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Influence of Seedling Age and Spacing on Productivity and Quality Traits of Rice Under System of Rice Intensification

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Studies on age of seedlings and spacing schedule adopted under SRI were taken up at Seed Research and Technology Center, Rajendranagar during *Kharif,* 2008 using popular rice cultivar, Swarna (MTU 7029). The results indicated that yield components, yield and seed quality parameters differed significantly due to age of seedlings and spacing schedule. Twelve days old seedlings planted at 30 x 30 cm spacing recorded significantly higher number of productive tillers plant^{-1} (26.7). Seed yield ha^{-1} was significantly higher with 14 days aged seedlings (61.08 q ha^{-1}). The seed yield ha^{-1} increased by 52.43% over 12 days aged seedlings followed by 16 days (25.11%) and 27 days (21.44%) old seedlings. Treatment combination of 14 days aged seedlings planted at 20 x 20 cm spacing recorded maximum yield of 64.70 q/ha followed by the same aged seedlings at 30 x 30 spacing (60.55 q/ha). Twelve days old seedlings planted at 30 x 30 cm recorded high establishment of 100%, more vigorous with respect to seedling length (26.12 cm) and seedling vigour index I (2612).

Key words: SRI paddy, yield components, yield and seed quality**.**

System of Rice Intensification (SRI) developed in Madagascar in the 1980s, has spread in the last three years to more than 15 other countries in Asia, Africa and Latin America. This involves reduced water applications, including adoption of alternate wet and dry irrigation (AWDI) as a part of a new strategy of rice intensification. The research conducted in countries like Madagascar, Sri Lanka and China regarding SRI technique is very encouraging and in India, it is at researchable stage.

India is the second most populous nation and the largest producer of rice next to China in the world. Increased and sustained production of rice is essential for food security in India.

Challenges in maintaining the sustainability of rice farming have been increasing with the increased scarcity of water and competition for water resources (Tejendra Chapagain and Eiji Yamaji, 2010). In spite of these constraints, rice production must rise dramatically over the next generation to meet the world's food needs and especially those of the poor. Hence, producing more rice with less resource input is a formidable challenge for ensuring the food, economic, social, and water security. One strategy proposed is the system of rice intensification (SRI) a more efficient, resource-saving, and productive way to practice rice farming. It involves changes in certain management practices which jointly provide better growing conditions for rice plants, particularly in the root zone. SRI is a set of ideas and insights that emphasize the use of younger seedlings (less than 15 days) planted singly and at wider spacing, together with the adoption of intermittent irrigation, organic fertilization, and active soil aeration to the extent possible (Uphoff, 2007). Hence an attempt has been made to study the influence of seedling age and spacing on productivity and quality traits of rice under system of rice intensification.

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Materials and Methods

Treatments and their combination

The present experiment was conducted using one of the most popular rice cultivars, Swarna (MTU 7029) at Seed Research and Technology Center, Rajendranagar, Hyderabad during *kharif*, 2008. The experiment was laid out in a split plot design with age of seedling (12 days seedlings, 14 days seedlings, 16 days seedlings and 27 days seedlings) in main plot and spacing schedule in sub plots (30 x 30 cm, 25 x 25 cm and 20 x 20 cm). There were totally twelve treatment combinations replicated thrice. The treatment combinations are shown in Table 1.

The main purpose of the study was to observe the effects of key SRI components such as age of the seedlings and spacing on performance of rice. Integrated crop management practices were employed to raise a healthy crop. Butachlor at the rate of 2kg ha^{-1} was sprayed in the paddy field 5 days after transplanting.

Observations on yield attributing characters like plant height, number of tillers plant^{-1}, ear bearing tillers, productive tillers, filled spikelets, spikelet

Table 1. Treatment details of rice variety, Swarna during *Kharif*, 2008

Treatments	Age of seedlings (days)	Spacing (cm)	Plant population (m^2)
D1T1	12	30 x 30	11
D1T2	12	25 x 25	16
D1T3	12	20 x 20	25
D2T1	14	30 x 30	11
D2T2	14	25 x 25	16
D2T3	14	20 x 20	25
D3T1	16	30 x 30	11
D3T2	16	25 x 25	16
D3T3	16	20 x 20	25
D0T1	28	30 x 30	11
D0T2	28	25 x 25	16
D0T3	28	20 x 20	25

fertility, 100 seed weight and grain yield were recorded on five randomly selected plants. The seeds obtained from all the treatments were tested for laboratory germination (paper towel method) as per the ISTA rules (ISTA, 1985). The first count and final count were recorded and expressed in percentage. After final germination count, ten normal seedlings were selected at random in each replication for recording seedling length in centimeters (cm) and same seedlings were oven dried at 80^{o}C for 17 h and weighed (g) for seedling dry weight. Seed vigour index I and II were calculated by multiplying germination per cent with seedling length and dry matter production, respectively (Abdul - Baki and Anderson, 1973).

Results and Discussion

Growth components yield components, yield and seed quality parameters differed significantly due to age of seedlings and spacing schedule (Tables 2 to 5). Number of productive tillers (Table 3) varied significantly due to age of seedlings and spacing schedule. 12 days old seedlings recorded more productive tillers plant^{-1} (23.8) compared to other age of seedlings. Similarly, seedlings planted at 30 x 30 cm recorded significantly higher number of productive tillers (26.1) compared to closer spacing of 25 x 25 cm and 20 x 20 cm. Krishna and Biradir Patil (2009) substantiated that planting in square method with wider spacing might have resulted in profuse tillering under SRI cultivation which might have facilitated plants for better utilization of the resources. Similarly Gaini *et al.,* (2002) reported enhanced tiller numbers under SRI method. Among the 12 treatments under study, 12 days aged seedlings planted at 30 x 30 cm spacing recorded significantly higher number of productive tillers plant^{-1} (26.7).

Table 2. Influence of spacing and age of seedlings on growth components of Swarna (MTU 7029) under SRI during *kharif*, 2008

Seedling age	Total tillers hill^{-1} (no.)					Plant height at harvest (cm)					Ear bearing tillers hill^{-1} (no.)				
	12	14	16	27	Mean	12	14	16	27	Mean	12	14	16	27	Mean
30 x 30 cm	60.7	52.9	59.6	59.0	58.1	67.3	73.5	66.3	65.2	68.1	35.3	31.6	31.3	30.3	32.1
25 x 25 cm	56.8	46.7	42.5	49.6	48.9	64.5	67.3	65.2	67.1	66.0	31.5	27.1	25.5	25.5	27.4
20 x 20 cm	46.3	46.3	39.5	38.1	42.6	69.7	66.7	67.2	70.1	68.4	23.2	24.3	19.9	20.7	22.0
Mean	54.6	48.6	47.2	48.9	49.8	67.2	69.2	66.2	67.5	67.5	30.0	27.7	25.6	25.5	27.2
	S.E.		C.D.			S.E.		C.D.			S.E.		C.D.		
Main	3.8		9.3			1.9		4.6			3.1		7.7		
Sub	2.2		4.7			1.7		3.7			1.1		2.3		
Sub at same level of main	4.5		9.5			3.5		7.4			2.2		4.6		
Main at same or different level of sub	6.0		13.6			3.3		7.4			4.6		10.9		

Number of total tillers and ear bearing tillers per hill (Table 2) varied significantly due to age of seedlings and spacing schedule adopted. Twelve days aged seedlings recorded maximum number of tillers (54.6) and were significantly higher than 27 days old seedlings (48.9); 14 days old seedlings (48.6) and 16 days old seedlings (47.2). Similarly, 30 x 30 cm spacing recorded 58.1 tillers hill^{-1} and was significantly higher than 25 x 25 cm (48.9) and 20 x 20 cm (42.6). Further, 12 days seedlings when planted at 30 x 30 cm spacing recorded maximum number of tillers hill^{-1}. Krishna and Biradir Patil (2009) substantiated that planting in square method with wider spacing might have resulted in profuse tillering under SRI cultivation which might have facilitated plants for better utilization of the resources leading to high spikelet fertility. Gaini *et al.,* (2002) reported enhanced tiller numbers under SRI method. Krishna *et al.,* (2008) reported highest number of tillers with twelve day old seedlings and Reddy (2002) reported that the tiller number declined with closer spacing.

Similarly ear bearing tillers hill^{-1} were found to be more (30.0) when 12 days aged seedlings were planted and were on par with 14 (27.7), 16 (25.6) and 27 (25.5) days old seedlings. 30 x 30 cm spacing recorded 32.1 tillers and was significantly higher than 25 x 25 cm (27.4) and 20 x 20 cm (22.0) (Table 2).

Among the yield components and yield, filled spikelets panicle^{-1}, spikelet fertility, and test weight

Table 3. Influence of spacing and age of seedlings on yield components of Swarna (MTU 7029) under SRI during *kharif*, 2008

Seedling age / Spacing	Productive tillers hill^{-1} (no.)					Filled spikelets panicle^{-1} (no.)					Per cent spikelet fertility				
	12	14	16	27	Mean	12	14	16	27	Mean	12	14	16	27	Mean
30 x 30 cm	26.7	26.6	26.1	24.9	26.1	110	110	109	105	109	84.97	93.53	82.80	83.26	86.14
25 x 25 cm	26.1	22.2	20.7	20.2	22.3	110	94	106	101	103	82.29	87.76	80.65	79.95	82.66
20 x 20 cm	18.7	19.9	16.4	16.1	17.8	91	112	111	107	105	80.24	84.65	81.07	83.97	82.48
Mean	23.8	22.9	21.1	20.4	22.1	104	105	109	104	105.50	82.50	88.65	81.51	82.39	83.76
	S.E.		C.D.			S.E.		C.D.			S.E.		C.D.		
Main	2.7		6.7			11		28			1.90		4.70		
Sub	1.0		2.2			9		20			1.50		3.20		
Sub at same level of main	2.1		4.4			19		41			3.10		6.50		
Main at same or different level of sub	4.0		9.5			19		44			3.20		7.30		

directly contributed to higher seed yield. Fourteen days aged seedlings recorded maximum spikelet fertility of 88.65. Similarly paddy transplanted at 30 x 30 cm recorded maximum of 86.14. Control plots recorded low spikelet fertility compared to SRI treatments. With respect to treatment combination, 14 days aged seedlings planted at 30 x 30 cm spacing recorded high spikelet fertility of 93.53. Seedlings planted at 30 x 30 cm recorded significantly higher number of productive tillers (26.1) compared to closer spacing of 25 x 25 cm and 20 x 20 cm. Among the 12 treatments under study, 12 days aged seedlings planted at 30 x30 cm spacing recorded significantly higher number of productive tillers per plant (26.7).

Seed yield ha^{-1} was significantly higher with 14 days aged seedlings (61.08 q ha^{-1}). The seed yield ha^{-1} increased by 52.43% over 12 days aged seedlings followed by 16 days (25.11%) and 27 days (21.44%) aged seedlings. Biradir Patil (1999) attributed that the reduction in seed yield with 20 and 30 days old seedlings was due to low productive tillers plant^{-1}. Similarly, seedlings planted at 20 x 20 cm recorded maximum yield of 55.93 q

Table 4. Influence of spacing and age of seedlings on yield components of Swarna (MTU 7029) under SRI during *kharif*, 2008

Seedling age / Spacing	Yield of graded seed plot^{-1} (kg)					Yield of graded seed (q ha^{-1})					100 seed weight (g)				
	12	14	16	27	Mean	12	14	16	27	Mean	12	14	16	27	Mean
30 x 30 cm	8.11	12.11	9.33	9.15	9.68	40.55	60.55	46.65	45.75	48.38	16.64	16.71	16.80	15.27	16.36
25 x 25 cm	8.10	11.60	8.00	9.31	9.25	40.50	58.00	40.00	46.55	46.26	16.70	17.85	16.02	16.26	16.71
20 x 20 cm	7.83	12.94	11.96	12.01	11.19	39.15	64.70	59.8	60.05	55.93	15.16	16.85	17.98	17.11	16.78
Mean	8.01	12.22	9.76	10.16	10.04	40.07	61.08	48.82	50.78	50.19	16.17	17.14	16.93	16.213	16.61
	S.Ed.		C.D.			S.Ed.		C.D.			S.E.		C.D.		
Main	0.60		1.50			3.00		7.40			0.10		0.20		
Sub	0.60		1.30			3.10		6.50			0.10		0.10		
Sub at same level of main	0.60		1.30			3.10		6.50			0.10		0.20		
Main at same or different level of sub	0.90					4.40					0.10		0.30		

ha^{-1} and was significantly different from the seedlings planted at 30 x 30 cm spacing (48.38 q ha^{-1}). Treatment combination of 14 days aged seedlings planted at 20 x 20 cm spacing recorded maximum yield of 64.70 q ha^{-1} followed by the same aged seedlings at 30 x 30 spacing (60.55 q ha^{-1}). Krishna and Biradir Patil (2009) attributed high seed yield ha^{-1} under 30 x 30 cm spacing to optimum level of plant population coupled with better yield parameters. Similar findings were also reported by Zhang *et al.,* (2004). Improved aeration in rhizosphere and enhanced microbial activity under SRI might have enabled the plants to efficiently utilize the inputs; thereby encouraging the plants to put forth huge amount of biomass in the form of tillers. Consequently, leading to early and uniform maturity as compared to conventional method (Udaykumar, 2005). Further, the interaction effect between various components also expressed yield gains in SRI. Thiyagarajan (2006) reported that root growth, tiller density, panicle density, number of grains per panicle, dry matter production during grain filling period and better uptake of nutrients acted synergistically and contributed to the higher yield.

Data on seedling parameters such as germination, seedling length, seedling dry weight, seedling vigour index I and seedling vigour index II are presented in Table 5. There was no significant differences among the treatments under study indicating that method of planting has no effect on the germination capacity of the harvested produce. Sreedhar and Ganesh (2010) indicated that SRI will not interfere with germination capacity of the resultant seed, in comparison to normal methods and attributed to better source – sink translocation

Table 5. Influence of spacing and age of seedlings on seed quality of Swarna (MTU 7029) under SRI during *kharif*, 2008

Treatment	Germination %			Total seedling length (cm)			Seedling dry weight			(g) Seedling vigour index I	Seedling vigour index II
12 / 30 x 30 cm	100			26.12			0.0146			2612	1.46
12 / 25 x 25 cm	100			24.06			0.0134			2406	1.34
12 / 20 x 20 cm	99.5			23.74			0.016			2362	1.59
14 / 30 x 30 cm	99.7			23.71			0.0197			2364	1.96
14 / 25 x 25 cm	100			24.66			0.0155			2466	1.55
14 / 20 x 20 cm	100			25.34			0.0168			2534	1.68
16 / 30 x 30 cm	99.3			25.18			0.0164			2500	1.63
16 / 25 x 25 cm	100			24.04			0.021			2404	2.10
16 / 20 x 20 cm	100			22.72			0.0137			2272	1.37
27 / 30 x 30 cm	100			24.83			0.0146			2483	1.46
27 / 25 x 25 cm	98.5			24.07			0.0184			2371	1.81
27 / 20 x 20 cm	100			23.67			0.0157			2367	1.57
G. Mean	99.75			24.35			0.0163			2428	1.63
	S.Em	S.Ed	C.V.	S.Em	S.Ed	C.V.	S.Em	S.Ed	C.V.		
Main	0.29	0.41	0.62	0.75	1.07	6.56	0.001	0.002	16.62		
Sub	0.26	0.36	0.63	0.59	0.83	5.92	0.001	0.002	21.64		
Interaction	0.36	0.51	0.6	0.83	1.18	5.90	0.002	0.003	21.6		

of assimilates under just saturated field conditions. Twelve days seedlings planted at 30 x 30 cm recorded high germination of 100%, were more vigorous with respect to seedling length (26.12). The seedling vigour index I (2612) was also significantly higher. This was followed by 16 days seedlings planted at 30 x 30 cm spacing. On the other hand, 16 days seedlings planted at 25 x 25 cm were found vigorous with respect to seedling dry weight and seedling vigour index II (0.021 and 2.10, respectively followed by 14 days seedlings at 30 x 30 cm spacing (0.0197 and 1.96, respectively). Krishna and Biradir Patil (2009) reported non - significant differences for seed germination due to the age of seedlings and spacing. He further reported high vigour index I with 12 days old seedlings planted under wider spacing (40 x 40 cm).

The better seed quality with seed produced from wider spacing may be due to good aeration to the plants. All the plants might have been exposed to sunlight thereby inhibiting the growth of pathogens in the seed. Krishna and Biradir Patil (2009) attributed better seed quality under wider spacing to higher test weight values.

On the basis of the above study it can be concluded that seed yield ha^{-1} increased by 52.43% over 12 days aged seedlings followed by 16 days (25.11%) and 27 days (21.44%) old seedlings. Treatment combination of 14 days aged seedlings planted at 20 x 20 cm spacing recorded maximum yield of 64.70 q/ha followed by the same aged seedlings at 30 x 30 spacing (60.55 q/ha).

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