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Research Article

EFFECT OF HIGH-DENSITY PLANTING ON LIGHT INTERCEPTION, GROWTH AND YIELD OF RICE (*Oryza Sativa* L.) UNDER MODIFIED SYSTEM OF RICE INTENSIFICATION

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Abstract: Field investigation 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 light interception, growth and yield of rice (*Oryza sativa* L.) under modified system of rice intensification. The treatments comprised of T_1 - 25 × 25cm with 100% Recommended Dose of Fertilizer (RDF) (SRI), T_2 - 25 × 20cm with 100% RDF, T_3 - 25 × 15cm with 100% RDF, T_4 - 25 × 15cm with 125% RDF, T_5 - 20 × 20cm with 100% RDF, T_6 - 20 × 15cm with 100% RDF, T_7 - 20 × 15cm with 125% RDF and T_8 - Conventional cultivation with 100% RDF. The experiment was arranged in Randomised Complete Block Design with three replications. The result revealed that plant height was significantly higher in T_4 and was statistically similar with all other treatment except T_8 in all the stages, but not at maturity stage. The LAI was significantly higher in conventional method of planting compared to all other treatments. Higher light interception were recorded with T_5 over others but was statistically comparable with T_6, T_7 and T_8, respectively. Grain yield was higher with T_5, T_4, T_2 and T_3 compared to other treatments.

Keywords: *Rice, High Density Planting, Light Interception, Modified System of Rice Intensification, LAI, Grain Yield*

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Introduction

Rice (*Oryza sativa* L.) is the world's important staple food crop and plays a vital role in food security. It accounts for 25 percent of total cereal grain production next to wheat. By the year 2025, the targeted demand of rice for Indian population is 130 mt. Much of the demand will be arising from Asia, which is the home of two-third of the world's population and where 90 percent of total rice supply is grown in diverse environments. The productivity of rice per unit area is much lower to satisfy the food to increasing population and food security [1]. Plant density plays a significant role in increasing yields, as it influences the tiller formation, solar radiation interception, nutrient uptake and leaf gas exchange parameters, which ultimately affect its growth and development [2]. Improper plant spacing reduced yield of rice up to 20-30 percent while optimum spacing ensures better plant growth through efficient utilization of solar radiation and nutrients [3]. For attaining higher productivity, proper light interception by each segment of the canopy is important. In rice, the number of panicle per hill also a determinant factor in maximizing the yield. High density planting helps in maintain panicle number and optimum yield level. The rice yield increases as the density of planting increases to some extent and then starts declining [4]. System of rice intensification (SRI) is the method of rice cultivation enhanced the yield of rice by following various principles. However, lower planting density in SRI affected the growth and yield of rice compared to conventional method [5]. Due to poor establishment and vigour, the number of productive tillers may get reduced and in turn grain yield of rice. Hence, modified SRI is one in which modification in certain principles of SRI using scientific knowledge of management practices to adapt to local climatic condition in view of increasing yield and farmers income [6]. In keeping the above principles, the high density planting in rice with some modified SRI principles, the present study was conducted to examine the effect on light interception, growth, and yield of rice.

Material and Methods

The field trial was conducted at Wetland farm of the Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore in late Samba (September to January) season of during 2018-19. The experimental site belongs to Western agro-climatic zone of Tamil Nadu with an elevation of 426.7 m above mean sea level (MSL) and located geographically at 11°83' N latitude, 76°71' E longitude. The soil of the experimental field was clay loam in texture with the nutrient status of the field during start of the experiment was low in nitrogen, medium in phosphorous and high in potassium. The field experiment was designed with randomized complete block design with three replications. The treatments comprised of eight plant spacing levels *viz*., T_1 - 25 × 25cm + 100% RDF (Recommended dosage of fertilizer) (SRI), T_2 - 25 × 20cm + 100% RDF, T_3 - 25 × 15cm + 100% RDF, T_4 - 25 × 15cm + 125% RDF, T_5 - 20 × 20cm + 100% RDF, T_6 - 20 × 15cm + 100% RDF, T_7 - 20 × 15cm + 125% RDF) follows System of rice intensification (SRI) principles and T_8 - Conventional cultivation. Latest released variety Rice CO-52 was used in this field experiment. Recommended dose of fertilizers (150: 50: 50 kg N: P_2O_5: K_2O/ha) are applied as urea, single super phosphate and muriate of potash to all the plots as per the treatment. Nitrogen and potassium were given in four equal split doses at basal, active tillering (50 DAT), panicle initiation (70 DAT) and flowering stages (100 DAT). Full dosage of phosphorus, 25 percent of nitrogen and potassium were applied as basal prior to transplanting.

Top dressing was done based on LCC observations in all plots. Excluding the conventional cultivation plots, weeding operation was done on 15, 25, 35 and 45 DAT using hand operated rotary weeder in both direction for square planted plots, while in one direction in all other plots. All other practices were followed as per CPG (2012).

Measurement of Plant height (cm) and Leaf Area Index (LAI)

Observation on plant height was measured upto tip in the longest leaf at active tillering and panicle initiation stages, and upto the panicle tip at flowering and maturity stages from randomly tagged five plants and expressed in centimetres. The leaf area index was calculated as suggested by Palanisamy and Sivaraman (1996) [7], using the formula as given below:

$$LAI = \frac{L\ x\ B\ x\ K\ x\ Total\ number\ of\ green\ leaves/hill}{Spacing\ (cm^2)} \times 100$$

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

Measurement of light interception

Light interception (%) by the canopy was assessed by measuring light intensity above the canopy (I_0) and under the canopy (I_b) at near the soil surface between intervals of 1 m apart both in the inter-row space and in the inter-hill space in plants, respectively. The light intensity was measured with the AccuPAR ceptometer (Model LP-80) that measure PAR in the range of 400 to 700 nm waveband on a bright sunny day between 1230 to 1300 hrs at active tillering, panicle initiation, flowering and maturity stages. Light interception by the canopy (LIC) was calculated from the following equation and it is expressed as percentage.

$$LIC\ (\%) = \left(1 - \frac{I_b}{I_o}\right) \times 100$$

Where, LIC, Io and Ib are light interception by the canopy, PAR measured at above canopy and PAR measured at below canopy, respectively.

Grain yield

Grains from each treatment plots were taken after hand threshing and grain weight at 14 percent moisture content was recorded and was expressed in kg/ha.

The data collected from field experiment at different growth stages were statistically analysed for Least Square Difference (LSD) at 5 percent probability level as described by Gomez and Gomez (2010) [7].

Result and Discussion

Light interception (%)

Light interception (%) was significantly influenced due to high density planting at active tillering, panicle initiation, flowering and at maturity stages [Fig-1]. Light interception values varied between 45 to 56 percent at active tillering stage with maximum interception (56.15%) in spacing level 20 × 20cm which is on par 20 × 15cm (55.75%) and 20 × 15cm at 125% RDF (54.71%). The conventional cultivation (T_8) recorded lower light interception values (45.43%) than others. The reason for lesser interception in conventional planting is due to late transplanting (30 DAS) which had not covered the soil with the canopy as planted earlier in SRI treatments. During all growth stages, the treatments following SRI principles increased the light interception upto maturity stage, while in conventional method it increased upto flowering stage and decreased at maturity stage. Planting density with spacing 20 × 20cm recorded the maximum light interception values throughout the crop growing stages and on par with plant spacing of 20 × 15cm at 100 and 125% RDF and the conventional planting 20 × 10cm, respectively. While lower interception of light was recorded in plant spacing of 25 × 25cm. Similar result was reported by Thakur *et al.* (2010) [9] where the light interception was significantly higher at plant spacing 20 × 20cm compared to other plant spacing. Closer spacing treatments covered the soil better with the canopy than wider spacing (25 × 25cm) which was the reason for better light interception by the closer spacing treatments.

Plant height (cm)

The plant height was significantly influenced by high density planting at active tillering, panicle initiation and at flowering stages [Table-1]. At active tillering stage, the plant spacing with 25 × 15cm at 125% RDF produced taller plants (59.4cm) which was on par with all the treatments except conventional method of spacing (20 × 10cm) which produced shorter plants. The reason for lesser height is due late transplanting (30 DAS) in conventional treatment which emerged latter and grown slower. During panicle initiation and flowering stages also similar nature of results were repeated. At maturity stage, the plant height was not significantly influenced by the high density planting. Similar results were confirmed with the findings of Ashraf *et al*. (1999) [10]. At maturity stage though the conventional method planted later, it also attained maturity and grown equally since the plant height is more influenced by genetic factor rather environmental reasons.

Leaf Area Index (LAI)

Leaf area index of rice was varied significantly under high density planting [Table-1]. At active tillering stage, the LAI was maximum (2.97) in plant spacing of 20 × 15cm (T_6) which was on par with spacing levels of 20 × 15 (T_7) and 25 × 15cm (T4) with 125% RDF and minimum value was recorded in 25 × 25cm (T_1) planting density. At panicle initiation, flowering and at maturity stages, the conventional method of spacing 20 × 10cm (T_8) showed higher leaf area index followed by planting spacing 20 × 15cm, 20 × 15cm with 125% RDF and 20 × 20cm, respectively. There was no significant increase in LAI due to increase in fertilizer level at both spacing levels of 25 × 15 cm and 20 × 15 cm. Our findings conform the results of Kumar *et al*. (2006) [11]. During the entire growth stages, the 25 × 25cm (T1) planting density recorded the lesser leaf area index. Higher leaf index in denser planting is due to more of leaves per unit area [12, 13]. At lesser planting density, lower leaf index is mainly due to minimum number of hills or tillers per unit area [9].

Yield

Grain yield was significantly influenced due to plant spacing. A significantly higher grain yield was recorded under 20 × 20cm (6392 kg/ha) planting geometry which was statistically on par with 25 × 20cm (6259 kg/ha), 25 × 15cm at 100% RDF (5951 kg/ha) and 25 × 15cm at 125% RDF (6372 kg/ha). The yields obtained under the rest of the plant spacing levels were lower and statistically identical. The lowest yield was recorded under conventional method of planting (5061 kg/ha). Reason for higher yield might be due to more light interception and LAI, and reduced competition for light, air and nutrients compared to other spacing levels. Similar results were recorded by Thakur *et al*. (2010) [9] and Mishra *et al*. (2010) [14].

Conclusion

Plant spacing is an important factor to be optimized, neither maximized nor minimized, with the aim of maximizing agronomic yield and economic returns of the farmers. Though the LAI and light interception were higher with higher population (closer spacing), optimum yield could be obtained with a population of 200000 to 266667/ha by following SRI principles.

Application of research: The study focus mainly on influence of high density planting on light interception, growth and yield performance of rice by following modified system of rice intensification principles.

Research Category: Agricultural production

Abbreviations: SRI – System of rice intensification, LAI – Leaf Area Index, PAR – Photosynthetically active radiation, DAT – Date after transplanting, CPG – Crop Production Guide

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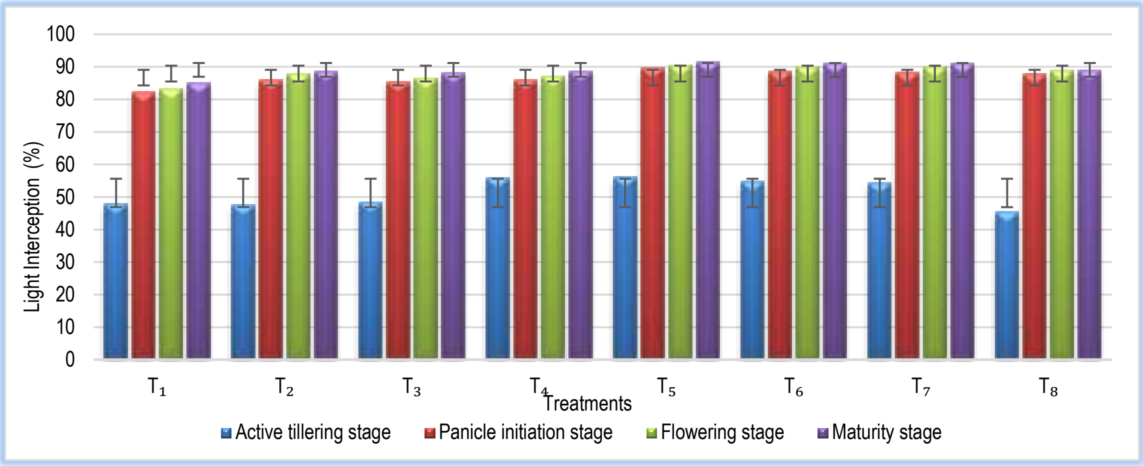
Table-1 *Influence of high density planting on Plant height (cm) and Leaf area index (LAI) of rice at different growth stages*.

Treatment	Plant Height (cm)				Leaf Area Index				Yield (kg/ha)
	AT	PI	FL	MT	AT	PI	FL	MT	
T_1 (25 × 25cm) 100% RDF	59.1	84.7	112.5	106.7	1.60	4.60	3.97	2.07	5667
T_2 (25 × 20cm) 100% RDF	58.1	86.4	114.7	111.0	2.17	5.30	4.43	2.47	6259
T_3 (25 × 15cm) 100% RDF	58.4	82.7	113.2	104.8	2.50	5.60	4.67	2.43	5951
T_4 (25 × 15cm) 125% RDF	59.4	86.0	109.2	105.0	2.57	5.77	4.70	2.93	6372
T_5 (20 × 20cm) 100% RDF	58.4	85.6	113.0	109.1	2.40	5.57	4.63	1.93	6392
T_6 (20 × 15cm) 100% RDF	55.7	87.5	113.8	107.3	2.97	6.73	5.50	2.10	5163
T_7 (20 × 15cm) 125% RDF	58.2	85.7	111.2	105.2	2.77	6.53	5.30	2.60	5193
T_8 (20 × 10cm) 100% RDF	48.8	78.2	104.1	105.3	2.47	7.17	5.82	3.17	5061
SEd±	2.5	2.2	2.9	6.2	0.13	0.31	0.29	0.10	351
CD (P=0.05)	4.1	4.8	6.2	NS	0.29	0.67	0.64	0.22	752

AT - Active tillering, PI – Panicle initiation, FL – Flowering, MT – Maturity



The vertical bars represent the standard deviation

Fig-1 Influence of high density planting on light interception (%) of rice at different growth stages

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Study area / Sample Collection: Wetland Farm, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu.

Cultivar / Variety: Rice CO-52

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