Influence of high density planting on growth and yield of rice (*Oryza sativa* L.) under modified system of rice intensification

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Abstract

A field study was conducted during the late *Samba* (September-January) season of 2018-19 at Wetland farms, TNAU, Coimbatore to study the effect of high density planting on growth and yield of rice (*Oryza sativa* L.) under modified system of rice intensification. The treatments comprised of T1 - 25 x 25cm with 100% Recommended Dose of Fertiliser (RDF) (SRI), T2 - 25 x 20cm with 100% RDF, T3 - 25 x 15cm with 125% RDF, T4 - 20 x 20cm with 100% RDF, T5 - 20 x 15cm with 125% RDF and T6 - Conventional cultivation with 100% RDF. The experiment was laid out in Randomised Complete Block Design with three replications. The results revealed that significantly higher LAI and tillers were recorded at conventional method of planting compared to all other treatments. Yield attributes such as number of grains and filled grains/panicle and panicle weight were higher and lower chaffy grains were recorded under T1 and T2 compared to others. Reverse trend was noticed with number of productive tillers/m². Grain yield was significantly higher with T3, T4, T5 and T6 compared to others. Whereas straw yield recorded superior values with closer spacing (T5, T6 and T7) treatments than others.

Keywords: Rice, high density planting, modified system of rice intensification, spacing levels, nutrient management

Introduction

Rice (*Oryza sativa* L.), ‘the Global grain’ is the most widely consumed staple food in the world. Ninety per cent of the world’s rice is grown and consumed in Asia. India has the largest area (43.5mha) under rice (IRRI STAT, 2018) (1) with a production of 110mt and a productivity of 3.76t/ha, accounting for 40 per cent of the country’s total food grain production (Anon., 2018) (2). The targeted demand of rice for burgeoning Indian population is 130mt by the year 2025. Much of the demand will be arising from Asia, which is the home of two-thirds of the world’s population and where 90 per cent of total rice supply is grown in diverse environments. A great breakthrough to attain the production potential of rice in the 21st century is System of rice intensification (SRI), which enhanced the production of 50-100 per cent (Mishra *et al*., 2010) (3). The use of SRI as an alternative to conventional water and chemical intensive cultivation is highly promising.

Plant spacing is an important agronomic parameter which directly influences the growth and yield attributes. Improper spacing reduced yield of rice up to 20-30 per cent while optimum spacing ensures better plant growth through efficient utilization of solar radiation and nutrients (Khan *et al*., 2005) (4); Mohaddesi *et al*., 2011 (5). Therefore, maintenance of an optimum level of rice plant population in field is necessary to maximize grain yields. Counce (1987) (6) suggested that population density ranging from 150 to 304 plants/m² could produce maximum yield under a dry seeded and flooded rice production systems.

Planting of single, young seedlings at a wider square geometry under SRI may lead to population loss due to poor establishment of seedlings. Under SRI, a square meter with 16 plants and 450 productive tillers/m² is necessary to produce a potential yield of 10t/ha. Among the 16 plants in a meter square area, some of plants may fail to grow vigorously as expected in the biological system which forces other plants to fulfill the same. Due to poor establishment and vigor, the number of productive tillers may get reduced and in turn grain yield of rice. Hence, the SRI methodology need to be modified with high density planting which may enhance the yields. There are research evidences showing a positive correlation between plant population and yield. Hence keeping the above points, the present study was undertaken to determine the optimum plant density under modified SRI to get the maximum yield.
Material and methods

The present study was conducted during the late Samba (September-January) season of 2018-19 at Wetland farms, Tamil Nadu Agricultural University, Coimbatore located in the western Agro-climatic zone of Tamil Nadu (1° 02' N latitude and 76° 09' E longitude, with altitude of 426.7 m above MSL) and received a mean annual rainfall of 332.4 mm rainfall over 33 rainy days.

The experimental soil was clay loam in texture with 45.7 per cent clay, 41.8 per cent sand and 12.3 per cent silt and a slightly alkaline reaction (8.5) and a non-saline condition (0.5 dS/m). The initial nutrient status of the soil was low in available N (226.8kg/ha), medium in available P (19.25kg/ha) and high in available K (571.1kg/ha). The recently released TNAU variety, CO 52 with maturity duration of 130-135 days and an average yield of 6191kg/ha was used for the study.

The experiment was laid out in Randomized Completely Block Design (RCBD) and consisted of eight treatments and three replications. The treatments comprised of: T1-25x25cm with 100% Recommended Dose of Fertilizers (RDF) (SRI), T2 - 25 x 20cm with 100% RDF, T3 - 25 x 15cm with 100% RDF, T4 - 25 x 15cm with 125% RDF, T5 - 20 x 20cm with 100% RDF, T6 - 20 x 15cm with 100% RDF, T7 - 20 x 15cm with 125% RDF and T8 - Conventional cultivation (transplanting 25-30 days old seedlings at 20 x 10cm, 2-3 seedlings/hill) with 100% RDF.

The cultural operations were carried out as per CPG (2012). Eight kilograms of seeds were kept for 10 hours soaking followed by incubation for 24 hours in dark room to enhance germination. Pre-germinated seeds were sown on 4th September, 2018 on raised nursery beds. Field was first ploughed using 11 tine cultivator twice, followed by puddling by roto puddler after stagnating water for two days. Transplanting was carried out in a well puddled and levelled field on 18th September, 2018 (14 DAS) at single seedling/hill with different spacing levels as per the treatment except for conventional system of planting, where transplanting was taken on 3rd October, 2018 (30 DAS) at 2-3 seedlings/hill. Gap-filling was done on 8 DAT in all plots for maintaining optimum plant population.

The recommended fertilizer dose for medium duration variety is 150:50:50 kg N: P2O5:K2O/ha. Urea (46% N), single super phosphate (16% P2O5) and muri ate of potash (60%K2O) were used as the sources of nitrogen, phosphorus and potassium, respectively. Full dose of phosphorus, 25 per cent nitrogen and 25 per cent potassium were applied as basal prior to transplanting. The rest of 75 per cent nitrogen and potassium were given in three equal split doses i.e., at active tillering (50 DAT), panicle initiation (70 DAT) and flowering stages (100 DAT). Top dressing of N was done based on LCC practices were carried out as per CPG (2012).

The plant height of five tagged plants from each treatment plot were measured from ground level to the tip of panicle at maturity stage and the mean value expressed in centimeter. The leaf area index was calculated as suggested by Palanisamy and Gomez (1974) [7], using the formula as given below:

\[
\text{LAI} = \frac{L \times B \times K \times \text{Total number of green leaves/hill}}{\text{Spacing (cm)}^2}
\]

Where, L, B and K are length and breadth of the third leaf from top (cm) and constant (0.75), respectively.

The total number of tillers and productive tillers produced in the individual hill from five randomly tagged plants were recorded and the average was expressed as number of tillers/m² and number of productive tillers/m², respectively. Total number of grains, number of filled grains and chaffy grains in a panicle were counted separately in ten randomly selected panicles from five tagged hills of each treatment plots and the mean value was recorded as number of grains/panicle, number of filled grains/panicle and chaffy grains/panicle, respectively. The panicle length was measured from the scar to the tip of the panicle in centimeter (cm) and the panicle weight in grams (g) from ten randomly selected panicles the mean value was recorded. From each treatment plot, one thousand grain weight at 14 per cent moisture content was recorded in grams (g). Grain weight at moisture content of 14 per and straw weight were taken separately from each treatment plots after hand threshing and was expressed in kg/ha. Harvest index was calculated as the ratio of economical yield to biological yield as given by Yoshida (1972) [8] using the following formula:

\[
\text{Harvest index} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}}
\]

The recorded data were statistically analysed as described by Gomez and Gomez (2010) [9] by the Least Significant Difference (LSD) test at 5 per cent level of probability.

Results and Discussion

Plant height (cm)

Plant height at maturity stage was found statistically identical at the different spacing levels. The plant height is a genetically made character which might not vary with the change of spacing levels. The results were confirmed with the findings of Ashraf et al. (1999) [10].

Leaf area index (LAI)

There existed a significant difference in leaf area index of rice due to high density planting. Significantly higher LAI (5.82) was observed under conventional system of planting (20 x 10cm – T8) followed by 20 x 15cm at 100 % RDF and at 125 % RDF (T7 and T6) which are on par with each other. A lower LAI was recorded under a wider spacing level of 25 x 25cm (1.89). There was no significant increase in LAI due to increase in fertilizer level at both spacing levels of 25 x 15cm and 20 x 15cm. Our findings confirm the results of Kumar et al. (2006) [11]. Higher LAI at closer spacing was due to increased number of tillers and hence leaves in a unit area without much variation of leaf breadth when compared to wider spacing levels. Similar results were observed by Chakrabortty et al. (2014) [12], Clerget et al. (2016) [13] and Rajput et al. (2017) [14].

Tiller characteristics

Plant spacing showed a significant variation in number of tiller/m² at maturity. A significantly higher number of tillers per unit area was observed under a closer spacing level of 20 x 10cm (418.3/m²) which was on par with that under 20 x 15cm under 100% RDF (391.1/m²). A lower number of tiller
was obtained under a wider spacings of 25 x 25cm (260.3/m²) and 25 x 20cm (301.3/m²) which were statistically identical to each other. Higher number of hills/m² at closer plant spacing was due to the increased population and greater nutrient uptake. These results are in close confirmation with that of Baloch et al. (2002) [15], Pasha et al. (2016) [16] and Rajput et al. (2016) [17] who had reported a higher number of tillers at closer spacing levels.

The number of productive tillers were higher at 20 x 10cm (330/m²) which was statistically similar to 20 x 15cm (322.2/m² at 100% RDF and 313.3/m² at 125% RDF), 20 x 20cm (311.7/m²) and 25 x 15cm (304.0/m² at 100% RDF and 309.8/m² at 125% RDF). Different nutrient levels did not show any significant effect on number of panicles/m². Mishra et al. (2010) [18] recorded a greater number of productive tillers at closer spacing than wider spacing levels. Number of tillers/m² were significantly higher at closer spacing was mainly due to more number of plants/unit area than other populations. This corroborate the results by Chapagain et al. (2010) [19] and Clerget et al. (2016) [13].

### Table 1: Effect of high density planting on growth characters of rice under modified SRI

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height at maturity (cm)</th>
<th>LAI at flowering stage</th>
<th>Tiller/m² at maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁: 25 x 25 cm + 100% RDF</td>
<td>106.7</td>
<td>3.97</td>
<td>260.3</td>
</tr>
<tr>
<td>T₂: 25 x 20 cm + 100% RDF</td>
<td>111.0</td>
<td>4.43</td>
<td>301.3</td>
</tr>
<tr>
<td>T₃: 25 x 15 cm + 100% RDF</td>
<td>104.0</td>
<td>4.67</td>
<td>357.4</td>
</tr>
<tr>
<td>T₄: 25 x 15 cm + 125% RDF</td>
<td>105.0</td>
<td>4.70</td>
<td>341.4</td>
</tr>
<tr>
<td>T₅: 20 x 20 cm + 100% RDF</td>
<td>109.1</td>
<td>4.63</td>
<td>348.3</td>
</tr>
<tr>
<td>T₆: 20 x 15 cm + 100% RDF</td>
<td>107.3</td>
<td>5.50</td>
<td>391.1</td>
</tr>
<tr>
<td>T₇: 20 x 15 cm + 125% RDF</td>
<td>105.2</td>
<td>5.30</td>
<td>351.1</td>
</tr>
<tr>
<td>T₈: 20 x 10 cm + 100% RDF</td>
<td>105.3</td>
<td>5.82</td>
<td>418.3</td>
</tr>
<tr>
<td>SED</td>
<td>13.21</td>
<td>0.12</td>
<td>22.7</td>
</tr>
<tr>
<td>CD (P = 0.05)</td>
<td>NS</td>
<td>0.67</td>
<td>48.8</td>
</tr>
</tbody>
</table>

**Grain characteristics**

Total number of grains/panicle showed significant variation due to high density planting. A significantly higher number of grains/panicle (222.2/panicle) was found under 25 x 25cm, which was statistically identical to 25 x 20cm (208.1/panicle), 20 x 20cm (202.8/panicle) and 25 x 15cm at 100% RDF (198.8/panicle). A lower number of grains were recorded at 20 x 10cm (163.3/panicle), which was on par with 20 x 15cm at both 100% RDF and 125% RDF (178.3 and 175.1, respectively). A similar trend was recorded in the number of filled grains/panicle. The increased plant spacing considerably resulted in advantage of space, less competition for nutrition with greater exposure to sunlight and circulatory air which might resulted in a vigorous plant growth, increased nutrient uptake and better drymatter assimilation leading to a consequent increase in total grains/panicle and filled grains/panicle under wider spacing compared to closer spacing. Baloch et al. (2002) [15], Chapagain et al. (2010) [18] and Veeramani et al. (2011) [19] also reported similar results. The spacing levels had a significant influence on number of chaffy grains/panicle, which was recorded higher under 20 x 10cm (50.0/panicle), followed by 20 x 15cm (48.1/panicle). The number of unfilled grains in a panicle were lower under 25 x 25cm (29.3), which was statistically identical to 25 x 20cm (31.6) and 25 x 15cm (33.8). The higher number of chaffy grains/panicle under closer spacing levels is due to higher competition for utilization of resources due to increased plant population. Kumar et al. (2006) [11], Thakur et al. (2010) [20], Gorgy (2010) [21], Ogbedo et al. (2010) [22] and Durga (2012) [23] also reported similar results. S Test weight (1000 grains) recorded were statistically identical at all spacing levels since test weight is a varietal characteristics which is seldom affected by spacing levels. Similar findings were reported by Ram et al. (2014) [24].

**Panicle parameters**

There was no significant difference observed among the panicle length at all spacing levels. The non-significant response of panicle length to different spacing levels might be due to the genetic characteristics of the variety used for the study. A significantly higher panicle weight was recorded under 25 x 25cm (2.8g) which was statistically similar to 25 x 20cm (2.72g). A lower panicle weight was recorded under conventional planting (1.74g). Similar results were reported by Rajput et al. (2016) [17], Rajesh and Thanunathan (2003) [25] reported that the use of wider spacing led to lesser below and above ground competition for better grain filling, higher grain weight and more number of filled grains/panicle.

**Yield of rice**

Grain yield was significantly influenced due to spacing levels. A significantly superior grain yield was recorded under 20x20cm (6392kg/ha) planting geometry which was statistically identical to 25x20cm (6259kg/ha), 25 x 15cm at 100% RDF (5951kg/ha) and 25 x 15cm at 125% RDF (6372 kg/ha). The yields obtained under the rest of the spacing levels were statistically identical. The least yield was recorded under conventional planting (5061kg/ha). Higher yield was attributed to increased productive tillers/m², higher number of filled grains/panicle, increased grain weight due to reduced competition for light, air and nutrients compared to other spacing levels. Similar results were recorded by Tripathi et al. (2004) [26] and Mishra et al. (2010) [3]. Significantly higher straw yield was recorded under conventional planting methods (8523kg/ha) which is on par with spacing levels of 20x15cm at 100% and 125% RDF and 25x15cm at 125% RDF. A lower straw yield was obtained from SRI plots (7084 kg/ha). Higher straw yield
A higher harvest index was recorded under 20 x 20cm spacing (0.46) which was statistically similar to 25 x 25cm (0.44), 25 x 15cm at 100% RDF (0.43) and 125% RDF (0.44) and 25 x 20cm (0.44). Harvest index recorded was lower under conventional planting system (0.37) which is on par with 20 x 15cm at 100% RDF (0.38) and 125% RDF (0.39). Higher harvest index might be due to greater partitioning of photosynthesis towards the production of straw and higher grain ratio in total biological yield.

Conclusion
The present field experiment inferred that a planting geometry of 20 x 20cm performed better under modified system of rice intensification which was on par with spacing levels of 25 x 20cm, 25 x 15cm at 100 % RDF and 25 x 15cm at 125% RDF. Hence, the present study revealed that the plant population of 200000 to 266667/ha with either square or rectangular planting pattern by following SRI principles was appropriate to obtain higher yield. A similar result was recorded by Rajput et al. (2016) [13].

References
1. www.agris.fao.org


