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Advantages of SRI cultivation in the tail end of Cauvery delta

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ABSTRACT

A field investigation was conducted to investigate the effect of System of Rice Intensification (SRI) practices on dry matter production, yield and nutrient uptake of short duration rice variety ADT 43 in the tail end of Cauvery delta zone at Karaikal during kharif season of 2006. 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 from a modified rice mat nursery; N refers to normal seedlings of 21 days old from 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 between rows in both directions with hand operated conoweeder and H refers to hand weeding twice at 20 DAT and 40 DAT. The results revealed 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) profoundly enhanced the dry matter production, root growth and nutrient uptake which in turn improved the grain yield by 68.25% over the traditional practice.

Key words: Growth, nutrient uptake, system of rice intensification (SRI), yield

Rice occupies one-third of the world's total area planted to cereals and provides 35 to 60% calories consumed by 2.7 billion people (Maclean *et al.*, 2002). The rice requirement by the year 2025 would be around 125 mt (Kumar *et al*., 2009). To meet the food requirement of the growing population, the rice production has to be stepped up with shrinking availability of land and water resources. The yield obtained for any crop is the net result of photosynthetic productivity and the nutrient uptake. Rice root systems play an important role in uptake of water and nutrients from soil. A high photosynthetic rate of shoots secures high root activity by supplying sufficient amount of photosynthates to the roots. Conversely, high root activity secures a high photosynthetic rate by supplying a sufficient amount of nutrients to shoots, thus ensures high productivity (Osaki *et al*., 1997). The system of rice intensification (SRI) was recently promoted as an alternative crop and resource management strategy for rice cultivation that may offer the opportunity to boost rice yields with less external inputs (Tsujimoto *et al*., 2009). Hence the present study was undertaken to investigate the influence of different SRI practices and its combination on dry matter production, root growth and nutrient uptake at various growth stages and yield of rice.

MATERIALS AND METHODS

A field experiment was carried out at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during *kharif* season with ADT 43 rice variety. The beneficial monsoon of Karaikal is North – East monsoon (October – December), which accounts for 64.95% of total rainfall and the south – west monsoon (June–September) contributes 24.32%. During the cropping period of *kharif* 2005, a total rainfall of 129.8 mm was received in eight rainy days. The soil of the experimental plot was sandy loam in texture, low in available nitrogen (188.3 kg ha^{-1}), medium in available phosphorus (17.8 kg ha^{-1}) and potassium (235 kg ha^{-1}). Totally, there were 12 treatments (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 from a modified rice mat nursery; N refers to normal seedlings of 21 days old from 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 between rows in both directions with hand operated conoweeder and H refers to hand weeding twice at 20 days after transplanting (DAT) and 40 DAT. Conoweeding was practiced four times at weekly intervals starting from 15 DAT to 36 DAT. The recommended fertilizer schedule of 120: 38: 38 kg NPK ha^{-1} was followed. Farm yard manure was applied @ 12.5 t ha^{-1} uniformly during the last ploughing in all the plots. Nitrogen was applied as urea in three splits *viz*., 50% at 30 days after sowing (DAS) and 25% each at 50 DAS and 70 DAS. The entire dose of phosphorus as single super phosphate was applied as basal before transplanting. Potassium in the form of muriate of potash was applied in two splits *viz*., 50% each at basal and at 50 DAS. Zinc sulphate @ 25 kg ha^{-1} was applied as basal before transplanting.

For dry matter estimation, five plants were randomly selected from sampling area and they were cut at ground level on 35 DAS onwards at weekly interval up to harvesting. The samples were dried in shade and

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again oven dried at 70°C, till a constant weight was obtained. The dry weight was recorded using an electronic top pan balance and the dry matter was expressed in kg ha^{-1}. Plant samples collected for dry matter estimation at active tillering (35 DAS), panicle initiation (50 DAS), flowering (80 DAS) and harvesting (112 DAS) were oven dried and finely ground in Willey mill. Then, nitrogen, phosphorus and potassium contents were estimated by Micro Kjeldahl's method (Humphries, 1956), Triple acid digestion with Vanado molybdate yellow color method (Jackson, 1973) and Triple acid digestion with flame photometric method (Stanford and English, 1949), respectively. The per cent concentration of the nutrients was multiplied by the respective dry matter content and NPK uptake values were thus worked out. For root character estimation, five hills were removed from sampling area of each plot carefully without much loss of roots as far as possible. The grain yield was adjusted to 14% moisture content.

RESULTS AND DISCUSSION

Dry matter production

The treatments involving different components of SRI significantly influenced the dry matter production (Table 1) at all the growth periods. The DMP gradually increased with the age of crop, irrespective of treatments. The combination of Young seedling, Multiple seedlings, Rectangular planting and Hand weeding (YMRH) recorded higher dry matter production up to panicle initiation stage (49 DAS), but it was similar to YORH. At 56 and 63 DAS, the combination of young seedling, multiple seedlings, square planting and conoweeding (YMSC) was superior to other treatments but it was comparable with YOSC and YMRH. Thereafter, from flowering to harvest, the combination of young seedling, one seedling, square planting and conoweeding (YOSC) recorded higher dry matter production which was comparable with YMSC. This could be attributed to young seedlings contain more nitrogen and starch which helped in producing new roots, better root growth and more tiller production (Yoshida, 1981) resulting in higher drymatter than old seedlings.

The closer spacing with rectangular geometry recorded higher DMP than wider spacing with square geometry up to panicle initiation stage. Thereafter wider spacing recorded more DMP. 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. Increased shoot: root ratio and production of more number of tillers $hill^{-1}$ recorded under wider spacing were the reasons for increased DMP (Rajesh and Thanunathan, 2003). In addition to that conoweeding increased the soil aeration which enhanced availability of dissolved oxygen in irrigation water thereby increasing shoot: root ratio and LAI and subsequently increasing DMP (Uphoff, 2002).

Root characters

In general, the root characters *viz*., root length, root volume and root dry weight gradually increased and attained their maximum at flowering stage, beyond which they were found to decline due to root degeneration (Table 2). The treatments involving SRI components significantly influenced the root traits at all the phenophases.

Root length

Conspicuously longer roots (21.3, 23.7 and 22.6 cm $hill^{-1}$ at PI, FL and HT stages, respectively) were observed in YOSC combination (young seedling, one seedling, square planting and conoweeding), followed by YMSC, NOSC, NMSC and YOSH combinations at all the crop growth stages. Whereas, NMRH recorded shorter roots (15.3, 16.6 and 15.1 cm $hill^{-1}$ at PI, FL and HT stages, respectively) and it was as good as NORH, YMRH, YORH and NMSH combinations.

Root volume

At all the growth stages, YOSC combination (young seedling, one seedling, square planting and conoweeding) registered higher root volume (22.7, 24.3 and 23.0 cc $hill^{-1}$ at PI, FL and HT stages, respectively) and it was comparable with YMSC. The root volume was recording lesser in treatment combinations with closer spacing *viz*., YORH, NORH, NMRH and YMRH which were comparable with each other at all the growth stages.

Root dry weight

The YOSC combination registered 15-21% more root dry weight throughout the crop growth period and it was comparable with YMSC, YORH, NOSC, YOSH and YMSH. The combinations such as YMSH, YOSH, NMSC, NMRH, NMSH and NOSH were found to be inferior by recording lower root dry weight (662, 644, 624, 620, 598 and 561 kg ha^{-1}). However, they were comparable with each other at all the stages of observation.

The young seedling, one seedling, square planting and conoweeding (YOSC) combination recorded improved root characters at all growth stages due to the fact that high amount of nitrogen and starch in the young seedlings might have helped in producing new roots thereby increasing the root volume and length (Yoshida, 1981). In addition to that planting of one seedling $hill^{-1}$ and wider spacing reduced intra-plant competition and resulted in more foraging area. Moreover, conoweeding was found to prune some of the upper roots and thus encouraged deeper root growth thereby increasing root length, volume and dry weight (Uphoff, 2002).

Nutrient uptake

Uptake being a product of nutrient concentration and DMP, it increased with the age of crop, though the nutrient concentration was found to reduce with increase in DMP due to the dilution effect.

The SRI components significantly influenced the NPK uptake at various growth stages (Table 3). The combination of young seedling, multiple seedlings, rectangular planting and hand weeding (YMRH) recorded higher NPK uptake at active tillering and panicle initiation stages because of higher DMP due to higher plant population per unit area. However, at flowering and at harvest, the trend was different. The combination of young seedling, one seedling, square planting and conoweeding (YOSC) registered higher nutrient uptake at flowering and at harvest. This might be due to better root activity as evident from lengthier roots and higher root volume of young seedlings and subsequently increased DMP (Rajesh and Thanunathan, 2003).

Planting one seedling hill^{-1} recorded higher nutrient uptake than that of multiple seedlings hill^{-1} and it was mainly attributed to better root activity and increased DMP, besides less intra-plant competition. Moreover, conoweeding might have contributed for greater biological N fixation by mixing aerobic and anaerobic soil horizons. Also, organic matter (weeds etc.) could have decomposed quickly under aerobic conditions when soil moisture and temperature are not limiting for increased uptake of nutrients (Das and Mandal, 1986). Root pruning due to conoweeding might have induced new fresh roots that could have also helped in increasing the nutrient absorption.

Grain yield

The grain yield was significantly influenced by SRI components of different combinations (Table 2). 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 comparable with YMSC (3,487 kg ha^{-1}). The supremacy of YOSC is attributable to higher growth, yield attributes and nutrient uptake. This is in conformity with the findings of Hugar *et al*. (2009) who stated that SRI gave higher grain yield due to larger root volume, strong tillers with improved yield attributes.

When look into the relative contribution of individual components of SRI *viz*., young seedlings of 14 days old, square planting with wider spacing, planting of one seedling hill^{-1} in comparison with normal practice of rice cultivation (NMRH) was 16.49, 10.28 and 5.35% respectively. This suggested that planting of young seedlings alone without any other SRI components could increase the yield considerably (16.49%). Vijayakumar *et al*. (2012) also reported that younger seedlings (14 days old) from dapog nursery recorded higher yield than conventional seedlings.

The relative contribution by any two combinations of SRI components revealed that SC (square planting and conoweeding), OS (one seedling and square planting) and YO (Young seedling and One seedling) contributed for 36.73, 24.81, 41.75 and 30.84%, respectively as compared to normal practice (NMRH). This indicated that the combination of young seedling and square planting contributed the maximum to the grain yield (41.75% increase over the normal practice).

When the question of combination of any three components of SRI is raised, it is very much cleared that the combination of YSC (young seedling, square planting and conoweeding) contributed the maximum (59.30%) to the yield, followed by OSC (52.54%) and YOS (48.42%) as compared to normal practice (NMRH). It was very interesting to note that when all the components of SRI *viz*., young seedling, one seedling, square planting and conoweeding (YOSC) were combined, their contribution for yield was phenomenal (68.25%) as compared to normal practice (NMRH).

The above results clearly brought out the fact that if a farmer is able to practice all the four components of SRI (YOSC), he has the maximum advantage of 68.25%, increase in yield over the normal practice (NMRH). Even if he is able to follow any three components of SRI (OSC, YSC or YOS) he will able to get 48.52 to 59.30%, yield advantage over normal practice (NMRH). If due to some compelling reason, if he is able to follow at least any two components of SRI (SC, OS, YS, and YO), he will be able to get a yield advantage of 24.81 to 36.73%, compared to NMRH.

If a farmer is able to follow at least any one of the SRI components (S, Y or O), he can get 5.35 to 16.49%, higher yield than normal practice of rice cultivation (NMRH). Conoweeding alone was found to contribute 17.43%, for grain yield when the average grain yield under the conoweeding treatments 3376 kg ha^{-1} was compared against the average grain yield under hand weeding treatments 2875 kg ha^{-1}.

From the investigation, it could be inferred that combination of young seedling, one seedling, square planting and conoweeding (YOSC) performed better in terms of dry matter production, nutrient uptake and grain yield due to the synergistic effect of SRI components.

Table 1: Effect of SRI practices on dry matter production (kg ha^{-1}) at different growth periods

Treatments	Days after sowing											
	35	**42**	**49**	**56**	**63**	**70**	**77**	**84**	**91**	**98**	**105**	**112**
YOSC	758	1344	2201	2900	3801	4902	6164	6743	7398	8026	8470	8664
NOSC	727	1271	2055	2661	3449	4389	5495	5974	6543	7077	7460	7625
YMSC	791	1388	2259	2941	3810	4847	6040	6558	7158	7742	8145	8328
YOSH	722	1259	2023	2623	3383	4283	5312	5768	6292	6802	7101	7254
NMSC	742	1259	1963	2521	3228	4100	5084	5516	6016	6502	6772	6914
NOSH	644	1131	1811	2337	3029	3885	4841	5242	5729	6188	6450	6590
YMSH	685	1191	1900	2454	3152	4006	4986	5433	5946	6436	6719	6867
YORH	1193	1627	2207	2772	3457	4321	5089	5427	5878	6339	6636	6798
NMSH	587	975	1557	2035	2672	3469	4380	4764	5238	5695	5945	6081
YMRH	1302	1719	2307	2872	3538	4365	5119	5418	5810	6241	6538	6657
NORH	949	1371	1901	2449	3137	3935	4673	4963	5364	5786	6071	6185
NMRH	1054	1405	1893	2407	3053	3822	4549	4832	5211	5609	5873	5981
SEm (±)	**55**	**71**	**84**	**119**	**140**	**148**	**148**	**171**	**181**	**176**	**184**	**182**
LSD (0.05)	**114**	**147**	**174**	**246**	**289**	**307**	**307**	**354**	**375**	**365**	**382**	**378**

Table 2: Effect of SRI practices on root characters of rice at various growth stages

Treatments	Root length (cm hill^{-1})			Root volume (cc hill^{-1})			Root dry weight (kg ha^{-1})		
	PI	**FL**	**HT**	**PI**	**FL**	**HT**	**PI**	**FL**	**HT**
YOSC	21.3	23.7	22.6	22.7	24.3	23.0	706	752	741
NOSC	19.0	21.9	19.7	19.0	20.0	20.0	644	723	692
YMSC	20.4	22.1	20.9	21.0	22.0	20.7	678	729	717
YOSH	18.5	21.5	19.1	17.7	18.7	18.3	623	644	632
NMSC	18.9	21.7	19.1	17.7	19.7	19.0	597	624	612
NOSH	17.5	20.0	18.2	13.3	14.7	14.3	529	561	557
YMSH	18.0	20.4	17.7	13.0	16.3	14.7	620	662	653
YORH	16.7	19.6	17.1	8.3	9.7	8.3	649	723	693
NMSH	17.2	19.7	17.5	11.7	12.7	12.3	546	598	549
YMRH	15.7	17.7	16.3	4.0	6.0	4.7	524	712	701
NORH	15.1	16.8	15.6	6.3	7.0	5.3	606	750	741
NMRH	15.3	16.6	15.1	4.7	5.7	4.0	616	620	612
SEm (±)	**1.4**	**1.5**	**1.2**	**1.3**	**1.2**	**1.7**	**44**	**45**	**42**
LSD (0.05)	**3.0**	**3.1**	**2.4**	**2.8**	**2.5**	**3.4**	**91**	**93**	**86**

Note: PI: Panicle Initiation FL: Flowering HT: Harvest stage

Table 3: NPK uptake and yield of rice as influenced by different SRI practices

Treatments	Nitrogen uptake (kg ha^{-1})				Phosphorus uptake (kg ha^{-1})				Potassium uptake (kg ha^{-1})				Grain yield (kg ha^{-1})
	AT	**PI**	**FL**	**HT**	**AT**	**PI**	**FL**	**HT**	**AT**	**PI**	**FL**	**HT**	
T_1: YOSC	15.41	32.05	76.54	86.93	3.19	7.74	17.73	18.06	7.75	20.77	50.59	56.83	3683
T_2: NOSC	14.21	28.01	64.58	81.34	3.12	7.23	15.19	16.72	7.62	19.89	45.81	54.44	3339
T_3: YMSC	16.22	33.29	74.91	81.92	3.41	7.61	17.07	17.20	8.09	21.31	48.91	54.08	3487
T_4: YOSH	14.48	28.68	64.44	76.95	3.10	7.11	14.86	16.09	7.47	19.31	43.33	51.15	3249
T_5: NMSC	14.58	26.79	58.89	71.47	3.15	6.80	14.17	14.81	7.41	18.04	40.04	45.40	2993
T_6: NOSH	11.89	25.21	58.35	66.16	2.50	6.45	13.59	13.85	6.55	16.99	38.92	42.97	2732
T_7: YMSH	13.67	26.05	58.20	73.87	2.66	6.54	13.73	15.17	6.72	17.25	38.80	47.64	3103
T_8: YORH	23.28	32.50	63.58	72.06	4.50	7.65	14.32	14.92	12.00	20.41	40.91	48.67	2864
T_9: NMSH	11.39	22.95	55.22	60.22	2.36	5.32	12.44	12.66	6.06	14.85	36.25	41.61	2414
T_{10}: YMRH	25.53	33.82	63.06	65.52	4.77	7.64	14.27	14.39	13.32	21.75	41.84	45.82	2550
T_{11}: NORH	17.94	26.28	55.01	59.64	3.57	6.57	12.96	13.05	9.78	18.08	38.50	41.80	2306
T_{12}: NMRH	20.34	25.81	51.34	58.81	4.13	6.27	12.54	12.55	10.95	18.16	37.85	40.99	2189
SEm (±)	**1.07**	**1.46**	**2.72**	**0.80**	**0.27**	**0.30**	**0.76**	**0.82**	**0.58**	**0.82**	**1.77**	**2.58**	**130**
LSD (0.05)	**2.21**	**3.03**	**5.65**	**1.65**	**0.56**	**0.63**	**1.58**	**1.70**	**1.20**	**1.70**	**3.67**	**5.35**	**272**

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

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