decreases as planting dates delayed further. The optimum dates of planting had marked effect on number of panicles/m^2, number of filled grains per panicle, 1000 grain weight, grain and straw yields per ha. Rice varieties sown in the field showed highest grain yield when sown on 6th August as compared to 13th and 20th August. As the dates of planting delayed crop yield subsequently decreased. This observation is in the same alignment with the previous published literatures. Among varieties, DRR-44 sown on 6th August produced significantly higher grain yield and HUR-4-3 sown on 20th August produced the least grain yield. Harvest index is the function of grain yield to the total biological yield (grain + straw). Harvest index was also influenced significantly due to various planting methods. Highest harvest index belonged to the first planting date. The remarkable reduction of harvest index from the first date resulted from the impact of high stress on panicle infertility rate, the decrease in yield components, severe photosynthesis declines along with exceeding respiration. Higher yield level in rice can be confirmed by adjusting the planting dates with the proper climatic conditions. So that the crop phenological phase can coincide with the suitable weather condition to boost the photosynthetic efficiency and ultimately increase the grain yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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