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GROWTH ANALYSIS AND YIELD OF RICE AS AFFECTED BY DIFFERENT SYSTEM OF RICE INTENSIFICATION (SRI) PRACTICES

V. SRIDEVI & V. CHELLAMUTHU

Department of Agronomy, Pandit Jawaharlal Nehru College of Agriculture and Research Institute,
Karaikal, Tamil Nadu, India

ABSTRACT

A field investigation was conducted to determine the influence of various System of Rice Intensification (SRI) components on growth analysis and yield of rice variety ADT 43 in Karaikal during *kharif* season. Twelve treatment combinations (YOSC, NOSC, YMSC, YOSH, NMSC, NOSH, YMSH, YORH, NMSH, YMRH, NORH and NMRH) were replicated thrice in a Randomised block design in which Y refers to young seedlings of 14 days old raised in a modified rice mat nursery; N refers to normal seedlings of 21 days old raised in a conventional nursery; O refers to one seedling hill^{-1}; M refers to multiple seedlings (3 seedlings hill^{-1}); S refers to square planting (22.5 cm x 22.5 cm); R refers to rectangular planting (12.5 cm x 10.0 cm); C refers to conoweeding in both directions with conoweeder and H refers to hand weeding.. The results of the investigation showed that the combination of young seedling (14 days old), one seedling hill^{-1}, square planting with wider spacing (22.5cm x 22.5cm) and conoweeding four times at weekly interval starting from 15 DAT (YOSC) enhanced the growth parameters which in turn improved the grain yield by 68.25 per cent over the traditional practice.

KEYWORDS: Dry Matter, Growth Analysis, Grain Yield, Rice, SRI

INTRODUCTION

Low productivity of rice (*Oryza sativa* L.) in India is a major concern for food security. In such scenario, the system of rice intensification (SRI) appears to be a viable alternative of rice cultivation that saves the expensive inputs, improves yield, soil health/quality and protects the environment substantially (Satyanarayana *et al*. 2007). Crop growth analysis is an explanatory, holistic and integrative approach to interpreting plant form and function (Hunt *et al*., 2002). Studies of growth pattern and its understanding not only tell us how plant accumulates dry matter, but also reveals the events which can make a plant more or less productive singly or in population (Ozalkan *et al*., 2010). With this background, the present study was conducted to evaluate the different components of System of Rice Intensification (SRI) on growth analysis and yield of rice.

MATERIALS AND METHODS

A field experiment was carried out at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Union Territory of Pondicherry during *kharif* season. The objective was to study the effect of System of Rice Intensification (SRI) practices on dry matter production, growth analysis and yield of rice. The short duration (110 days) rice variety ADT 43 was used as test variety. The soil of the experimental site was sandy loam in texture with a pH 7.20, EC 0.33 dSm^{-1} and organic carbon content 0.49%. The fertility status of the soil was low (188.3 kg ha^{-1}) in available N ($KMnO_4$- N), medium (17.8 kg ha^{-1}) in available P (Olsen P) and medium (235 kg ha^{-1}) in available K (NH_4OAc-K). There were 12 treatment combinations (YOSC, NOSC, YMSC, YOSH, NMSC, NOSH, YMSH, YORH, NMSH, YMRH, NORH and NMRH) replicated thrice in a Randomised Block Design in which Y refers to young seedlings of 14 days old raised in a modified rice mat nursery; N refers to normal seedlings of 21 days old raised in a conventional nursery; O refers to one seedling $hill^{-1}$; M refers to multiple seedlings (3 seedlings $hill^{-1}$); S refers to square planting with wider spacing (22.5 cm x 22.5 cm); R refers to rectangular planting with closer spacing (12.5 cm x 10.0 cm); C refers to conoweeding four times between rows at weekly intervals starting from 15 DAT to 36 DAT in both directions with hand operated conoweeder and H refers to hand weeding twice at 20 DAT and 40 DAT. The recommended fertilizer schedule of 120: 38: 38 kg NPK ha^{-1} for the short duration rice variety and farm yard manure @ 12.5 t ha^{-1} were applied for all the treatments.

Leaf Area Index (LAI)

The LAI was worked out using the formula proposed by Yoshida *et al.* (1976).

$$\text{LAI} = \frac{\text{L} \times \text{W} \times K \times \text{ Number of leaves plant}^{-1}}{\text{Land area occupied by the plant}}$$

Where,

L = Length of 3rd leaf from the top (cm)

W = Maximum width of the same leaf (cm)

K = Correction factor (0.75)

Crop Growth Rate (CGR)

The CGR was calculated by using the formula as suggested by Watson, 1958.

$$\text{CGR} = \frac{W_2 - W_1}{P\ (t_2 - t_1)} \text{ g m}^{-2} \text{ day}^{-1}$$

Where,

W_1 and W_2 = Plant dry weight at time t_1 and t_2, respectively.

P = Spacing occupied by the crop

Relative Growth Rate (RGR)

The RGR was measured by using the following formula (Williams, 1946).

$$\text{RGR} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \text{ mg g}^{-1} \text{ day}^{-1}$$

Where,

W_1 and W_2 = Plant dry weight at time t_1 and t_2, respectively.

Net Assimilation Rate (NAR)

The NAR during the crop growth period was estimated by using the following formula (Williams, 1946).

$$\mathrm{NAR} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1} \ \mathrm{mg\ cm^{-2}\ day^{-1}}$$

Where,

L_1 and L_2 = Leaf area of plant at time t_1 and t_2 respectively.

W_1 and W_2 = Plant dry weight at time t_1 and t_2 respectively.

Leaf Area Ratio (LAR)

The LAR was calculated by the following formula (Radford, 1967).

$$\mathrm{LAR} = \frac{\text{Total leaf area of the plant (cm}^2\text{)}}{\text{Total dry weight of the plant (g)}}$$

Leaf Area Duration (LAD)

The LAD during the crop growth period was calculated by the formula as suggested by Power *et al*. (1967) which was further modified by Kvet *et al*. (1971).

$$\mathrm{LAD} = \frac{L_1 + L_2}{2} \times (t_2 - t_1) \ \mathrm{days}$$

Where,

L_1 = Leaf area index at time t_1

L_2 = Leaf area index at time t_2

Plant samples collected for dry matter estimation were oven dried at 70°C till a constant weight was obtained. Grain yield was recorded at 14 per cent moisture content. The data on various parameters were subjected to statistical scrutiny as suggested by Gomez and Gomez (2010).

RESULTS AND DISCUSSIONS

Growth Analysis

Leaf Area Index (LAI) was significantly differed among the treatments at all the growth stages (Table 1). At active tillering stage, YMRH (Young seedling, Multiple seedlings, Rectangular planting and Hand weeding) recorded higher LAI. This might be attributed to more number of tillers per unit area there by resulting in increased LAI. Whereas, at panicle initiation stage, the combination of Young seedling, One seedling, Rectangular planting and Hand weeding (YORH) recorded higher LAI but it was comparable with YMRH, YOSC and NORH. At flowering stage, the combination of Young seedling, One seedling, Square planting and Conoweeding (YOSC) registered higher LAI but it was on par with YORH, YMSC, YMRH, NOSC and NORH. This might be attributed to better root growth which facilitated increased cell division and cell enlargement due to increased photosynthetic rate and subsequently increasing LAI (Shrirame *et al*., 2000).

Crop Growth Rate (CGR) was significantly influenced by the treatments involving SRI components at all the growth stages (Table 1). The CGR increased up to flowering thereafter it started declining, irrespective of treatments. The combination of Young seedling, One seedling, Square planting and Conoweeding (YOSC) showed its superiority by recording higher CGR than other combinations throughout the crop growth period. It could be attributed to better soil aeration, less competition which favoured more root growth and photosynthetic activity.

Relative Growth Rate (RGR) was high in the early stages and it started declining progressively with the aging of the crop (Table 1). Significant difference was noticed in respect of RGR due to SRI components in various treatments at all the growth stages. Throughout the crop period, the combination YOSC (Young seedling, One seedling, Square planting and Conoweeding) almost showed higher RGR.

Net Assimilation Rate (NAR) was high in the early stages between active tillering and panicle initiation and thereafter the rate of increase was slow with advancement in the age of the crop (Table 2). The SRI components of various treatments significantly influenced the NAR. Higher and comparable NAR was recorded in the combination of NOSH, YOSH, YMSH, NOSC, YOSC and NMSH up to flowering stage. In general, the rectangular planting with closer spacing recorded lesser NAR than square planting with wider spacing at all the growth stages, irrespective of age of seedlings, number of seedlings hill^{-1} and method of weeding. Reduction in NAR could be attributed to less leaf area and shortage of other growth factors (nutrient, space, water etc.).

Leaf Area Ratio (LAR) was significantly influenced by the treatments involving SRI components only at active tillering stage, whereas at panicle initiation and flowering stages, there was no significant difference among the treatments (Table 2). At active tillering stage, the combination of NORH, NMRH, YMSC, YMRH, YOSC and YORH recorded higher and comparable LAR. In general square planting had lower LAR than rectangular planting, irrespective of age of seedlings, number of seedlings hill^{-1} and method of weeding.

Leaf Area Duration (LAD) increased with the age of the crop, with maximum LAD at flowering stage. Significant difference in respect of LAD was noticed at all the growth stages among various SRI components (Table 2). The combination of Young seedling, One seedling, Rectangular planting and Hand weeding (YORH) and NMRH recorded the longer and comparable LAD between active tillering and panicle initiation. Similar trend was observed between panicle initiation and flowering. The combination of YORH, YOSC, YMRH, YMSC, NORH and NOSC recorded higher and comparable LAD from panicle initiation to flowering stage.

Dry Matter Production (DMP) was significantly influenced at all the phenophases by the treatments involving different components of SRI (Table 3). The DMP increased with the age of crop, irrespective of treatments. The combination of Young seedling, Multiple seedlings, Rectangular planting and Hand weeding (YMRH) recorded high dry matter production up to panicle initiation stage but it was comparable with YORH. Thereafter, from flowering to harvest, the combination of Young seedling, One seedling, Square planting and Conoweeding (YOSC) recorded higher dry matter production which was similar to YMSC. This result is in conformity with the findings of Shao-hua *et al.* (2002) who reported that DMP was lower under SRI than that of conventional method at jointing stage, while at heading and maturity stages, the DMP under SRI was higher than that under conventional method.

Grain Yield is the manifestation of various yield components and it was profoundly influenced by different SRI components (Table 3). The combination of Young seedling, One seedling, Square planting and Conoweeding (YOSC) produced the highest grain yield of 3,683 kg ha^{-1} which was on par with YMSC (3,487 kg ha^{-1}). There is a considerable yield advantage when any one, two or three components of SRI are followed as compared to normal practice of rice cultivation. But the yield increase was more with more number of components. The highest yield advantage was realized in the combination of YOSC (Young seedling, One seedling, Square planting and Conoweeding) which recorded higher grain yield as compared to other combinations which might be attributed to increase in growth parameters besides increase in physiological activities with high LAI, LAD, CGR, NAR and RGR, better rooting ability and finally the highest DMP. This is in accordance with the findings of Thakur and Patel (1998) who reported that dry matter production, LAI, LAD, CGR, NAR and RGR are ultimately reflected in higher grain yield.

CONCLUSIONS

It is concluded that agronomic manipulation like planting of young seedling (14 days old) singly at 22.5 cm x 22.5 cm and conoweeding four times at weekly interval starting from 15 DAT had profound contribution for the enhancement of growth parameters *viz*, LAI, CGR, NAR, RGR and LAR and dry matter and yield of rice during *kharif* season.

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APPENDICES

Table 1: Effect of SRI Practices on LAI, CGR and RGR of Rice

Treatments	LAI			CGR (g m^{-2} day^{-1})			RGR (mg g^{-1} day^{-1})		
	AT	PI	FL	AT-PI	PI-FL	FL-HT	AT-PI	PI-FL	FL-HT
T_1: YOSC	0.71	2.53	4.31	10.59	14.40	7.26	77.59	36.79	9.73
T_2: NOSC	0.60	2.37	3.87	9.49	12.28	6.09	74.40	35.14	9.36
T_3: YMSC	0.76	2.46	4.01	10.48	13.51	6.54	75.10	35.15	9.18
T_4: YOSH	0.55	2.29	3.66	9.29	11.75	5.55	73.71	34.50	8.90
T_5: NMSC	0.61	2.28	3.68	8.72	11.15	5.23	69.67	34.01	8.79
T_6: NOSH	0.43	2.21	3.50	8.34	10.82	5.00	74.14	35.13	8.82
T_7: YMSH	0.51	2.22	3.43	8.68	11.02	5.37	73.01	34.48	9.15
T_8: YORH	1.13	2.80	4.24	7.92	11.51	5.30	46.95	31.29	8.27
T_9: NMSH	0.45	1.96	3.14	6.93	10.08	4.86	69.94	36.99	9.38
T_{10}: YMRH	1.27	2.63	3.97	7.68	11.10	4.71	43.00	29.88	7.51
T_{11}: NORH	0.98	2.53	3.78	7.27	10.93	4.65	52.11	33.55	8.01
T_{12}: NMRH	1.07	2.26	3.56	6.58	10.51	4.42	44.88	32.60	7.82
SEd	**0.04**	**0.14**	**0.28**	**0.20**	**0.19**	**0.08**	**2.21**	**0.55**	**0.08**
CD (0.05)	**0.08**	**0.29**	**0.58**	**0.41**	**0.40**	**0.17**	**4.59**	**1.13**	**0.17**

Note: AT: Active tillering PI: Panicle Initiation FL: Flowering HT: Harvest stage

Table 2: Effect of SRI Practices on NAR, LAD and LAR of Rice

Treatments	NAR (mg cm^{-2} day^{-1})		LAD (days)		LAR (cm^2 g^{-1})		
	AT-PI	PI-FL	AT-PI	PI-FL	AT	PI	FL
T_1: YOSC	0.546	0.319	22.73	95.76	128.1	152.8	92.8
T_2: NOSC	0.547	0.297	20.76	87.41	111.4	155.9	95.3
T_3: YMSC	0.538	0.317	22.56	90.51	131.7	147.6	89.7
T_4: YOSH	0.564	0.298	19.88	83.30	104.0	152.9	93.2
T_5: NMSC	0.511	0.284	20.24	83.45	111.7	157.4	98.0
T_6: NOSH	0.571	0.287	18.48	79.96	90.0	164.8	97.4
T_7: YMSH	0.553	0.294	19.08	79.02	101.1	157.8	92.9
T_8: YORH	0.324	0.253	27.51	98.57	126.3	162.0	102.3
T_9: NMSH	0.499	0.299	16.88	71.30	106.1	170.2	96.7
T_{10}: YMRH	0.309	0.257	27.25	92.36	129.9	147.4	96.5
T_{11}: NORH	0.334	0.264	24.56	88.28	138.3	171.5	100.0
T_{12}: NMRH	0.310	0.276	23.34	81.48	136.0	152.7	96.4
SEd	**0.020**	**0.017**	**1.00**	**5.41**	**10.0**	**10.0**	**7.2**
CD (0.05)	**0.040**	**0.034**	**2.09**	**11.21**	**20.7**	**NS**	**NS**

Note: AT: Active tillering PI: Panicle Initiation FL: Flowering

Table 3: Effect of SRI Practices on DMP and Grain Yield of Rice

Treatments	DMP (kg ha^{-1})				Grain Yield (kg ha^{-1})
	AT	PI	FL	HT	
T_1: YOSC	758	2201	6164	8664	3683
T_2: NOSC	727	2055	5495	7625	3339
T_3: YMSC	791	2259	6040	8328	3487
T_4: YOSH	722	2023	5312	7254	3249
T_5: NMSC	742	1963	5084	6914	2993
T_6: NOSH	644	1811	4841	6590	2732
T_7: YMSH	685	1900	4986	6867	3103
T_8: YORH	1193	2207	5089	6798	2864
T_9: NMSH	587	1557	4380	6081	2414
T_{10}: YMRH	1302	2307	5119	6657	2550
T_{11}: NORH	949	1901	4673	6185	2306
T_{12}: NMRH	1054	1893	4549	5981	2189
SEd	**55**	**84**	**148**	**182**	**130**
CD (0.05)	**114**	**174**	**307**	**378**	**272**

Note: AT: Active tillering PI: Panicle Initiation FL: Flowering HT: Harvest stage