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Yield and Yield Attributes Influenced by Different Planting Methods and Nitrogen Treatments

S. Praneeth[1*], D. Vishnu Vardhan Reddy[1], R. Mahender Kumar[2], P.C. Latha[3], T. Ramesh[1] and Raguveer Rao[1]

[1]Department of Crop Physiology, College of Agriculture, PJTSAU, Hyderabad, Telangana, India
[2]Deptartment of Agronomy, [3]Deptartment of Soil Science, IIRR, Hyderabad, Telangana, India
**Corresponding author*

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A B S T R A C T

This paper examines the yield and yield attributes under different planting methods and nitrogen treatments. Yield attributes like panicle length, filled grain and unfilled grain percentage, test weight, grain yield, straw yield and harvest index performed well under system of rice intensification compared to normal transplantation. Among the nitrogen management practices 75% inorganic+ 25% organic (N_5) treatment showed better performance compared to 100% inorganic (N_6), 100 % organic (N_2), 50% organic + 50% inorganic (N_4), 75% organic +25% inorganic (N_3) and control (N_1). Grain yield was increased significantly by 18.3% under SRI over NTP. Among nitrogen treatments N_5 enhanced 37.8% yield over N_1.

Introduction

Rice is the most important staple food crops in the world. India has the largest area (42.27 m ha) and it is the second largest producer (105.24 m t) of rice next to China (144 m t). Rice is a heavy water consumer but water for rice production is becoming scarce and expensive due to the increased demand for water from the ever growing population (Choudhary *et al.,* 2013). Future predications on water scarcity limiting agricultural production have estimated that by 2025, about 15-20 m ha of Asia's irrigated rice fields will suffer from water shortage in the dry season especially since flood irrigated rice uses more than 45 % of 90 % of total freshwater used for agricultural purposes (Tuong and Bouman, 2003). Traditional planting has been the most important and common method of crop establishment practice under irrigated lowland rice ecosystems in tropical Asia. In irrigated lowland rice which not only consumes more water but also causes wastage of water resulting in degradation of land. In recent years to tackle this problem, many methods of cultivation have been developed and one among them is System of Rice Intensification (SRI). The SRI was developed in Madagascar during early 1980s (Laulanie, 1993) is a system approach to increase rice productivity with less external and inexpensive inputs. SRI method of cultivation is slowly gaining momentum all over the world including India.

Among nutrients, nitrogen is the most important limiting element in rice growth (Jayanthi *et al.,* 2007). Organic manures have the capacity to fulfil nutrient demand of crops adequately and promote the activity of macro and micro flora in the soil. Organic nutrition to rice is assuming significance in the context of an increasing concern about sustaining soil health with increasing use of inorganic nutrition on one hand and expected shortage in nitrogen fertilizer for rice cultivation on the other hand. Keeping these points how rice plants performed better under SRI method with different nitrogen treatments.

Materials and Methods

The present investigation entitled "Yield and yield attributes influenced by different planting methods and nitrogen treatments" was conducted during the *rabi* for two annual season of 2015 and 2016 at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR) farm, ICRISAT, Patancheruv, Hyderabad. The experiment was laid out in a split plot design with main plots consisting of two methods of cultivation i.e., System of rice intensification (SRI) and normal traditional cultivation (NTP) and sub plots comprising of six nitrogen management practices like Control (N_1), 100% organic (N_2), 75 % organic + 25% inorganic (N_3), 50 % organic + 50% inorganic (N_4), 25 % organic + 75% inorganic (N_5), 100 % inorganic (N_6).

The treatments were replicated three times. Ten panicles were selected randomly from the net plot area for recording the panicle length. It was measured from the base of the primary rachis to top most spikelet and average length was expressed in cm. After counting filled and unfilled grains present on panicle the filled grain percentage and spikelet sterility percentage was calculated with help of following formula (Filled grain percentage= Number of filled grains/Total number of graims x 100 and Spikelet sterility percentage = Number of unfilled grains /Total number of grains x 100). Thousand grains were counted from the grains obtained from five randomly selected hills and the weight was recorded as test weight in grams (g). Plants in the net plot area were harvested separately in each plot threshed and grains were separated, dried under sun and the grain yield per plot was recorded after cleaning. From this yield per plot was computed and expressed as kg ha^{-1}.After threshing the grain, the remaining straw was dried under sun and yield per plot was recorded and the yield per hectare was computed and expressed in kg ha^{-1}.

Results and Discussion

Significantly higher panicle length was noticed in system of rice intensification (6.2, 5.2 and 5.7 % in 2015, 2016 and pooled means, respectively) over NTP. The SRI was found to produce larger individual plants and which resulted in better light distribution, larger total leaf area, higher plant dry weight and longer panicles (Table 1). Several researchers (Mohanty *et al.,* 2014) also reported similar results. In nitrogen treatments, higher panicle length was (24.1, 24.7 and 24.4 cm in 2015, 2016 and pooled means, respectively) obtained with 25 % organic + 75% inorganic (N_5) nitrogen treatment over other nitrogen treatments. N_6, N_2, N_4, N_3 treatments were statistically on par with each other but significantly superior than control (N_1) during both the years of study. The lowest panicle length was found in control (N_1) (22.1, 22.2 and 22.1 cm in 2015, 2016 and pooled means, respectively). Application of organic and inorganic nitrogen supply as in 25 % organic + 75% inorganic (N_5) nitrogen treatment results in continuous supply of nutrients throughout crop growth period (Damodaran *et al.,* 2012), contributing higher panicle length observed.

Planting methods significantly influenced the test weight of rice. Mean values were high for test weight in SRI (22.5, 22.7 and 22.6g in 2015, 2016 and in pooled means, respectively) as compared to NTP (20.7, 21.2 and 20.9 g in 2015, 2016 and in pooled means, respectively). This might be due to, alternate wetting and moderate soil drying with wider spacing, which possibly improved the root growth with open canopy structure. These conditions perhaps delayed leaf senescence while facilitating greater light utilization for higher photosynthetic rates during reproductive and grain filling stages. In SRI these features might also contribute to the improvement of grain filling and grain weight in SRI grown plants (Thakur *et al.*, 2011). Significant variation was observed in test weight due to the nitrogen treatments.

The higher average value of test weight was found in N_5 (23.4 and 23.3g during 2015 and 2016, respectively) followed by N_6, N_2, $N_4$and N_3. The minimum test weight was recorded in N_1 (17.6 and 19.0g during 2015 and 2016, respectively). Higher test weight in N_5 treatment was recorded in present investigation might be due to availability of nitrogen in two forms with 36% nitrate nitrogen and 64% in ammonical nitrogen in N_5 nitrogen treatment. Similar results were also supported by Kronzucker *et al.*, (1999).

Percentage of grain filling recorded differed significantly between NTP and SRI during both the years of study. Higher percentage of grain filling was recorded in SRI (89 and 90.0 %) compared to NTP during 2015 and 2016, respectively (Table 2). This was because of longer panicle length and higher biomass production in SRI as supported by more leaf area, which was a major source of carbohydrate production. This positively improved the grain filling percentage in SRI. These results could be substantiated by the findings of Thakur *et al.*, (2013). Application of nitrogen through N_5 treatment recorded significantly higher percentage of grain filling over other nitrogen treatments during both the years of study. In N_5 percentage of grain filling was significantly maximum as 90.3 and 90.5% during 2015 and 2016, respectively, compared to N_6, N_2, N_4 and N_3 treatments.

Supply of nitrogen through splits application to the crop, which might have available nitrogen to the crop, thus provided better nitrogen uptake and lead to greater dry matter production and its translocation to sink. Similar observations were also reported by (Sathiya and Ramesh, 2009 and Singh *et al.*, 2015). The lowest percentage of grain filling was observed in N_1 (80.6, 80.4 and 80.5 during 2015, 2016 and in pooled means, respectively).

The NTP registered significantly higher percentage of spikelet sterility (15.4 and 16.0%) as compared to SRI (11.0 and 10.1%) during 2015 and 2016, respectively. The possible reason could be lack of sufficient photosynthates and higher inter and intra tiller competition with closer spacing during dry matter partitioning under NTP. These results have been supported by the findings of Rajendran *et al.*, (2013). Application of nitrogen through N_5 recorded significantly lower percentage of spikelet sterility (9.7 and 9.5 %) which was significantly different with other nitrogen treatments. The N_1 treatment registered higher percentage of spikelet sterility (19.4 and 19.6 %) during 2015, 2016 and in pooled means, respectively. Application and combination of organic manures sustained the plants green even at the time of maturity. Hence, the contribution of carbohydrates from current photosynthetic activity and the efficient translocation into the grain has resulted in increased number of filled grains and reduced the unfilled grains panicle^{-1}. These results were in agreement with the Wijebandara *et al.*, (2009).

Table.1 Panicle length (cm) and test weight (g) influenced by Planting methods and nitrogen treatments in Rice

Treatments	Panicle length (cm)			Test weight (g)		
	2015	2016	Pooled	2015	2016	Pooled
Mean values of main treatments (M)						
M1- System of Rice Intensification (SRI)	24.4	24.4	24.4	22.5	22.7	22.6
M2-Normal Transplantation (NTP)	23.0	23.2	23.1	20.7	21.2	20.9
S.Em±	0.52	0.1	0.29	0.03	0.14	0.06
C.D. at 5%	N S	0.6	1.8	0.19	0.86	0.34
Mean values of sub treatments (N)						
N1 – Control	22.1	22.2	22.2	17.6	19	18.3
N2 - 100% Organic	23.9	23.9	23.9	22.3	22.5	22.4
N3 - 75 % organic + 25% inorganic	23.6	23.8	23.7	20.6	21.9	21.3
N4 - 50 % organic + 50% inorganic	23.8	23.9	23.9	22.9	22.2	22.5
N5 - 25 % organic + 75% inorganic	24.6	24.7	24.7	23.4	23.3	23.4
N6 - 100 % inorganic	24.2	24.2	24.2	22.8	22.8	22.8
S.Em±	0.5	0.49	0.44	0.48	0.47	0.33
C.D. at 5%	1.47	1.45	1.17	1.42	1.4	0.96
TXM	N S	N S	N S	N S	N S	N S
MXT	N S	N S	N S	N S	N S	N S

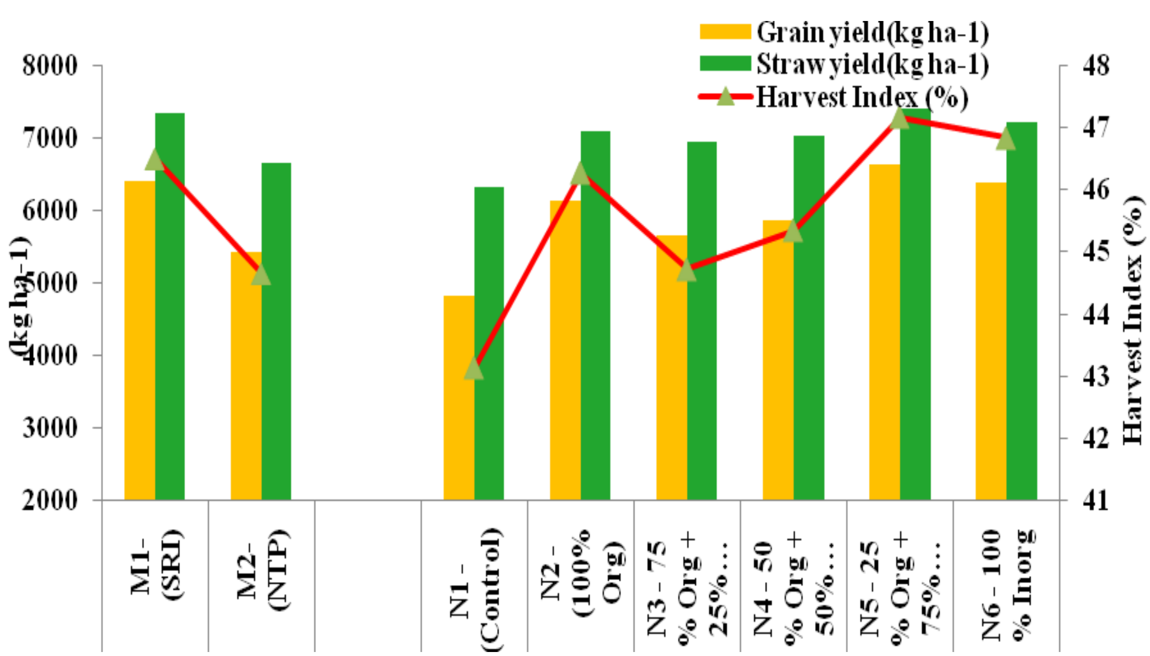
Table.2 Grain filling (%) and Spikelet sterility (%) influenced by Planting methods and nitrogen treatments in Rice

Treatments	Grain filling (%)			Spikelet sterility (%)		
	2015	2016	Pooled	2015	2016	Pooled
Mean values of main treatments (M)						
M1- System of Rice Intensification (SRI)	89.0	90.0	89.5	11.0	10.1	10.5
M2-Normal Transplantation (NTP)	84.7	84.0	84.3	15.4	16.0	15.7
S.Em±	0.4	0.5	0.3	0.4	0.5	0.3
C.D. at 5%	2.2	2.8	1.7	2.2	2.8	1.7
Mean values of sub treatments (N)						
N1 – Control	80.6	80.4	80.5	19.4	19.6	19.5
N2 - 100% Organic	87.7	88.5	88.1	12.3	11.5	11.9
N3 - 75 % organic + 25% inorganic	86.3	85.5	85.9	13.7	14.5	14.1
N4 - 50 % organic + 50% inorganic	87.3	87.2	87.2	12.8	12.8	12.8
N5 - 25 % organic + 75% inorganic	90.3	90.5	90.4	9.7	9.5	9.6
N6 - 100 % inorganic	88.8	89.6	89.2	11.2	10.4	10.8
S.Em±	0.4	0.4	0.3	0.4	0.4	0.3
C.D. at 5%	1.1	1.3	0.8	1.1	1.3	0.8
TXM	N S	N S	N S	N S	N S	N S
MXT	N S	N S	N S	N S	N S	N S

Table.3 Grain yield, straw yield and harvest index (%) influenced by Planting methods and nitrogen treatments in rice

Treatments	Grain yield (Kg ha^{-1})			Straw yield (Kg ha^{-1})			Harvest index (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Mean values of main treatments (M)									
M_1	6384	6442	6413	7495	7180	7338	46	47	47
M_2	5413	5424	5418	6830	6505	6668	44	45	45
S.Em±	88.99	130.42	70	104.81	51.83	77.67	0.53	0.42	0.14
C.D.5%	541.48	793.61	425.94	637.77	315.39	472.62	N S	N S	0.86
Mean values of sub treatments (N)									
N_1	4832	4812	4822	6570	6084	6327	42	44	43
N_2	6053	6208	6131	7210	6969	7089	46	47	46
N_3	5740	5578	5659	7100	6787	6944	45	45	45
N_4	5900	5820	5860	7184	6884	7034	45	46	45
N_5	6527	6762	6644	7565	7255	7410	46	48	47
N_6	6338	6417	6378	7346	7078	7212	46	47	47
S.Em±	189.82	307.04	179.83	180.61	114.83	107.89	1.03	1.23	0.6
C.D.5%	559.97	905.77	530.5	532.79	338.74	318.27	N S	N S	1.77
TxM	N S	N S	NS	N S	N S	N S	N S	N S	N S
TxM	N S	N S	NS	N S	N S	N S	N S	N S	N S

Fig.1 Grain yield, straw yield and harvest index (%) influenced by Planting methods and nitrogen treatments in rice



The per cent grain yield increase in SRI was 17.93, 18.77 and 18.33 % over NTP during 2015, 2016 and their pooled means, respectively (Table 3). System of rice intensification planting method provides better aeration, wider spacing and less competition, which enabled the plants to grow vigorously. The increased seed yield under SRI could be attributed to the higher root growth which enabled them to access nutrients from much greater volume of soil, capturing all the essential nutrient elements important for plant growth and there by leading to higher tillering and dry matter production as has been reported earlier (Thiyagarajan *et al.*, 2002).

The yield attributing characters such as panicle length, panicle weight, filled grains per panicle and test weight were higher in SRI method than in NTP, which was responsible for the increased grain yield (Mohanty *et al.,* 2014). Application of nitrogen based on 25 % organic + 75% inorganic (N_5) treatment was found to give significantly higher grain yield during both the years of study. The grain yield of rice in 25 % organic + 75% inorganic (N_5) (6527, 6762 and 6644 kg ha^{-1}), 100% inorganic (N_6) (6338, 6417 and 6378 kg ha^{-1}) and 100% organic (N_2) (6053, 6208 and 6131 kg ha^{-1}) treatments based on nitrogen management practices were statistically at par with each other but these nitrogen management practices were significantly superior over 50 % organic + 50% inorganic (N_4) and 75 % organic + 25% inorganic (N_3) and control (N_1) during 2015, 2016 and in pooled means, respectively.

The higher availability of nitrogen in 75 % inorganic and 25 % organic (N_5) treatment results in higher grain yields as higher availability of nitrogen influenced the synthesis of chlorophyll molecule, lead to proportional increases Photosynthetic rate activity and photosynthetic assimilates. These conditions improve the effective tillers, test weight of grains, filled grain percentage, and finally improve the grain yield (Thakur *et al.,* 2013).
Straw yield of rice was significantly higher in SRI (7495 and 7180 kg ha^{-1}) than NTP (6830 and 6505 kg ha^{-1}) during 2015 and 2016, respectively. It could be because of more dry matter production per unit area caused by better nutrient absorption from soil, increased rate of metabolic processes, higher rate of light absorption and increased rate of photosynthetic activity that produced higher number of tillers and leaf area as compared to NTP planting method (Rajendran *et al.*, (2013) and Mohanty *et al.*, (2014)). Application of nitrogen based on N_5 treatment was found to have significantly higher straw yield during both the years of study. The straw yield of rice in N_5 treatment was maximum (7565 and 7255 kg ha^{-1} during 2015 and 2016, respectively) N_6 and N_2 treatments were statistically at par with N_5 but these nitrogen treatments were significantly superior over N_4, N_3 and N_1 treatments. This might be because of adequate supply of nitrogen throughout crop growth period that led to higher dry matter production Alam *et al.*, (2013). N_1 treatment recorded lower straw yield (6570 and 6084 kg ha^{-1} during 2015 and 2016, respectively).

The harvest index of rice was not significantly different among the planting methods and nitrogen treatments as well as interaction effect during both the years of study (Table 3). Significant difference was however observed among pooled means as observed in SRI (47%) compared to NTP (45%). Maximum harvest index was observed in N_5 (47%) and lowest was recorded in N_1 (43%). Increased harvest index in SRI system and N_5 treatment might be due to highest tiller number, leaf area, total dry matter production, and grain yield and yield parameters (Fig. 1).

In conclusion, SRI compared to NTP, yield attributes like panicle length, percentage of grain filling and test weight was significantly superior. N_5 treatment significantly enhanced panicle length, percentage of grain filling and test weight in the order of N_6>N_2>N_4>N_3> N_1. Grain yield was increased significantly by 18.3% under SRI over NTP. Among nitrogen treatments N_5 enhanced 37.8% yield over N_1 in both the years of pooled means.

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