Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 3376-3380
Received: 13-03-2019
Accepted: 15-04-2019

Sandra Maria Saju
M.Sc. Student, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

N Thavaprakaash
Tamil Nadu Associate Professors Agronomy, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

N Sakthivel
Associate Professors Agronomy, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

P Malathi
Assistant Professor (SS&AC), HC& RI, Periyakulam, Tamil Nadu, India

Correspondence
N Thavaprakaash
Tamil Nadu Associate Professors Agronomy, Department of Agronomy, TNAU, Coimbatore, Tamil Nadu, India

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

Sandra Maria Saju, N Thavaprakaash, N Sakthivel and P Malathi

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 T_1 - 25 x 25cm with 100% Recommended Dose of Fertiliser (RDF) (SRI), T_2 - 25 x 20cm with 100% RDF, T_3 - 25 x 15cm with 100% RDF, T_4 - 25 x 15cm with 125% RDF, T_5 - 20 x 20cm with 100% RDF, T_6 - 20 x 15cm with 100% RDF, T_7 - 20 x 15cm with 125% RDF and T_8 - 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 T_1 and T_2 compared to others. Reverse trend was noticed with number of productive tillers/m^2. Grain yield was significantly higher with T_5, T_4, T_2 and T_3 compared to others. Whereas straw yield recorded superior values with closer spacing (T_8, T_7 and T_6) 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-third 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 159 to 304 plants/m^2 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/m^2 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 (11˚ 02' N latitude and 76˚93' 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: T_1-25x25cm with 100% Recommended Dose of Fertilizers (RDF) (SRI), T_2 - 25 x 20cm with 100% RDF, T_3 - 25 x 15cm with 100% RDF, T_4 - 25 x 15cm with 125% RDF, T_5 - 20 x 20cm with 100% RDF, T_6 - 20 x 15cm with 100% RDF, T_7 - 20 x 15cm with 125% RDF and T_8 - 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: P_2O_5:K_2O/ha. Urea (46% N), single super phosphate (16% P_2O_5) and muri ate of potash (60%K_2O) 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 observations. Hand operated rotary weeder was used for weeding on 15, 25, 35 and 45 DAT in both directions for square planted plots while in one direction for the rest of the plots excluding conventional system of planting. Pre-emergence herbicide, Butachlor @ 1.0kgai/ha on 3 DAT followed by hand weeding on 45 DAT was made in conventional method of planting. All other package of 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:

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

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/m^2 and number of productive tillers/m^2, 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 –T_8) followed by 20 x 15cm at 100 % RDF and at 125 % RDF (T_7 and T_6) 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/m^2 at maturity. A significantly higher number of tillers per unit area was observed under a closer spacing level of 20 x 10cm (418.3/m^2) which was on par with that under 20 x 15cm under 100% RDF (391.1/m^2). A lower number of tiller was obtained under a wider spacings of 25 x 25cm (260.3/m^2) and 25 x 20cm (301.3/m^2) which were statistically identical to each other. Higher number of hills/m^2 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/m^2) which was statistically similar to 20 x 15cm (322.2/m^2 at 100% RDF and 313.3/m^2 at 125% RDF), 20 x 20cm (311.7/m^2) and 25 x 15cm (304.0/m^2 at 100% RDF and 309.8/m^2 at 125% RDF). Different nutrient levels did not show any significant effect on number of panicles/m^2. Mishra *et al.* (2010) [3] recorded a greater number of productive tillers at closer spacing than wider spacing levels. Number of tillers/m^2 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) [18] and Clerget *et al*. (2016) [13].

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

Treatments	Plant height at maturity (cm)	LAI at flowering stage	Tiller/m^2 at maturity
T_1: 25 x 25 cm + 100% RDF	106.7	3.97	260.3
T_2: 25 x 20 cm + 100% RDF	111.0	4.43	301.3
T_3: 25 x 15 cm + 100% RDF	104.0	4.67	357.4
T_4: 25 x 15 cm + 125% RDF	105.0	4.70	341.4
T_5: 20 x 20 cm + 100% RDF	109.1	4.63	348.3
T_6: 20 x 15 cm + 100% RDF	107.3	5.50	391.1
T_7: 20 x 15 cm + 125% RDF	105.2	5.30	351.1
T_8: 20 x 10 cm + 100% RDF	105.3	5.82	418.3
SED	13.21	0.12	22.7
CD (P = 0.05)	NS	0.67	48.8

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 x20 cm (31.6) and 25 x15 cm (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], Ogbodo *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/m^2, higher number of filled grains/panicle, increased panicle 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

Table 2: Effect of high density planting on yield attributes of rice under modified SRI

Treatments	Productive tillers/m² (No./m²)	Number of grains/panicle	Filled grains/panicle	Chaffy grains/panicle	1000 seed weight(g)	Panicle length (cm)	Panicle weight (g)
T_1: 25 x 25 cm + 100% RDF	247.9	222.2	192.9	29.3	14.17	23.63	2.80
T_2: 25 x 20 cm + 100% RDF	279.7	208.1	176.5	31.6	14.20	24.27	2.72
T_3: 25 x 15 cm + 100% RDF	304.0	198.8	158.5	40.3	14.20	23.37	2.51
T_4: 25 x 15 cm + 125% RDF	309.8	192.7	158.9	33.8	14.17	24.17	2.56
T_5: 20 x 20 cm + 100% RDF	311.7	202.8	163.7	39.1	14.10	23.40	2.52
T_6: 20 x 15 cm + 100% RDF	322.2	178.3	147.8	44.5	14.00	24.35	2.18
T_7: 20 x 15 cm + 125% RDF	313.3	175.1	127.0	48.1	14.20	23.80	2.54
T_8: 20 x 10 cm + 100% RDF	330.0	163.3	113.3	50.0	14.17	23.27	1.74
Sed	16.12	11.1	8.2	2.4	0.13	0.91	0.09
CD (P = 0.05)	34.6	23.8	17.6	5.1	NS	NS	0.21

was due to increased population and number of tillers/unit area without altering the number of leaves which in turn increased the straw yield of rice. A similar result was recorded by Rajput *et al.* (2016) [17].

Table 3: Effect of high density planting on yield of rice under modified SRI

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index
T1	5667	7084	0.44
T2	6259	7478	0.45
T3	5951	7725	0.43
T4	6372	7972	0.44
T5	6392	7484	0.46
T6	5163	8278	0.38
T7	5193	8090	0.39
T8	5061	8523	0.37
SED	327	302	0.02
CD(P = 0.05)	705	647	0.03

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 planting or rectangular planting pattern by following SRI principles was appropriate to obtain higher yield.

References

1. www.agris.fao.org
2. Anonymous, 2018. Annual Report, NRRI, Cuttack, 2017-18.
3. Mishra A, Salokhe VM. Flooding stress: The effects of planting pattern and water regime on root morphology, physiology and grain yield of rice. J Agronomy & Crop Science. 2010; 196(5):368-378.
4. Khan MB, Yasir TA, Aman M. Growth and yield comparison of different linseed genotypes planted at different row spacing. Int. J Agric. Biol. 2005; 7(3): 515-517.
5. Mohaddesi A, Abbasian A, Bakhshipour S, Aminpanah H. Effect of different levels of nitrogen and plant spacing on yield, yield components and physiological indices in high yield rice. Amer-Eur. J Agric Environ. 2011; 10(5):893-900.
6. Counce PA. Asymptotic and parabolic yield and linear nutrient content responses to rice population density. Agron. J. 1987; 79(5):864-869.
7. Palanisamy SP, Sivaraman K. Methods of leaf area estimation and their evaluation in rice under different levels of nitrogen, variety and growth stages. Oryza. 1996; 12(1):1-7.
8. Yoshida S. Physiological aspects of grain yield. Annual Review of Plant Physiology. 1972; (1):437-64.
9. Gomez KA, Gomez AA. Statistical Procedure for Agricultural Research. A Willey Indian Pvt. Ltd. New Delhi, 2010.
10. Ashraf M, Khalid A, Ali K. Effect of seedling age and density on growth and yield of rice in saline soil. Pak. J Biol. Sci. 1999; 2(30):860-862.
11. Kumar MS, Yakadri M, Shaik-Mohammad. Evaluation of genotypic response for system of rice intensification-a noval technology. Plant Archives. 2006; 6(1):329-31.
12. Chakrabortty S, Biswas PK, Roy TS, Mahmud MA, Mehraj H, Uddin AF. Growth and yield of boro rice BRRI Dhan 50 as affected by planting geometry under system of rice intensification. J Biosci. 2014; 2(1):36-43.
13. Clerget B, Bueno C, Domingo AJ, Layaoen HL, Vial L. Leaf emergence, tillering, plant growth, and yield in response to plant density in a high-yielding aerobic rice crop. Field Crops Res. 2016; 199:52-64.
14. Rajput A, Rajput S, Jha G. Physiological parameters leaf area index, crop growth rate, relative growth rate and net assimilation rate of different varieties of rice grown under different planting geometries and depths in SRI. Int. J Pure App. Biosci. 2017; 5(1):362-367.
15. Baloch AW, Soomro AM, Javed MA, Ahmed M. Optimum plant density for high yield in rice. Asian J Plant Sci. 2002; 1(1):25-27.

16. Pasha ML, Rami Reddy PR. Performance of Kharif rice *Oryza sativa* L. under different nursery densities and plant population. Int. J bio-resource environ. agric. sci. 2016; 7(1):60-65.
17. Rajput A, Rajput SS, Jha G. Performance of rice varieties grown under different spacings with planting depths in system of rice intensification. Int. J Agric. Environ. Bio technol. 2016; 9(5):833.
18. Chapagain T, Yamaji E. The effects of irrigation method, age of seedling and spacing on crop performance, productivity and water-wise rice production in Japan. Paddy Water Environ. 2010; 8(1):81-90.
19. Veeramani P. Enhancement of Mat Nursery management and planting pattern (using rolling markers) in System of Rice Intensification (SRI) Technique. Res. J Agril. Sci. 2011; 2(2):371-375.
20. Thakur AK, Uphoff N, Anthony E. An assessment of physiological effects of system of rice intensification (SRI) practices compared with recommended rice cultivation practices in India. Exp. Agric. 2010; 46(1):77-98.
21. Gorgy RN. Effect of transplanting spacings and nitrogen levels on growth, yield and nitrogen use efficiency of some promising rice varieties. J Agric. 2010; 36(2):259-77.
22. Ogbodo EN, Ekpe II, Utobo EB, Ogah EO. Effect of plant spacing and N rates on the growth and yields of rice at Abakaliki Ebonyi State, Southeast Nigeria. Res. J Agric. Biol. Sci. 2010; 6(5):653-658.
23. Durga KK. Influence of seedling age and spacing on productivity and quality traits of rice under system of rice intensification. Madras Agric. J. 2012; 99(4-6):301-304.
24. Ram H, Singh JP, Bohra JS, Singh RK, Sutaliya JM. Effect of seedlings age and plant spacing on growth, yield, nutrient uptake and economics of rice *Oryza sativa* genotypes under system of rice intensification. Indian J Agron. 2014; 59(2):256-60.
25. Rajesh V, Thanunathan K. Effect of seedling age and population management on growth and yield of traditional Kamba n chamba rice. J Eco biol. 2003; 15(2):99-102.
26. Thirupathi I, Vidya Sagar GE, Mahender Kumar R, Surekha K, Prasad JVNS, Narender Reddy S. Assessment of energetics of rice with irrigation and nitrogen management practices under different establishment methods. Int. J Curr. Micro biol. App. Sci. 2018; 7(1):2313-2319.