

Effect of sowing and harvesting times on growth characters and grain yield of *rabi* rice (*Oryza sativa* L.)

ABSTRACT

Keywords: Rice varieties, sowing and harvesting dates, growth characters, grain yield.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important food crop, providing 70 % direct employment in rural India and forming the staple diet of billions of people (Reference). Rice cultivation is critical to Asia's food security because it accounts for more than 90 % of rice production and consumption. Rice provides 32-59 % of dietary energy and 25-44 % of dietary protein. Rice demand is expected to rise by 70 % in the next 30 years to maintain current per capita availability (69 kg yr⁻¹), while keeping land productivity constant Patra and

Haque[16]. Rice production is the world's single largest land use for food production, covering 164 M ha and producing about 750 million tonnes of paddy each year FAO [6]. India is the second largest producer of rice after China. In India, rice is cultivated in 45.7 M ha with production of 124.3 million tonnes and productivity of 2717 kg ha⁻¹GOI [10].

The timing of transplanting in rice is critical to ensure adequate vegetative growth during a period of moderate temperature and high solar radiation. Proper transplanting date for each cultivar ensures that the cold sensitive stage occurs when the minimum night temperatures have historically been the warmest and planting at the right time ensures that grain filling occurs when temperatures are more likely to be mild, resulting in high-quality grain Farrell et al.[8]. Transplanting too soon or too late reduces yields in ways that no other input or practice can compensate for Kapoor et al.[11]. Temperatures that are too high or too low can affect flowering and prevent pollen shedding, resulting in high infertility and chaffy grain production, resulting in yield loss. To achieve a maximum yield level and quality of grain, it is necessary to optimise transplanting time. The harvesting of the crop at the right time ensures the maximum quantity and quality of rice. Harvesting the crop too early may result in a lower yield of the crop with poor quality grains as there will be a number of green or immature grains. If the rice crop is harvested too late, the grains may shatter and be eaten by birds and rodents, resulting in grain loss. Grains develop sun cracks as a result of over-maturity and over-drying in the field, resulting in severe breakage during milling. A critical evaluation of the optimal harvest stage is considered necessary for farmers to maximize the return on their produce.

Of the total rice crop area of 45.7 M ha in India, the *kharif* and *rabi* percentages are 88.18 and 11.81 respectively, where as in Telangana, the rice crop area in *kharif* and *rabi* season are almost same (20.99 M ha and 20.78 M ha) which as a unique GOT [9]. Traditionally, Telangana farmers used to cultivate market demand fine grain varieties to the tune of 40 % in *kharif*, where as in *rabi* ,almost 90 % of rice area with long slender grain type varieties . The long slender grain varieties are procured by government through Indira kranthipathakam right from the villages. Telangana *rabi* rice season is typical with sunny days, cold nights (large diurnal variations) and temperatures raising sharply from March onwards with low relative humidity. These weather conditions though very good for higher yields , at the same time limits the quality of rice (Low head rice recovery). To minimize the broken rice percentages, millers practices paraboiling for *rabi* rice. This rice is exported to Kerala, Tamil Nadu and other southern states for grain consumption. But those too have started cultivation of long sender varieties to meet their needs. As a result, there is no market for long slender varieties. As the buffer stocks (268.32 mt) are sufficient, the Food Corporation of India is not showing much interest to purchase parboiled rice during the *rabi* FCI [7]. With the change of central government policy of not to procure parboiled rice is big jolt to the farming community of Telangana state.

It is well known fact that, *rabi* sowing time depends on the harvestings of the previous *kharif* farmers rice crop. The different rice agroecosystems coupled with farmers management practices (varieties, fertilisers, systems of cultivation) are the right reasons for different sowings in *kharif* ultimately different harvesting dates [Reference]. Farmers in Telangana starts *rabi* nursery sowing from 10th November to 20th January, subjecting the rice crop to wide environmental variations. Though some studies were carried out regarding performance of long slender rice varieties in *rabi* season. pertaining to yield Anil and Siddi.[1], no research studies were conducted with market demand fine grain rice varieties especially under delayed sowings/ harvestings, which is a common problem in most of the farmers fields. By considering all the above facts, the following work was put forth.

2. MATERIAL AND METHODS

A Field experiment was conducted during *rabi* season of 2021 at Rice Research

Centre, Agricultural Research Institute, Rajendranagar, Hyderabad with eighteen treatments laid out in strip plot design with three replications. The soil of experimental site was clay loam in texture and slightly alkaline in reaction (pH 7.8), low in organic carbon (0.48%) and available nitrogen (213 kg ha^{-1}), high in available phosphorus (27.2 kg ha^{-1}) and potassium (453.1 kg ha^{-1}). Treatments included were 3 treatments of varieties (i) M_1 =Telangana sona (ii) M_2 = Jagtial rice 1 (iii) M_3 = Chintu and 6 sowing and harvesting dates (i) S_1 =Normal sowing time (November 15) and harvesting at physiological maturity (ii) S_2 = Normal sowing time (November 15) and harvesting at 7 days after physiological maturity (iii) S_3 =Delay sowing by 15 days (November 30) and harvesting at physiological maturity (iv) S_4 =Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity (v) S_5 =Delay sowing by 30 days (December 15) and harvesting at physiological maturity (vi) S_6 =Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity randomly placed in subplots of the main plot. Nursery of three varieties *i.e.*, Telangana sona, Jagtial rice 1 and Chintu was raised as per the dates of sowing *i.e.*, 15th November, 30th November, 15th December. The sprouted seeds were broadcasted on well prepared raised beds adopting seed rate of 50 kg ha^{-1} , 62.5 kg ha^{-1} and 15 kg ha^{-1} respectively maintaining a spacing of $15 \text{ cm} \times 15 \text{ cm}$. The crop was fertilized with $150\text{-}60\text{-}40 \text{ Kg ha}^{-1}$ N, P_2O_5 and K_2O in the form of urea, DAP and MOP.

3.RESULTS AND DISCUSSION

3.1 Growth parameters

3.1.1 Plant height

The data pertaining to plant height (cm) was depicted in Table 1 (Add some discussion on plant height here)

3.1.1.1 Rice varietal performance

At 30 days after transplanting, significantly higher plant height was observed in M_1 (Telangana sona) and was on par with M_2 (Jagtial rice 1), which was **inturn** on par with M_3 (Chintu). At 60 days after transplanting Significantly higher plant height was observed in M_1 (Telangana sona) over all other varieties followed by M_2 (Jagtial rice 1), which was on par with M_3 (Chintu). At 90 DAT, similar trend was observed like that of 30 DAT. At harvest, similar trend was observed like that of 60 DAT. It maybe due to the genetic character of the variety. The results consistent with the findings of Nizamani et al. [14] and Suleiman et al. [18], who observed plant height, differed significantly among the varieties.

3.1.1.2 Performance of rice under varied sowing and harvesting dates

At 30 DAT, S_5 (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) shown significantly higher plant height and was on par with S_6 (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), which was **inturn** on par with S_3 (Delay sowing by 15 days (November 30) and harvesting at physiological maturity) and S_4 (Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity). The lowest values of plant height **was** observed in S_2 (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). At 60 DAT, significantly higher plant height was observed in S_5 (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) and was on par with S_6 (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), followed by S_3 (Delay sowing by 15 days (November 30) and harvesting at physiological maturity), which was in turn

on par with S₄ (Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity). The lowest plant height was recorded in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). At 90 DAT, S₅ (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) shown significantly higher plant height and was on par with S₆ (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), followed by S₃ (Delay sowing by 15 days (November 30) and harvesting at physiological maturity), which was inturn on par with S₄ (Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity) and S₁ (Normal sowing time (November 15) and harvesting at physiological maturity). The lowest plant height was observed in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). At harvest, similar trend was observed like that of 90 DAT. Plant height is directly proportional to the length of the vegetative phase of the crop. Koireng et al. [12] reported that significantly different responses of different genotypes to various management variable and environments with respect to growth attributes due to inherent characteristics.

3.1.2 Number of tillers m⁻²

The data pertaining to number of tillers m⁻² was depicted in Table 2 (Add some discussion on plant height here)

3.1.2.1 Rice varietal performance

The data presented in Table 2 shows that at 30 DAT, M₃ (Chintu) shown significantly higher number of tillers m⁻² over all other varieties followed by M₂ (Jagtial rice 1), which was on par with M₁ (Telangana sona). At 60DAT, significantly higher number of tillers m⁻² were observed in M₃ (Chintu) over all other varieties followed by M₁ (Telangana sona), which was on par with M₂ (Jagtial rice 1). Similar trend like that of 60 DAT was observed at 90 DAT, at harvest.

The number of tillers m⁻² varied among the cultivars. It might be due to differences in genetic makeup of these rice varieties. The results are in close conformity with Mali and Choudhary [13] and Sarwari et al. [17].

3.1.2.2 Performance of rice under varied sowing and harvesting dates

At 30 DAT, S₅ (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) shown significantly higher number of tillers m⁻² over all other treatments followed by S₆ (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), which was on par with S₃ (Delay sowing by 15 days (November 30) and harvesting at physiological maturity). The lowest values of number of tillers m⁻² were observed in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). At 60 DAT, Significantly higher number of tillers m⁻² were observed in S₅ (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) and was on par with S₆ (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), however S₆ (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity) was inturn on par with S₃ (Delay sowing by 15 days (November 30) and harvesting at physiological maturity). The lowest number of tillers m⁻² was found in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). At 90 DAT, similar trend was observed like that of 60 DAT. At harvest, S₅ (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) shown significantly higher number of tillers m⁻² and was on par with S₃ (Delay sowing by 15 days (November 30) and

harvesting at physiological maturity) and S₆ (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), however S₆ was on par with S₄ (Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity). The lowest values of tillers m⁻² were found in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). This may be due to availability of favorable soil and air temperature during growing cycle of the crop. Similarly these findings were supported by Sharma [19] and Osman et al. [15].

3.1.3 Dry matter accumulation

The data pertaining to dry matter accumulation was depicted in Table 3 (Add some discussion on plant height here)

3.1.3.1 Rice Varietal performance

At 30 DAT, there was no significant difference in dry matter accumulation among varieties. At 60, 90 DAT and at harvest, significantly higher dry matter accumulation was observed in M₁ (Telangana sona) and was on par with M₂ (Jagtial rice 1). The lowest dry matter accumulation was observed in M₃ (Chintu). The difference in dry matter accumulation among the genotypes might be due to their genetic potential and differential plant height. Similar results were obtained by Dileepet al.[4].

3.1.3.2 Performance of rice under varied sowing and harvesting dates

At 30, 60 and 90 DAT, significantly higher dry matter accumulation was found in S₅ (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) and was on par with S₆ (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), which was in turn on par with S₃ (Delay sowing by 15 days (November 30) and harvesting at physiological maturity). The lowest values of dry matter accumulation were found in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). At harvest, significantly higher dry matter accumulation was found in S₅ (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) and was on par with S₆ followed by S₃ (Delay sowing by 15 days (November 30) and harvesting at physiological maturity), which was in turn on par with S₄ (Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity). The lowest values of dry matter accumulation were found in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity). Increase in plant height, tillers hill⁻¹ resulted in better interception of sunlight and efficient photosynthesis thus provided favourable condition for enhancement of dry matter production during sowing of rice in mid of December. These findings are in accordance with Duvvada et al.[5]

3.2 Grain yield

The data pertaining to grain yield was depicted in Table 3 (Add some discussion on plant height here)

3.2.1 Rice Varietal performance

Among different varieties tested, M₁ (Telangana sona) shown significantly higher grain yield and was on par with M₂ (Jagtial rice 1). The lowest values of grain yield were found in M₃ (Chintu). The superiority of Telanganasona and Jagtial rice 1 might resulted from its better growth character*i.e.*, dry matter accumulation .These results are in accordance with Bindu [2]

3.2.2 Performance of rice under varied sowing and harvesting dates

S₅ (Delay sowing by 30 days (December 15) and harvesting at physiological maturity) shown significantly higher grain yield over all other treatments followed by S₆ (Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity), which was on par with S₁ (Normal sowing time (November 15) and harvesting at physiological maturity)and S₃ (Delay sowing by 15 days (November 30) and harvesting at physiological maturity).The lower values of grain yield were found in S₂ (Normal sowing time (November 15) and harvesting at 7 days after physiological maturity).The increased yield might be due to result of higher dry matter accumulation associated with favorable weather condition responsible for more growth and development resulted in more storage of photosynthates in the grain. These results are in accordance with Anil and Siddi [1] and Chendge et al. [3].

Interaction of rice varieties, sowing and harvesting dates

The interaction effect was found non significant for plant height, number of tillers m⁻², dry matter accumulation and grain yield of rice crop.

Table 1.Plant height (cm)at different growth intervals of rice as influenced by varieties, sowings and harvesting dates

Treatments	30 DAT	60 DAT	90 DAT	Harvest
Main plots : Varieties				
M₁ - Telangana sona	54.0	75.4	82.3	93.8
M₂ - Jagtial rice 1	50.1	67.1	73.4	82.9
M₃ - Chintu	47.8	65.7	71.6	80.1
SE(m)±	1.07	1.17	2.62	2.62
CD (p=0.05)	4.2	4.6	10.3	10.3
Sub plots: Sowing and harvesting dates				
S₁ - Normal sowing time (November 15) and harvesting at physiological maturity	46.8	63.3	71.4	81.7
S₂ - Normal sowing time (November 15) and harvesting at 7 days after physiological maturity	43.1	60.8	69.2	78.5
S₃ - Delay sowing by 15 days (November 30) and harvesting at physiological maturity	51.4	70.7	75.7	86.0
S₄ - Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity	51.2	67.5	72.0	81.4
S₅ - Delay sowing by 30 days (December 15) and harvesting at physiological maturity	57.0	78.1	84.1	94.4
S₆ - Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity	54.4	75.8	82.3	91.7
SE(m)±	1.13	1.04	1.76	1.76
CD (p=0.05)	3.6	3.3	5.5	5.5
Interaction				
M×S				
SE(m)±	1.59	2.22	3.48	3.48
CD (p=0.05)	NS	NS	NS	NS
S×M				
SE(m)±	1.58	2.06	2.78	2.78
CD (p=0.05)	NS	NS	NS	NS

Table 2 Number of tillers m² at different growth intervals of rice as influenced by varieties, sowing and harvesting dates

Treatments	30 DAT	60 DAT	90 DAT	Harvest
Main plots : Varieties				
M₁ - Telangana sona	297	397	383	359
M₂ - Jagtial rice 1	305	376	359	353
M₃ - Chintu	482	590	579	566
SE(m)±	7.07	12.58	12.65	15.50
CD (p=0.05)	28	49	50	61
Sub plots: Sowing and harvesting dates				
S₁ - Normal sowing time (November 15) and harvesting at physiological maturity	330	430	416	403
S₂ - Normal sowing time (November 15) and harvesting at 7 days after physiological maturity	312	404	398	389
S₃ - Delay sowing by 15 days (November 30) and harvesting at physiological maturity	369	457	446	436
S₄ - Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity	352	443	429	419
S₅ - Delay sowing by 30 days (December 15) and harvesting at physiological maturity	418	512	490	462
S₆ - Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity	389	479	463	446
SE(m)±	9.00	10.96	8.48	8.51
CD (p=0.05)	28	35	27	27
Interaction				
M×S				
SE(m)±	16.66	21.55	21.96	23.19
CD (p=0.05)	NS	NS	NS	NS
S×M				
SE(m)±	16.83	19.81	18.93	18.36
CD (p=0.05)	NS	NS	NS	NS

Treatments	30 DAT	60 DAT	90 DAT	Harvest	Grain yield (kg ha ⁻¹)
Main plots : Varieties					
M₁ - Telangana sona	4366	9120	13115	14263	6127
M₂ - Jagtial rice 1	4117	8880	12863	14005	6000
M₃ - Chintu	3679	7592	10858	11979	4927
SE(m)±	236.41	189.33	187.81	195.13	92.99
CD (p=0.05)	NS	743	737	766	365
Sub plots: Dates of sowings and harvestings					
S₁ - Normal sowing time (November 15) and harvesting at physiological maturity	3585	7916	11688	12832	5665
S₂ - Normal sowing time (November 15) and harvesting at 7 days after physiological maturity	3243	7573	11310	12475	5316
S₃ - Delay sowing by 15 days (November 30) and harvesting at physiological maturity	4168	8741	12436	13517	5663
S₄ - Delay sowing by 15 days (November 30) and harvesting at 7 days after physiological maturity	3907	8334	12104	13284	5395
S₅ - Delay sowing by 30 days (December 15) and harvesting at physiological maturity	4901	9564	13363	14501	6235
S₆ - Delay sowing by 30 days (December 15) and harvesting at 7 days after physiological maturity	4520	9055	12771	13885	5835
SE(m)±	129.64	204.82	190.71	188.94	74.52
CD (p=0.05)	409	645	601	595	235
Interaction					
M×S					
SE(m)±	359.38	410.38	400.61	401.03	223.48
CD (p=0.05)	NS	NS	NS	NS	NS
S×M					
SE(m)±	286.23	399.73	384.29	380.53	205.57
CD (p=0.05)	NS	NS	NS	NS	NS

Table 3 Plant dry matter accumulation (kg ha⁻¹) at different growth intervals and grain yield (kg ha⁻¹) as influenced by varieties, sowing and harvesting dates

Figure 1 Plant height (cm) at different growth intervals of rice as influenced by varieties, sowing and harvesting dates

Figure 2 Number of tillers m⁻² at different growth intervals of rice as influenced by varieties, sowing and harvesting dates.

Figure 3 Dry matter accumulation (kg ha⁻¹) at different growth intervals of rice as influenced by varieties, sowing and harvesting dates.

Figure 4 Grain yield (kg ha⁻¹) of rice as influenced by varieties, sowing and harvesting dates.

4. CONCLUSION AND RECOMMENDATIONS

Based on the research work, it can be inferred that among the varieties, Telangana sona (M₁) performed better in terms of growth and grain yield. Among different sowing and harvesting times, Delay sowing by 30 days (December 15) and harvesting at physiological maturity (S₅) will be more effective in obtaining better growth and higher grain yield under *rabi* conditions.

ETHICAL APPROVAL

No ethical issues were reported during the research work.

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