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Effect of sowing window on growth parameters and yield of different rice varieties in Krishna western delta

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Abstract
A field experiment was conducted to evaluate the effect of different sowing dates on yield and yield components of the different rice varieties during *kharif* 2015 at Agricultural Research Station, Bapatla. The experiment was laid-out in split plot design with three replications. The four rice varieties *viz*, BPT 5204, BPT 2270, BPT 2231 and BPT 1768 were considered as main treatments and four dates of sowing like 15th July, 1st August, 15th August and 1st September were considered as sub treatments. The results revealed that BPT 2231 rice sown on 15th July proved to be the best for obtaining highest plant height, productive tillers, panicle length and grain yield (5900 kg ha^{-1}) and straw yield (7178 kg ha^{-1}) followed by BPT 2270 variety.

Keywords: Krishna, parameters, Bapatla

Introduction
Rice (*Oryza sativa* L.) is one of the world's most important staple food crops. In Asia, rice is the main item of the diet of 3.5 billion people. Therefore, increase in population will require 70 per cent more rice in 2025 than is consumed today (Kim and Krishnan, 2002) [9]. In India, rice is grown in an area of 44.6 million hectare with a production of 109.5 million tones and average productivity of 2.62 tons per hectare. Projection of India's rice production target for 2025 AD is 140 million tones which can be achieved only by increasing rice production by 2 million tons per year over the existing in the coming decade (Sridhar *et al*., 2011) [21].
The optimum period of time for sowing and transplanting of rice is critical in achieving high grain yield. However, optimum rice planting dates vary with regional, location and genotypes (Bashir, 2010) [1]. Rice plants require a particular temperature for its phenological affairs such as panicle initiation, flowering, panicle exertions from flag leaf sheath and maturity. Rice needed before or afterthe window of optimum dates usually has slow germination and emergence, poor crop stand establishment, increased soil borne, seedling diseases damage under cold conditions, and seeds lose by birds or mice. Seedling at the optimum time is an important factor of transplanting for uniform stand establishment of rice. On the other hand, seedling sown with the delay of sowing more than optimum produces fewer tillers due to the reduction of the vegetative period and hence results in poor yield. Among the crop production tools, 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-ecology zone (Vange and Obi, 2006) [23]. 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 (Farrell *et al.*, 2003) [4]. Early date of sowing is the best time of sowing for important properties such as maximum tillering, panicle initiation, chlorophyll content, leaf area index, sink capacity, panicle length, number of panicles m $^{-2}$, and grain yield (Khalifa, 2009) [8]. 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 (Reddy and Narayana, 1984) [18]. Early dates of planting increase the physiological parameter and grain of rice as compared to late planting (Mukesh *et al.*, 2013) [12]. Grain yield was significantly influenced by sowing time. Therefore, to evaluate the impact of different sowing dates of different rice cultivars on crop growth and yield.

Materials and methods

A field experiment was conducted at Agricultural Research Station, Bapatla during *kharif*, 2015 to evaluate the effect of different sowing dates on yield and yield components of the different rice varieties. The experiment was laid out in split plot design with three replications. The four rice varieties *viz*., BPT 5204, BPT 2270, BPT 2231 and BPT 1768 were considered as main treatments and four dates of sowing like 15th July, 1st August, 15th August and 1st September were considered as sub treatments. Crop was fertilized with N, P and K at recommended rate using urea, SSP and Murate of Potash as source. All other agronomic practices under study were kept normal. Plant protection measures were taken as and when necessary in all the treatments. Harvesting was done as and when crop was mature. Data on yield parameters *i.e* plant height (cm), number of productive tillers (m^{-2}), number of grains per panicle, test weight (g), grain yield (kg/ha) and straw yield (kg/ha) were recorded. Data recorded were analysed statistically using Fishers analysis of variance technique. Difference among the treatment means were compared using least significant difference (LSD) test at 5% probability level.

Results and discussion

Plant height (cm)

Plant height was significantly affected by different sowing dates. The crop sown on 15th July produced the maximum plant height (105.4 cm) and it was statistically on a par with 1st August sowing in plant height. Plant height decreased significantly as sowing was delayed. The lowest plant height (88.3 cm) was observed when the crop was sown on 1st September (Table-1). It is obvious that the reduction in plant height was attributed to the reason that late planting had shorter growing period due to photoperiodic response. Early planted crop produced taller plants and higher drymatter production as compared to the late planting dates. These results are in line with Paraye and Kandalkar (1994) [17] and Khakwani *et al.* (2006) [7]. Among different rice varieties BPT 2231 recorded significantly highest plant height (104.2 cm) which was statistically at par with BPT 2270 (101.5 cm). The lowest plant height (92.6 cm) was recorded with BPT 5204 variety. Significant interaction was observed between dates of sowing and different rice varieties. The highest plant height (108.6 cm) was recorded with BPT 2231 variety in 15th July sowing and the lowest plant height (77.3 cm) was recorded with BPT 5204 variety in 1st September sowing. Dhiman *et al*. (1995) [2] observed that higher plant height in earlier planting of 15th July than delayed planting on 25th July and 5th August.

Table 1: Effect of dates of sowing on plant height (cm) of different rice varieties

Varieties	Sowing dates				
	15th July	1st August	15th August	1st September	Mean
BPT5204	99.6	97.6	95.9	77.3	92.6
BPT2270	106.3	106.3	101.6	91.8	101.5
BPT2231	108.6	108.3	102.4	97.4	104.2
BPT1768	107.3	98.7	98.3	86.6	97.7
Mean	105.4	102.8	99.6	88.3	
	SEm±	CD (0.05)	CV (%)		
Varieties	1.6	5.2	5.1		
Sowing dates	1.8	5.7	6.4		
Interaction	2.2	6.5	6.1		

Productive tillers/plant

There is a vital role of time of planting in paddy crop because of the variation in the duration, photo-sensitiveness, thermo-sensitiveness and vegetative lag period of the variety. Number of tillers per plant was influenced by various sowing dates. Maximum number of tillers per plant (13) was observed the crop sown on 15th July and 1st August whereas the rice crop sown on 15th August and 1st September gave minimum tillers per plant (11).

Among yield components, productive tillers plays very important role because the final yield is mainly depends on the number of panicles bearing tillers (productive tillers) per unit area. Results revealed that the highest number of fertile tillers per plant was recorded with 15th July and 1st August sowing. The favorable environmental conditions which enabled the plant to improve its growth and development as compared to other sowing dates. Our results are in alignment with the findings of Nayak *et al*. (2003) [14], Shah and Bhurer (2005) [19] and Osman *et al.* (2015) [15]. Significantly more number of tillers was produced by BPT 2231 variety (13) and BPT 2270 (13) than BPT 1768 and BPT 5204 variety (Table-2). Significant interaction was observed between dates of sowing and different rice varieties. Maximum number of tillers (14) was observed with BPT 2270 variety in 15th July sowing and the minimum number of tillers (11) was recorded with BPT 5204 variety in 1st September sowing. Results are in agreement with Pandey *et al*. (2001) [16] noted that PA6201 gave significantly higher productive tillers per hill of the crop transplanted on 20th July and 4th August than that of the crop transplanted on 20th August.

Table 2: Effect of dates of sowing on number of productive tillers/plant of different rice varieties

Varieties	Sowing dates				
	15th July	1st August	15th August	1st September	Mean
BPT5204	13	13	11	10	12
BPT2270	14	12	12	12	13
BPT2231	13	13	12	12	13
BPT1768	12	13	11	11	12
Mean	13	13	11	11	
	SEm±	CD (0.05)	CV (%)		
Varieties	0.2	0.8	5.6		
Sowing dates	0.2	0.6	5.7		
Interaction	0.3	0.9	5.6		

Panicle length (cm)

In fact, the variable trend and limit of vegetative growth during successive growth stages, before the start of reproductive phase is mainly governed by the genetic behavior inherited in the high yielding rice genotypes as well as the crop management practices and by the existing agro-climatic conditions of the region. As regards with the effect of different sowing dates, 15th July sowing produced significantly highest panicle length (22.4 cm) followed by 1st August sowing and the lowest panicle length (20.5 cm) was recorded in 1st September sowing. Gill *et al.* 2009 [5] reported that significantly higher yield attributes like panicle length and number of grains/panicle was higher in 20th July sowing date. All the varieties were also showed significant differences in panicle length under observation. Among the varieties, BPT 2231 showed significantly higher panicle length (22.3 cm) and it was on a par with BPT 2270 (22.2 cm) variety. Significantly the lowest panicle length was observed in BPT 5204 variety (20.3 cm). Such type of variation in physiological parameters among the different varieties might be owing to differences in their parental origin which caused variation in their genetically inheritance for such traits. The present findings corroborate with those of several researchers (Mukesh *et al*., 2013 and Walia *et al.*, 2014) [12, 24]. The

interaction between dates of sowing and different rice varieties were recorded non-significant in case of panicle length (Table-3).

Table 3: Effect of dates of sowing on panicle length (cm) of different rice varieties

Varieties	Sowing dates				
	15th July	1st August	15th August	1st September	Mean
BPT5204	19.9	21.1	20.6	19.4	20.3
BPT2270	24.5	21.7	21.3	21.2	22.2
BPT2231	22.3	22.6	22.4	21.9	22.3
BPT1768	22.9	21.0	21.3	19.5	21.2
Mean	22.4	21.6	21.4	20.5	
	SEm±	CD (0.05)	CV (%)		
Varieties	0.6	1.6	6.2		
Sowing dates	0.4	1.3	5.4		
Interaction	0.8	NS	6.3		

Number of grains per panicle

Number of grains per panicle is significantly influenced by different sowing dates. Fifteenth July produced significantly maximum number of grains (179) and it was on par with st August sowing (177), whereas minimum number of grains per panicle (162) was produced by 1st September sowing. Late sowing, shortened the growth period of the plant which reduced the leaf area, length of panicle and number of kernels per panicle than early sowing. These are in line with the findings of Shah and Bhurer (2005) [19] and Hussain *et al.* (2009) [6]. Among the four rice varieties the highest number of grains per panicle was registered in BPT 2231 variety (179) and the lowest number of grains per panicle 163 was registered in BPT 5204 variety. There is significant interaction was observed between dates of sowing and different rice varieties. Maximum number of grains /panicle (196) was recorded with BPT 2231 variety in 15th July sowing and the minimum number of grains/panicle (150) was recorded with BPT 5204 in 1st September sowing.

Table 4: Effect of dates of sowing on number of grains/panicle of different rice varieties

Varieties	Sowing dates				
	15th July	1st August	15th August	1st September	Mean
BPT5204	175	166	158	150	163
BPT2270	178	187	184	162	178
BPT2231	196	184	167	169	179
BPT1768	165	169	166	165	166
Mean	179	177	169	162	
	SE m±	CD (0.05)	CV (%)		
Varieties	3.6	10.7	5.2		
Sowing dates	2.8	9.5	7.9		
Interaction	5.2	15.7	8.2		

Test weight (g)

Test weight was significantly affected by different sowing dates. Rice sown on 15th July produced heavier grains (17.2g), when compared to 1st September sowing. This indicated that the environmental conditions like temperature, humidity was most favourable for grain development during earlier dates of sowing as compared to late sowing dates. BPT 1768 recorded the maximum test weight (20.1 g) followed by BPT 2231 (17.9 g). The lowest test weight (14.4 g) was recorded with BPT 5204 variety. There is significant difference was observed among rice varieties and their interaction with various dates of sowing in case of test weight. The highest test weight (20.3 g) was recorded with BPT 1768 variety of 15th July sowing and the lowest test weight was recorded with BPT 2270 variety in 1st September sowing (14.1 g).

Table 5: Effect of dates of sowing on test weight (g) of different rice varieties

Varieties	Sowing dates				
	15th July	1st August	15th August	1st September	Mean
BPT5204	15.7	15.6	15.6	15.4	15.6
BPT2270	14.5	14.5	14.3	14.1	14.4
BPT2231	18.2	18.0	17.9	17.7	17.9
BPT1768	20.3	20.1	19.8	19.6	20.1
Mean	17.2	17.1	16.9	16.7	
	SEm±	CD (0.05)	CV (%)		
Varieties	1.1	3.4	6.2		
Sowing dates	0.1	0.3	4.3		
Interaction	1.5	4.5	5.1		

Grain yield (kg/ha)

Grain yield is a function of interplay of various yield components such as number of grains per panicle, productive tillers and test weight. The data pertaining to the grain yield as affected by different sowing dates are given in Table-6. A glance of table indicated that all sowing dates differ significantly with respect to grain yield. July 15th sowing produced maximum grain yield (5594 kg/ha) whereas less grain yield (5185 kg ha) was observed in 1st September sowing. The decreasing trend in the grain yield in delayed sowing might be associated with significantly lower number of productive tillers m^{-2}, less number of filled grains per panicle. These results are also in conformed to the findings of Shah and Bhure (2005) [19], Khakwani *et al.* (2006) [7] and Bashier *et al.* (2010) [1]. There was significant difference in grain yield of various rice varieties. Among the four rice varieties BPT 2231 has recorded significantly maximum grain yield 5478 kg/ha and the lowest grain yield of 4725 kg/ha was recorded in BPT 5204 varieties. All the growth, yield attributing parameters are responsible for grain yield and biological yield. Similar findings have been reported by Hussain *et al.* (2009) [6], Suresh *et al.* (2013) [22] and Walia *et al.* (2014) [24]. There is significant interaction was observed between dates of sowing and different rice varieties. The highest grain yield (5900 kg/ha) recorded with BPT 2231 variety in 15th July sowing and the lowest grain yield (4540 kg/ha) was recorded with BPT 5204 in 1st September sowing. Dongarwar *et al.* (2005) [3] reported that early transplanting on 15th July and 30th July resulted in significantly higher grain yield 31.29 and 32.61 q/ha, respectively than late transplanting on 15th August (28.40 q/ha).

Table 6: Effect of dates of sowing on grain yield (kg/ha) of different rice varieties

Varieties	Sowing dates				
	15th July	1st August	15th August	1st September	Mean
BPT5204	5000	4790	4570	4540	4725
BPT2270	5525	5400	5350	5200	5369
BPT2231	5900	5390	5320	5300	5478
BPT1768	5450	5335	5280	5200	5316
Mean	5469	5229	5130	5060	
	SE m±	CD (0.05)	CV (%)		
Varieties	170.2	505	8.1		
Sowing dates	110	325	9.2		
Interaction	240.4	723.4	8.0		

Straw yield (kg/ha)

Straw yield (7163 kg/ha) was maximum in case of 15th July sowing date. Significantly the lowest straw yield (6653 kg/ha) was noted in case of 1st September sowing (Table-7). The productive parameters were found exactly in accordance with the physiological parameters were found exactly in accordance with the physiological parameters under these

sowing dates. The yield reductions might be due to reduction in vegetative growth period on account of delayed sowing. The yield reduction under later sowing dates has been reported by Manjappa and Kumar (2002) [11], Khalifa (2009) [8], Singh *et al*. (2012) [20] and Limochi and Eskandari (2013) [10]. The variety BPT 2231 produced highest straw yield (7178 kg/ha) but lower straw yield was recorded in case of BPT 5204 (6520 kg/ha). All these parameters were found exactly in accordance with physiological parameters responsible for such a deviation. The Present results are in accordance with those of Nawlakha *et al.* (2009) [13], Suresh *et al*. (2013) [22] and Walia *et al.* (2014) [24]. There is significant interaction between dates of sowing and different rice varieties. The highest straw yield (7550 kg/ha) recorded with BPT 2231 variety in 15th July sowing and the lowest straw yield (5740 kg/ha) was recorded with BPT 5204 in 1st September sowing.

Table 7: Effect of dates of sowing on straw yield (kg/ha) of different rice varieties

Varieties	Sowing dates				
	15th July	1st August	15th August	1st September	Mean
BPT5204	6900	6790	6650	5740	6520
BPT2270	7200	7190	7160	6980	7133
BPT2231	7550	7130	6970	7060	7178
BPT1768	7000	6970	6880	6830	6920
Mean	7163	7020	6915	6653	
	SE m±	CD (0.05)	CV (%)		
Varieties	134.0	670.3	8.0		
Sowing dates	167.1	503.4	7.5		
Interaction	189.5	571.5	6.4		

Conclusion

The literature suggests that sowing date is most pivotal role which describes the rice yield to a major extent. The decreasing trend in grain yield with delayed sowing date might be associated with the reported significant lower number of filled grains per panicle, lower number of panicles m^{-2} and lowest test weight. Also there is a consensus in the literature that the synchronisation of the critical growth stages with the favourable weather regime ensures promising crop yield which is only possible by adjusting the sowing window. From the experiment it could be concluded that BPT 2231 and BPT 2270 variety sowing on 15th July to 1st August can be considered as the optimum sowing window for Krishna western delta. In tail end area of Krishna canal command area, while delay in sowing reduce the yield and yield attributing characters gradually.

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