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Effect of sowing dates and different crop establishment methods on yield and economics of rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted to study the "Effect of sowing dates and different crop establishment methods on yield, nutrient uptake and economics of rice (*Oryza sativa* L.) During *Kharif*, 2017 at Rice research Centre, Agricultural Research Institute, Rajendranagar, Hyderabad (TS), India. The experiment was laid out in split plot design with four replications, comprises two main plot treatments i.e., sowing dates M_1- Normal sowing: First fortnight of July, M_2- Delayed sowing: 20 days after normal sowing, three subplot treatments i.e., S_1- Machine transplanting, S_2- Manual transplanting in lines, S_3- Manual transplanting at random. The results revealed that normal (optimum) sowing i.e., first fort night of July with machine transplanting proved to be better for obtaining maximum grain yield and net returns.

Keywords: Rice, Sowing dates, Crop establishment methods, Yield

Introduction
Rice (*Oryza sativa* L.) is one of the world's most important staple food crops. Rice is the essential staple food for more than 65 percent of the people, also plays a key role in food security to 70 percent of Indian population. India is the second largest producer of rice after china. India has the largest area under rice (43.4 m ha) accounting for 29.4 percent of the global rice area with total production of 104.3 million tones and productivity of 2137 kg/ha (Ministry of Agriculture and Farmer welfare, 2015) during 2015-16. In Telangana State, rice occupies an average of 2 million ha area and production of 6.62 million tones with Average productivity 3290 kg/ha (Statistical Year book, 2015) [25].
Manual transplanting of the seedlings either in lines or at random in to puddle soil is the most common method of rice crop establishment used by the majority of farmers of Asian countries. The exact sowing date for transplanting of rice also plays a vital role in improving its growth and increasing the yield. The sowing time of 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 milder autumn temperatures are more likely, hence good quality is achieved (Farrell *et al*. 2003). Sowing date also has a direct impact on the rate of establishment of rice seedling (Tashiro *et al*. 1999) [26]. Therefore, it is imperative to confirm best sowing date for higher yield levels of rice for food security.
Rice is grown mostly through transplanting in India, in spite of the fact that transplanting is cumbersome practice and requires more labour. The in adequacy of irrigation water and scarce labour coupled with higher wages during the peak period of farm operations, invariably led to delay in transplanting. To overcome this problem, farmers are gradually switching over to alternate crop establishment methods *viz*., wet direct seeded methods- sowing of pre germinated seed on puddle soil directly by broadcasting or in lines with using drum seeder or machine trans planter (Parameshwari *et al*. 2014) [16]. Keeping in view, the present experiment was conducted for optimum sowing time of rice under different crop establishment methods.

Material and methods
A field experiment was carried out during the *Kharif*, 2017 at Rice Research Centre, Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India to study on "Effect of sowing date and different crop establishment methods on yield, nutrient uptake and economics of rice (*Oryza sativa* L.). The experimental site is located at $17^0\ 19^1$ North latitude and 78^023^1 East Longitude and 542.6 m above mean sea level. The composite soil of experimental site is clay loam in texture, low in available N 170 kg/ha (Subbaiah and Asija, 1956), high in available P 82 kg/ha

(Olsen *et al*, 1954) and available K 368 kg/ha (1N NH_4OAC – extractable K) with neutral in reaction (pH 7.3) and electrical conductivity 0.26 ds/m. The experiment was laid out in split plot design with four replications, comprises two main plot treatments i.e, Sowing dates M_1- Normal sowing: First fortnight of July, M_2- Delayed sowing: 20 days after normal sowing, three subplot treatments i.e, S_1- Machine transplanting, S_2- Manual transplanting in lines, S_3- Manual transplanting at random. In machine transplanting, the test variety RNR-15048 (Telangana Sona) was sown on 14th July, transplanted on 2nd August under normal sowing time whereas, in 20 days delayed sowing time, crop sown on 5th August and transplanted on 26th August. In manual transplanting in lines and at random, crop was sown on 14th July and transplanted on 5th August under normal sowing time whereas, in 20 days delayed sowing time, crop sown on 5th August and transplanted on 26th August. The treatment means were compared using least significant difference at 5% level of significance (Gomez and Gomez, 1984) [6]. The economics were also calculated on the basis of cost of cultivation, gross returns, net returns and benefit cost ratio. The cost of cultivation for each treatment was calculated by summing all the variable cost items in the production process. Similarly, gross returns were calculated based on prevailing market price of the produce. The net returns were obtained after deducting the cost of cultivation from gross returns. Thus the benefit cost analysis was obtained by dividing total returns from a unit with total cost of a unit.

Results and discussion

Plant population

Plant population *i.e*., number of hills/m^2 was not influenced significantly by dates of sowing as there was similar number of hills/m^2 in both the sowing dates *viz*., normal and delayed sowings.

Plant population was significantly influenced by different crop establishment methods as the plants were spaced at specific distance *i.e*., 30x12 cm in machine transplanting (26.7 hills/m^2), 15x15 cm in manual transplanting in lines (42 hills/m^2) and not spaced in transplanted at random (36.7 hills/m^2). Plant population was significantly higher with respect to manual transplanting in lines as compared to other establishment methods. Plant population was significantly lower in machine transplanting with 26.7 hills/m^2.

Plant height

Plant height an important growth parameter was influenced significantly by dates of sowing. Normal sowing recorded significantly higher plant height (101.9 cm) over delayed sowing (98.0 cm). Plant height decreased significantly as sowing was delayed. It is obvious that late sowing/planting crop had shorter growing period due to photoperiodic response. Longer growing season of normal sowing/planted crop produced taller plants and higher dry matter as compared to the delayed sowing/planting. These results are in line with Khakwani *et al.* (2006) [9], Paraye and Kandalkar (1994) [17] who reported that plant height was significantly affected by sowing dates. Similar results are also shown by Saika *et al.* (1989), Gravois and Hems (1998), they reported that early sowings produced taller plants than delayed sowing.

Plant height was not influenced significantly by different crop establishment methods. Machine transplanting recorded marginally higher plant height as compared to manual transplanting either in lines or at random. Plant height in machine transplanting was higher due to the reason that plants were at specific distance and the competition between the plants was minimum and deep penetration of roots resulting in efficient use of nutrient uptake and good plant growth. The plant height was responsible for more interception of solar radiation in rice canopy and increase in panicle length. Similar results were recorded by Mahajan *et al*. (2004) [12], Hardev *et al.* (2014) [8].

Days to 50% flowering

Number of days to 50% flowering was influenced significantly by sowing dates. Normal sowing taken significantly more number of days to 50% flowering. Days to 50% flowering was significantly lesser as sowing was delayed. It clearly shown that late sowing/planting crop had shorter growing period due to photoperiodic response. Longer growing season crop taken more number of days to 50% flowering. These results are in conformity with Wani *et al.* (2016) [27], he reported that day taken to reach flowering and harvest varied significantly among the sowing dates. The significantly higher number of days was taken by 15th standard meteorological week (SMW) sown crop however, was at par with 16th SMW crop while the significantly lowest number of days to 50% flowering was taken by 18th SMW sown crop.

Days to 50% flowering was influenced significantly by crop establishment methods. Manual transplanting in lines crop taken significantly more number of days to 50% flowering as compared to machine transplanting crop, manual transplanting crop at random.

Number of tillers/m^2

Number of tillers/m^2 though not influenced significantly by dates of sowing, normal sowing produced substantially higher number of tillers/m^2 (392.3) as compared to delayed sowing (348.0). Among the yield components, productive tillers are very important because the final yield is mainly a function of the number of panicle bearing tillers (productive tillers) per unit area. This increase of fertile tillers/m^2 with normal sowing was attributed to favorable environmental conditions which enabled the plant to improve its growth and development as compared to delayed sowing. These results are in alignment with the findings of Pandey *et al.* (2001) [15], Paraye and Kandalkar (1994) [17], Bashir *et al.* (2010) [2].

Though number of tillers/m2 was not influenced significantly by crop establishment methods, manual transplanting in lines recorded relatively higher number of tillers/m2 (382.7) followed by either manual transplanting at random (369.3), machine transplanting (358.3) Number of tillers/m2 was substantially higher because of the reason that plants were spaced at specific distance and competition between the plants was minimum for efficient utilization of all the available resources, thereby better translocation of photosynthates from source to sink in machine transplanting and manual transplanting in lines. Similar results also been reported by Ghasal *et al.* (2014) [5] and Kumhar *et al.* (2016) [11].

Number of panicles/m^2

Number of panicles/m^2 was not influenced significantly by sowing dates. Normal sowing produced more number of panicles/m^2 (325.7) over delayed sowing (317.0). Numbers of panicles/m2 are very important because the final yield is mainly function of number of panicles per unit area. The increase in number of panicles/m^2 by normal sowing was attributed to favorable environmental conditions which enabled the plant to improve its growth and development as compared to delayed sowing. Similar results reported by

Pandey *et al.* (2001) [15], Paraye and Kandalkar (1994) [17] and Bashir *et al.* (2010) [2].

The number of panicles/m^2 was not influenced significantly by crop establishment methods, manual transplanting at random recorded substantially higher number of panicles/m2 (333.5) followed by machine transplanting (326.3) manual transplanting either in lines (304.2). The maximum number of panicles/m^2 in manual transplanting at random was mainly because of higher tillers/m^2.

Panicle length

Panicle length was influenced significantly by dates of sowing. Normal sowing recorded higher panicle length (25.9 cm) and length of panicle was decreased in delayed sowing (24.4 cm). Late sowing, shortened the growth period of plant which reduced the leaf area, length of panicle and number of filled grains/panicle than normal sowing. These results are in line with findings of Khalifa (2009) [10], Bashir *et al.* (2010) [2], Shah and Bhurer (2005) [23]. They reported more length of panicle was visualized in normal sowing and declined in delayed sowing.

Panicle length influenced significantly by crop establishment methods. Machine transplanted recorded significantly higher panicle length (25.7cm) over manual transplanting at random (24.5cm) and it remained at par with manual transplanting in lines (25.1cm). Machine transplanting recorded higher panicle length, the reason might be due to lower competition for available resources space, sunlight, moisture, nutrients etc. Similar results were also reported by Kumhar *et al.* (2016) [11], Pandey *et al.* (2018) [14], Ramulu *et al.* (2019) [19].

Panicle weight

Panicle weight, though not influenced significantly by dates of sowing, normal sowing recorded marginally higher panicle weight (3.5g) as compared to delayed sowing (3.3g). Late sowing reduced the growth period of plant which lowered the leaf area, panicle length, panicle weight and number of filled grains /panicle than normal sowing. These results are in conformity with findings of Mahikar *et al.* (2001) [13], he reported that early sowing gave the highest number of effective tillers (110.26/m row length), panicle weight (2.89 g), grain yield (3252 kg/ha) and straw yield (6302 kg/ha).

Panicle weight did not influence significantly by crop establishment methods. Machine transplanting recorded marginally higher panicle weight (3.7g) as compared to manual transplanting either in lines (3.3g) and/or at random (3.2g). The higher panicle weight in machine transplanting might be due to lower competition for available resources i.e., sun light, moisture, nutrients etc, Similar results were also reported by Kumhar *et al.* (2016) [11].

Test weight

Test weight, though not influenced significantly by dates of sowing, normal sowing produced marginally higher test weight (12.3g) over delayed sowing (12.2g). This indicated that the environmental conditions like temperature, humidity was most favorable for grain development during normal sowing as compared to delayed sowing. Similar results were obtained by Bashir *et al.* (2010) [2], Shah and Bhurer (2005) [23], Biswas and Salokhe) (2001) [3].

Test weight, though did not influence significantly by crop establishment methods, manual transplanting produced marginally higher test weight (12.6g) as compared to machine transplanting (12.3g) and manual transplanting at random (11.9 g). These results were also reported by Pasha *et al.* (2009) [18], Sreenivasulu *et al.* (2014) [24], Ramulu *et al.* (2019) [19].

Grain yield

Grain yield is a function of inter play of various yield components such as productive tillers, number of grains /panicle and 1000 seed weight. Grain yield influenced significantly by dates of sowing. Normal sowing produced maximum grain yield (7394kg/ha) while less grain yield (5851kg/ha) was observed in delayed sowing. The decreasing trend in grain yield in delayed sowing might be associated with significantly lower number of productive tillers/m^2, number of grains/panicles and test weight. The higher grain yield was attributed to more number of productive tillers, number of grains /panicle and increased test weight. These results are also in line with findings of Nayak *et al.* (2003), Shah and Bhurer (2005) [23], Khakwani *et al.* (2006) [9], Bashir *et al.* (2010) [2].

Grain yield influenced significantly by crop establishment methods. Machine transplanting recorded significantly higher grain yield (7406kg/ha) as compared to manual transplanting either in lines (6550 kg/ha) and/or at random (5913kg/ha). This is due to better vegetative growth, dry matter accumulation and effective partitioning to the panicles resulting in more number of panicles/m^2, higher test weight which ultimately improved grain yield. The increase in grain yield of rice in machine transplanting was in agreement with the results reported by Revathi *et al.* (2016) [20], Satish *et al.* (2016) [22] and Ramulu *et al.*, (2019) [19].

Straw yield

Straw yield was influenced significantly by dates of sowing. Normal sowing recorded significantly higher straw yield (8808kg/ha) over delayed sowing (7007kg/ha). Sowing date has a direct impact on the rate of establishment of rice seedling (Tashiro *et al.* 1999) [26]. Normal sowing (optimum 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, grain and straw yields. These results are in conformity with findings of Khalifa (2009) [10], Bashir *et al.* (2010) [2], Shah and Bhurer (2005) [23].

Straw yield was influenced significantly by crop establishment methods. Machine transplanting recorded significantly higher straw yield (8956 kg/ha) followed by manual transplanting in lines (7591 kg/ha) and manual transplanting at random (7177 kg/ha). Higher straw yield in machine transplanting was mainly because of better establishment of seedlings, increased vegetative growth, higher dry matter accumulation, effective partitioning and more number of tillers/m2 which ultimately improved the straw yield. Similar results reported by Revathi *et al.* (2016) [20], Satish *et al.* (2016) [22] and Ramulu *et al.* (2019) [19].

Economics

The cost of cultivation, gross and net returns were higher in normal sowing over delayed sowing. In delayed sowing, increased cost of cultivation, decreased gross returns resulted in lowered net returns and BC ratio. In normal sowing, higher grain and straw yields resulted in increased gross, net returns and BC ratio, reduced cost of cultivation further increased the net returns (Rs. 73,450) and BC ratio (1.46).

Among the crop establishment methods, cost of cultivation was higher in machine transplanting due to raising of nursery on polythene sheet and involvement of more human labour.

The net returns (Rs. 68,667) as well as return per rupee invested (1: 1.24) is maximum in machine transplanting. The higher yields of grain and straw recorded in machine transplanting was the main reason for higher benefit cost ratio though cost of cultivation was higher than manual transplanting either in lines or at random (Table 2).

Conclusion

On the basis of results obtained from the present investigation, it is concluded that normal (optimum) sowing is found to be beneficial in improving the growth parameters, yield attributes and yield of rice as the synchronization of the critical phenol phases with the favorable weather regime ensures promising crop yield which is only possible by adjusting the sowing date.

Machine transplanting, an alternate crop establishment method to conventional manual transplanting, as it saves labour, ensures timely transplanting and attains optimum plant population to increase the grain yield.

Hence, machine transplanting with first fort night of July sowing date found to be better for higher productivity and profitability.

Table 1: Growth, yields attributes and yield as influenced by dates of sowing and crop establishment methods

	Plant population	Plant height (cm)	Days to 50% flowering	Tillers (No/m2)	Panicles (no/m2)	Panicle length (cm)	Panicle weight (g)	Test wt. (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
Main plot treatment										
Normal transplanting time July 2nd fortnight	35.5	101.9	92.7	392.3	325.7	25.9	3.5	12.4	7394	8808
20 days after normal sowing	37.7	98.0	88.7	348.0	317.0	24.4	3.3	12.0	5851	7007
SEm ±	1.67	0.41	0.23	17.02	18.68	0.19	0.08	5.90	145.17	192.07
CD (p=0.05)	N.S.	1.84	1.45	N.S.	N.S.	0.84	NS	NS	649.03	858.69
Sub plot treatment										
Machine transplanting	26.7	101.0	89.0	358.3	326.3	25.7	3.7	12.3	7406	8956
Manual transplanting in lines	42.0	100.3	94.0	382.7	304.2	25.1	3.3	12.6	6550	7591
Manual transplanting at random	36.7	98.6	89.0	369.3	333.5	24.5	3.2	11.9	5913	7177
SEm±	1.55	1.06	0.45	7.63	27.36	0.09	0.21	7.26	287.36	351.98
CD (p=0.05)	4.79	N.S.	1.48	N.S.	NS	0.27	NS	NS	885.29	1084.37

Table 2: Economics of rice as influenced by dates of sowing and crop establishment methods

Treatments	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C
Normal transplanting time	123450	50,000	73,450	1.46
20 days after normal sowing	97688	51,000	46,688	0.91
Machine transplanting	123667	55,000	68,667	1.24
Manual transplanting in lines	109359	54,000	55,359	1.02
Manual transplanting at random	98723	54,500	44,223	0.81

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