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Evaluation of Growth and Yield Parameters of Rice under Different Cultivation Methods

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ABSTRACT

Background: Water is the most important environmental factor for sustainability of rice production. Traditionally rice was cultivated by continuous flooding. Due to global climate change and rapid industrialization and urbanization, the amount of water utilised for agriculture is declining which increases the water scarcity for irrigated rice production.

Methods: The present experiment was carried out during *Kuruvai* (July-November) 2022 at Tamil Nadu Agricultural University, Coimbatore. Experiments were carried out with five treatments *viz*., T_1 - 100% Saturation under drip irrigation, T_2 - 150% Saturation under drip irrigation T_3 - 200% Saturation under drip irrigation, T_4 - System of Rice Intensification (SRI), T_5 - Conventional method.

Result: Results of the experiment showed that growth parameters was higher in SRI method and this was on par with conventinal method. SRI method recorded significantly higher yield parameters and grain yield. From the above results, it can be concluded that. SRI method performed well compared to different method of cultivation due to the synergistic effects of various cultivation principles followed in this method.

Key words: Automated system, Drip irrigation, Phenology, SRI.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important source of food for more than half of the world population and 90% of the rice area worldwide is in Asia (Jabran *et al*., 2015; Ullah *et al*., 2018) Rice is cultivated in a wide spectrum of locations and under a variety of climatic conditions ranging from the wettest areas in the world to the driest areas. In India rice is cultivated an area of 45.7 million hectares with a total production of 124 million tonnes and the productivity was 2717 kg ha^{-1}. Major area was occupied by Uttar Pradesh, West Bengal, Chhattisgarh and Odisha. In Tamil Nadu, it is cultivated in 20.36 lakh hectares with a production of 68.81 lakh tonnes and the productivity of 3379 kg ha^{-1} (Indiastat, 2021). The demand for food particularly rice will be mounting as the world population will reach 9.15 billion by 2050 (Crossette, 2010). The present and future food security of Asia and India depends upon the irrigated rice production system (Saha *et al*., 2015). The large amount of water is used in conventional method because puddling requires more water and the field was continuously flooded with 5 cm depth up to physiological maturity. In this method, the existence of flooded water creates more seepage, percolation beyond root zone and loss of water through evaporation. Most of the Indian farmers are utilizing about 15,000 litres of water to produce one kg of rice (Kanmony, 2001). Requirement of water to produce one kg was two to three times more than other cereals such as maize and wheat (Riaz, 2001).

Agriculture sector consumes 70% of the fresh water resource, due to the global climate change and rapid industrial development as well as urbanization, more amount of water will be needed to provide non-agricultural consumption requirements. Consequently, the amount of water utilised for agriculture has been declining. In order to secure the India's food security, rice production was maximized with less amount of water to maintain the sustainability in rice cultivation. Effective alternate water management practices such as, intermittent irrigation, midseason drainage, alternate wetting and drying, direct dry sowing and aerobic rice cultivation are the possible methods to mitigate the methane emission from irrigated rice cultivation (Feng *et al*., 2013; Trost *et al*., 2013). Aerobic rice can be adopted in places where water is scarce or limited and under rainfed condition. 50-60% water is saved in aerobic rice cultivation as compared to transplanted rice

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(Belder *et al*., 2004). System of rice intensification (SRI) is an effective rice cultivation method, that is still being evaluated. SRI enhances yield, declines water requirement by 25% to 50% and raises input productivity (Materu, 2018). In aerobic rice also water is applied by flooding method of irrigation where water is applied until the entire field is fully covered results in wastage of water and nutrients. The efficient irrigation is the applying the right amount of water to the plant at the correct time without causing any adverse effect to the soil-plant environment. Drip irrigation is the most efficient water and nutrient delivery system it delivers water and nutrients directly to the plant's roots zone. Till date less attempts have been made to study the growth and yield of rice under different cultivation methods. Therefore, the objective of the study was to evaluate the growth and yield of rice under different cultivation methods.

MATERIALS AND METHODS

Experimental site

The experiment was carried out during *Kuruvai* (July-November) 2022 at Wetland farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. (11°N latitude and 77°E longitude, 426.7 m above mean sea level). The region located in Semi-Arid Tropics and belongs to the Western Agro-climatic zone of Tamil Nadu. The annual rainfall of Coimbatore is 731.5 mm distributed over 48 rainy days. The annual mean maximum and minimum temperatures are 31.5°C and 21.4°C, respectively. During the cropping season, 364 mm rainfall was received. The mean maximum and minimum temperatures were 30.72°C and 23.4°C, respectively. The mean relative humidity in the morning and the afternoon was 83.32 per cent and 58.44 per cent, respectively. The mean bright sunshine hour was 5.2 with mean solar radiation of 282.7 Cal. cm^{-2} day^{-1}. The average evaporation was 5.42 mm day^{-1}. The relevant physical, physicochemical and chemical properties of the soil and weather conditions furnished in Table 1 and Table 1a.

Experimental design

The field study was carried out using a randomized complete block design (RCBD) in which the rice cultivation methods were evaluated. Five treatments *viz*., T_1- 100% Saturation through drip irrigation, T_2- 150% Saturation through drip irrigation, T_3- 200% Saturation through drip irrigation, T_4- SRI, T_5- Conventional method were selected for this study. Each treatment was replicated four times. Treatments T_1, T_2, T_3 were cultivation of rice in aerobic method with drip irrigation. T_1 was irrigated automatically based on soil moisture sensor then irrigation duration was calculated. Based on T_1 duration T_2 and T_3 were irrigated 1.5× times and 2× times respectively. T_4 was irrigated based on alternate wetting and drying and continuous flooding was done in conventional method (T_5).

Agronomic management

The experiment comprising three methods of cultivation *viz*., aerobic method (T_1, T_2, T_3), SRI (T_4), conventional method (T_5). The rice variety CO 53 was used for the experiment. In the beginning of the season, aerobic plots were prepared by using five tyne cultivator as the primary cultivation followed by nine tyne cultivation + rotavator used to prepare fine seed bed. In SRI and conventional plots, five tyne cultivator was used as dry tillage followed by land soaking was done. After that puddling, land levelling and finally standing water was maintained for transplanting. For aerobic method dry seeds (75 kg ha^{-1}) were sown by hand dibbling at 3 cm depth with the spacing of 22.5 cm × 15 cm in unpuddled condition. Fourteen days old seedlings were transplanted (one seedling $hill^{-1}$) in puddled field at 25 × 25 cm spacing in SRI. In conventional method, transplanting (two to three seedling $hill^{-1}$) was done in a well puddled field on 22 DAS with the spacing of 20 × 10 cm. Pendimethalin at 1.0 kg a.i. ha^{-1} was applied as pre-emergence on 3 DAS followed by early post emergence application of bispyribac sodium 25 g a.i. ha^{-1} on 25 DAS. Later one hand weeding was done on 40 DAS in aerobic method. For SRI and conventional method, pretilachor @ 1.0 kg a.i. ha^{-1} was applied as pre-emergence. Later, conoweeding was done from 10 days intervals, *i.e*., 25, 35 and 45 DAT in both the directions in SRI. For conventional method one hand weed was done at 35 DAT. Recommended dose of fertilizer (150: 50: 50 kg N,P,K ha^{-1}) was applied as per the TNAU crop production guide as blanket recommendation. Irrigation was applied through drip as per the treatments based on soil moisture sensor. In SRI irrigation was provided at 2.5 cm height and allowed for 2-3 days and the next irrigation was given immediately when hairline cracks developed. In conventional method irrigation was given at 2.5 cm height and stagnated in entire field up to 10 days before harvest. The recommended agronomic practices and standard plant protection techniques were followed in all the treatments. Harvesting was done after the crop attained physiological maturity.

Observations

Five plants were selected randomly from the net plot area of each treatment and tagged for recording growth and yield attributes throughout the crop growing period.

The mean values of each plot were recorded. The plant height was measured from the base of plant to the tip of the longest leaf up to panicle emergence after that plant height was measured from the base of the plant to the tip of the panicle during the flowering stage on 30, 60, 90 DAS and at harvesting stage. Leaf area index (LAI) is the ratio of leaf area to ground area. The length and breadth were measured from the third leaf from top on five tagged plants. The leaves were counted in the same tagged plants to get number of leaves per hill. Finally, the leaf area index was calculated using the following formula given by Palaniswamy and Gomez (1974).

$$LAI = \frac{L \times B \times K \times \text{Total numbers of green leaves hill}^{-1}}{\text{Spacing } (cm^2)}$$

Where:
L- Length of the third leaf from top (cm).
B- Breadth of the third leaf from top (cm).
K- Constant (0.7).

For Drymatter production, three plants were uprooted from the destructive sampling rows at 30, 60, 90 DAS and at harvest. The uprooted plants were cleaned with care, shade dried and oven- dried in hot air oven at 70°C to a constant weight. From the starting of the flowering, the tillers with flowering were counted and the percentage of flowering was determined by dividing the flowered tillers with the total tillers. When it reaches 50 per cent, that day was noted as 50 per cent flowering.

Data analysis

Analysis of variance (ANOVA) was evaluated using SPSS 16.0 software and Fisher's least significant difference at a significance of $P \leq 0.05$ was used to compare the difference between means.

RESULTS AND DISCUSSION

Effect of cultivation practices on growth parameters

Plant height showed significant difference among the treatments (Table 2). Plant height increased from 30 DAS to harvest stage. Statistically there is no difference in plant height at 30 DAS. At 60 DAS significantly taller plants was produced in SRI method. The wider spacing in SRI resulted to minimum competition between the crop thus favors better growth and development of plant height (Ali and Izhar, 2017). On 90 DAS and harvest stage SRI produced significant taller plants and this was on par with conventional method of irrigation. It may be due to higher cell elongation resulting in increased internodal length, which in turn had higher plant height was observed SRI and conventional method (Patel *et al*., 2010). Leaf area index responded to different cultivation methods (Table 3). Conventional method of cultivation recorded significantly higher leaf area index at all the stages of the crop. Sanjeewanie Ginigaddara and Ranamukhaarachchi (2009) observed the higher LAI in conventional flooding system. The gradual reduction in LAI with decreasing irrigation level could be ascribed to sustenance of decreased soil water accessibility especially during tillering stage which significantly reduced the leaf attribute (Choudhary, 2015; Nguyen *et al*., 2015). Dry matter production influenced to different cultivation methods (Table 4). Among the different cultivation method, SRI method recorded higher dry matter production at 60 DAS, 90 DAS and harvest stage and this was on par with conventional method. Higher plant height and higher number of tillers increases the photosynthetic capacity of the plant which leads higher dry matter accumulation (Thakur *et al*., 2010). In addition to that, adequate water availability in soil and plant system incresed cell division, promoted secondary wall formation and increased the large photosynthetic area.

In short duration crop the panicle primordium will differentiate at about 40 DAS and it was visible after eleven days. Different cultivation method altered the days to fifty percentage flowering (Table 5). SRI method produced the panicle earlier compare to other method. Similarly, Dahiru (2018) observed earlier flowering in SRI method and under un puddled condition.

Effect of conventional and water saving methods on yield parameters and yield

The influence of different cultivation methods on rice yield parameters was given in Table 6. Rice cultivated under SRI method (T_4) produced more number of productive tillers per hill, higher number of filled grains, lesser number of unfilled grains more total number of grains. Improved rate of photosynthesis, high chlorophyll content present in the SRI method help the rice plants function more efficiently, turning the majority of tillers into productive ones and increase the

Table 1: Physico-chemical properties of soil particle size composition.

I. Particle size composition	
Sand (%)	42.30
Silt (%)	11.71
Clay (%)	45.93
Texture	Clay loam
II. Physical properties	
Bulk density (g cc^{-1})	1.40
Particle density (g cc^{-1})	2.28
Porosity (%)	40.00
II. Chemical properties	
Soil reaction (pH) (1:2.5 soil-water suspension)	7.77
Electrical conductivity (dS m^{-1}) (1:2.5 soil-water suspension)	0.04
Available N (kg ha^{-1})	206
Available P_2O_5 (kg ha^{-1})	11.4
Available K_2O (kg ha^{-1})	697

Table 1a: Weather condition prevailed during the experiment period.

Parameters	Value
Mean maximum temperature	30.72°C
Mean minimum temperature	22.84°C
Mean relative humidity (07:22 hrs)	83.75%
Relative humidity (14:22 hrs)	58.44%
Rainfall	364 mm
Mean bright sunshine hour	5.2 hrs
Solar radiation	282.7 Cal. cm^{-2} day^{-1}

Table 2: Plant height as influenced by different methods of irrigation on rice at 30 DAS, 60 DAS, 90 DAS and harvest.

Treatments	30 DAS	60 DAS	90 DAS	Harvest
T_1	35.47	69.78	89.87	93.53
T_2	36.47	70.27	96.11	100.89
T_3	37.08	79.56	100.62	102.37
T_4	38.06	96.80	112.29	114.29
T_5	39.99	74.67	103.08	104.26
SEd	1.68	4.48	5.13	5.21
CD (P=0.05)	NS	9.76	11.18	11.33

Table 3: Leaf area index as influenced by different methods of irrigation on rice at 30 DAS, 60 DAS, 90 DAS and harvest.

Treatments	30 DAS	60 DAS	90 DAS	Harvest
T_1	0.26	2.11	3.69	2.35
T_2	0.31	2.75	4.30	2.56
T_3	0.32	3.62	5.14	3.19
T_4	0.21	9.43	11.74	6.82
T_5	0.68	6.49	7.83	4.70
SEd	0.02	0.33	0.43	0.25
CD (P=0.05)	0.05	0.73	0.94	0.54

Table 4: Dry matter production (kg ha^{-1}) as influenced by different methods of irrigation on rice at 30 DAS, 60 DAS, 90 DAS and harvest.

Treatments	30 DAS	60 DAS	90 DAS	Harvest
T_1	93.48	2939	6015	8296
T_2	124.22	3710	7052	9481
T_3	107.13	4731	7963	10519
T_4	138.48	9574	14500	17600
T_5	317.88	9306	13575	16500
SEd	7.13	411	556	553
CD (P= 0.05)	15.53	896	1212	1204

yield traits (Poddar *et al*., 2022). SRI method recorded significantly higher grain yield compared to other method of rice production. More productive tillers and a lower proportion of chaffy grains all contributed to a rise in the number of filled grains and the overall quantity of grains, which may have boosted the grain yield. These results line up with Hidayati *et al.* (2016) and Geethalakshmi *et al.* (2011) where SRI method recorded higher grain yield. According to Thakur *et al.* (2011) the rice plant's enhanced morphological and physiological characteristics were the main factors of the increase in grain yield during SRI cultivation. Improved grain yield under SRI

Table 5: Days to 50% flowering as influenced by different methods of irrigation on rice at 30 DAS, 60 DAS, 90 DAS and harvest.

Treatments	30 DAS
T_1	92.50
T_2	91.50
T_3	90.25
T_4	64.25
T_5	75.50
SEd	5.41
CD (P=0.05)	11.79

Table 6: Yield parameters and yield as influenced by different methods of irrigation on rice.

Treatments	Number of filled grains	Test weight (g)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
T_1 - 100%	108.80	21.15	20.15	2470	4885	0.34
T_2 - 150%	112.74	21.25	21.25	2779	4964	0.36
T_3 - 200%	116.94	21.55	21.55	3427	5152	0.40
T_4 - SRI	155.06	22.75	24.75	6011	8289	0.42
T_5 - Conv	127.46	22.35	25.35	5152	7586	0.40
SEd	8.28	1.11	1.63	243	339.8	-
CD (P = 0.05)	18.05	NS	3.56	530	740.3	-

is mostly attributable to the synergistic benefits of changes in cultivation techniques, such as the use of young, single seedlings per hill, limited irrigation and frequent topsoil tillage (conoweeding) to promote aeration (Stoop *et al*., 2002). Previous field experiments have shown that rice grows better under the intermittent water management of SRI than under traditional flooded irrigation (Kahimba *et al*., 2013; Suryavanshi *et al*., 2013; Thakur *et al*., 2011).

CONCLUSION

Results from the present investigation revealed that, Comparatively growth attributes was higher under SRI method. Higher growth attributes lead to higher yield in SRI method. it can be concluded that. SRI method performed well compared to different method of cultivation due to the synergistic effects of various cultivation principles followed in this method.

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Conflict of interest

The authors declare that they have no conflict of interest.

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