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Yield attributes and nutrient uptake of rice (*Oryza sativa*) as influenced by different crop establishment methods

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Abstract
A field experiment was conducted in clay loam soils of Jagtial, Telangana State during rainy season of 2015 to study the performance of rice under different establishment methods. The experiment was laid down in randomized block design with three replications. Eleven treatments were taken *viz.* dry or wet seeding with drum seeder at three row spacing *i.e*, 20, 25 and 30 cm, broadcasting of dry or sprouted seed in puddled soil, transplanting, SRI and MSRI methods. The yield attributes *viz*. panicles m^{-2}, spikelets $panicle^{-1}$ and percent filled grains were found to be high in MSRI method with less chaffyness of grains. The grain and straw yield was higher in MSRI method followed by SRI which was 31.5 and 23.4% higher than that in transplanting method, respectively. Drum seeding at 30 cm spacing with wet seed or dry seed registered an increase of 22.1 and 17.8% in yield over conventional transplanting method, respectively. The SPAD meter reading, test weight and harvest index were not influenced by different establishment methods. The nutrient (NPK) uptake was higher in MSRI method followed by SRI method which were superior to transplanting method.

Keywords: Drum seeding, SRI, MSRI, chaffy spikelets, nutrient uptake and harvest index

Introduction
Rice is a staple food crop for about 3 billion people, mostly living in Asia (Zhang *et al.*, 2009) [15]. India is the second largest producer and consumer of rice in the World. The area under rice crop in our country is about 43.95 Mha with a production of 106.54 MT and productivity of 2424 kg ha^{-1} (Ministry of Agriculture, 2014) [10]. With the current population growth rate, the rice requirement of India by the year 2025 would be around 125 million tonnes (Kumar *et al.*, 2009) [5]. Traditional method of rice cultivation is reported to be the best establishment method to achieve good yields (Sandhya Kanthi *et al.*, 2014) [12]. The disadvantage associated with this method is that it involves raising of nursery and requires more labour. The duration of the crop is longer along with high energy consumption. In the recent years, the area under rice cultivation is decreasing due scarcity of labour coupled with high wages during the peak period of farm operations which invariably lead to delay in transplanting. The plant population is often less than the optimum required for higher yields in contractual system of transplanting (Gill and Walia, 2013) [3]. This is aggravated by power crisis and water shortage due to late release of water into the canals, higher cost of cultivation and delayed monsoon showers which forced to identify alternate methods of rice cultivation without reduction in yield in addition to saving energy, water and time. Further, rice production under current inputs and technology is likely to fail to meet the projected demand (Leeper, 2010) [7] besides an urgent need to increase rice productivity per unit area in the world.
Different crop establishment methods have been developed such as wet and dry seeding, drum seeding, SRI, MSRI, aerobic rice. Broadcasting is also an age old method of cultivation of rice but with a disadvantage of high requirement of inputs, which ultimately increases the cost of cultivation (Manjappa and Kataraki, 2004) [9]. These alternate crop establishment techniques help the farmers in reduction of cost of cultivation and realizing higher net returns. Keeping this in view, the present study was taken up to study the performance of rice under different methods of establishment.

Materials and Methods

A fertilizer dose of 120, 60 and 40 kg N, P_2O_5 and K_2O ha^{-1} was applied. Phosphorus and Potash were applied as basal dose in the form of SSP and MOP, respectively. Nitrogen was applied as 3 equal splits *viz.*, as basal at the time of transplanting/sowing, maximum tillering and panicle initiation stage. Zinc was applied in the form of $ZnSO_4$ as foliar spray @ 2g lt^{-1} to all the plots at 30 DAS. Carbofuran 3G granules @ 25 kg ha^{-1} was applied on 27 August, 2015. Other plant protection measures were taken up as and when required. Harvesting in transplanting and the rest of the methods was done on 22 and 28 December, 2015, respectively.

Data on the number of panicles in one m^2 area in net plot was counted and expressed as panicles m^{-2}. Ten panicles were selected at random from each plot to compute the number of spikelets $panicle^{-1}$, number of chaffy grains $panicle^{-1}$ and percentage of filled spikelets. For 1000-grain weight five hand full of grain samples were collected at random from the net plot yield of each individual treatment. The grains were counted and weighed to arrive at test weight. The crop was harvested manually with the help of sickle when the grain almost matured and the straw had turned yellow and data on grain and straw yield was recorded. The plant samples collected at harvest were analysed for N uptake (microkjeldahl method), P uptake (vanadomolybdate phosphoric yellow colour method) and K uptake (flame photometry).

All the data were subjected to analysis of variance (ANOVA) as per the standard procedures. The comparison of treatment means was made by critical difference (CD) at P=0.05.

Results and Discussion

Yield Attributes

Yield attributes were also influenced by different crop establishment methods (Table 1). Highest number of panicles m^{-2} were recorded in MSRI method which was at par with SRI method (T_{10}) and dry or wet seeding with drum seeder at 30 cm row spacing (T_5 and T_6) and was superior to rest of the treatments. Significantly higher number of spikelets were found in MSRI method (T_{11}) compared to broadcasting (T_7 and T_8), drum seeding with dry or wet seed at 20 cm spacing (T_1 and T_2) or dry seed at 25 cm spacing (T_3) and transplanting method (T_9) and at par with other methods. MSRI method (T_{11}) registered highest percentage of filled spikelets which was superior to broadcasting (T_7 and T_8) and drum seeding at 20 cm spacing (T_1 and T_2) and at par with other methods. The number of chaffy spikelets $panicle^{-1}$ was in the reverse order. It was lower in MSRI method (T_{11}) which was at par with SRI method (T_{10}) and drum seeding with wet or dry seed at 30 cm row spacing (T_6 and T_5) or wet seed at 25 cm spacing (T_4). There was no significant difference among the establishment methods with respect to test weight.

Yield

The grain yield and straw yield of rice was higher in MSRI method (T_{11}) and significantly superior to transplanting method (T_9) (Table 2). It was at par with SRI method (T_{10}) and drum seeding at 30 cm row spacing (T_6 and T_5) or wet seeding at 25 cm spacing (T_4). The grain yield recorded in MSRI method (T_{11}) and SRI method (T_{10}) was 31.5 and 23.4% higher than that in transplanting method (T_9), respectively. The increase in yield in SRI establishment technique (SRI or MSRI) is attributed to planting of young seedlings i.e., before third phyllochron at shallow depth of planting in wider spacing (25 x 25 cm), which leads to large root volume, profuse and strong tillers with large panicles, more and well filled spikelets with higher grain weight (Satyanarayana and Babu, 2004) [13]. Anchal Dass *et al.* (2015) [1] in a review, concluded 50-100% increase in rice yield in India due to SRI method over conventional transplanting method. Latheef Pasha *et al.* (2014) [6] and Ramana *et al.* (2015) [11] also reported the superiority of MSRI or SRI method over conventional transplanting method. Drum seeding at 30 cm spacing with wet seed (T_6) or dry seed (T_5) also registered an increase of 22.1 and 17.8% in yield over conventional transplanting method, respectively. This can be attributed to more space, sunlight and nutrients available at wider spacing in drum seeding. Visalakshi and Sireesha (2014) [14] evaluated drum seeder in farmers' fields and inferred that drum seeding is superior to conventional transplanting and broadcasting methods.

Harvest index remained unaffected by the different crop establishment methods.

Nutrient uptake

Nutrient uptake (NPK) in rice at harvest was also significantly influenced by different crop establishment methods (Table 2). The uptake was the highest in MSRI method (T_{11}) which was at par with SRI (T_{10}) and drum seeding at 30 cm row spacing (T_5 and T_6) while lowest uptake was observed in broadcasting of dry seed in puddled soil (T_7). Farmers' method of transplanting was inferior in NPK uptake compared to SRI (T_{10}) or MSRI methods (T_{11}).

Uptake of nutrients (N, P and K) by crop is a function of the nutrient content in the plant and the dry matter accumulation per unit area. The differences in the uptake of nutrients were mainly due to the variable dry matter production in different crop establishment methods. These results are in accordance with Gangawar *et al.* (2008) [2], Mandhata Singh and Singh (2010) [8], Sandhya Kanthi *et al.* (2014) [12] and Kaur and Singh (2015) [4].

Table 1: Yield attributes of rice as influenced by different crop establishment methods

Treatment	No. of panicles m^{-2}	No. of spikelets $panicle^{-1}$	% filled spikelets	No. of chaffy spikelets $panicle^{-1}$	Test weight (g)
T_1: Drum seeding (dry) at 20 cm row spacing	314	154	70.5	44	13.4
T_2: Drum seeding (wet) at 20 cm row spacing	327	174	75.7	41	13.5
T_3: Drum seeding (dry) at 25 cm row spacing	342	189	79.2	39	13.5
T_4: Drum seeding (wet) at 25 cm row spacing	351	196	82.0	34	13.6
T_5: Drum seeding (dry) at 30 cm row spacing	377	201	84.4	32	13.6
T_6: Drum seeding (wet) at 30 cm row spacing	394	208	85.2	30	13.6
T_7: Broadcasting dry seed	277	127	56.0	52	13.2
T_8: Broadcasting sprouted seed	317	164	71.3	44	13.2
T_9: Transplanting	332	179	76.8	39	13.3

T_{10}: SRI method	412	229	86.6	29	13.7
T_{11}: MSRI method	431	249	90.2	24	13.7
SEm ±	34	28	6.6	6	0.2
CD (P=0.05)	71	59	13.8	13	NS

Table 2: Yield and nutrient uptake of rice as influenced by different crop establishment methods

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	N uptake (kg ha^{-1})	P Uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1: Drum seeding (dry) at 20 cm row spacing	4806	6268	43.4	75.2	17.9	124.0
T_2: Drum seeding (wet) at 20 cm row spacing	5108	6585	43.6	84.4	24.1	133.9
T_3: Drum seeding (dry) at 25 cm row spacing	5559	7032	44.1	95.8	27.0	141.4
T_4: Drum seeding (wet) at 25 cm row spacing	5771	7187	44.5	101.3	28.2	148.5
T_5: Drum seeding (dry) at 30 cm row spacing	6136	7527	44.9	106.7	29.5	153.4
T_6: Drum seeding (wet) at 20 cm row spacing	6358	7762	45.1	111.6	31.6	157.5
T_7: Broadcasting dry seed	4208	5705	42.4	69.6	14.0	115.7
T_8: Broadcasting sprouted seed	4888	6308	43.8	79.9	21.8	129.7
T_9: Transplanting	5207	6733	43.4	88.2	25.5	137.8
T_{10}: SRI method	6425	7871	45.0	116.9	35.2	161.7
T_{11}: MSRI method	6848	8313	45.0	123.6	38.9	169.9
SEm±	563	595	2.2	9.3	2.2	11.9
CD (P=0.05)	1176	1243	NS	19.4	4.7	24.8

Conclusion

From this study, it can be concluded that Mechanised SRI and SRI methods were found to be superior to conventional transplanting method with respect to growth and yield of rice. Drum seeding (dry or wet seed) at 30 cm row spacing which was at par with transplanting method can also be recommended in case of late onset of monsoon and water supply to catch up with the season.

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