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Effect of seedling age and spacing schedule on the productivity and quality traits of rice under system of rice intensification (SRI)

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Studies on the effects of seedling age and spacing schedule on the productivity and quality traits of rice adopted under system of rice intensification (SRI) was taken up at Seed Research and Technology Centre, Rajendranagar, Hyderabad during *kharif*, 2008 and 2009 using popular rice cultivar, Swarna (MTU 7029). 16 days seedlings planted at 20 × 20 cm, 12 days / 20 × 20 cm (56.2 q/ha) and 14 days / 20 × 20 cm (53.4 q/ha), 12 days / 25 × 25 cm (52.2 q/ha) and 12 days / 30 × 30 cm (51.2 q/ha) were found superior for grain yield and were significantly different from the rest of the treatments. Of all the five treatments, 12 days aged seedlings besides recording highest grain yield were also found superior for spikelet fertility and ear bearing tillers per hill. Further, 12 days old seedlings planted at 25 × 25 cm recorded 100% germination with longer seedlings and high seedling vigour Index I.

Key words: Seedling age, spacing schedule, system of rice intensification (SRI), grain yield.

INTRODUCTION

India is the second largest producer of rice next to china in the world. Enhanced and sustained production of rice is essential for food security in the country. Rice cultivation is a huge water-demanding enterprise. As the depletion of water table is a global phenomenon now-a-days, the rice growing countries are looking forward for alternative methods to reduce the water intake or requirement of rice crop which is mainly grown in submerged conditions. Challenges in maintaining the sustainability of rice farming have been increasing with the increased scarcity of water and competition for water resources, stagnant or declined yield levels with low grain quality, and increasing production costs due to high dependence on agri-inputs (Chapagain and Yamaji, 2010).

So, producing more rice with less resource input is a challenge for ensuring food, economic, social, and water security of the Asian region. The system of rice intensification (SRI) is one of the best alternatives to minimize the water consumption for the cultivation of rice and at the same time increasing the productivity.

System of rice intensification (SRI), a recently developed method in rice to increase its productivity was developed in Madagascar in the 1980’s, due to its less consumption of water, nearly 50% as compared to the other conventional methods. The cultivation under SRI is rapidly increasing. 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

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the adoption of intermittent irrigation, organic fertilization, and active soil aeration to the extent possible (Uphoff, 2007; Stoop et al., 2002). With this backdrop, an experiment was taken up to identify the correct age of the seedlings and spacing schedule for realizing good quality seed under SRI system of cultivation.

MATERIALS AND METHODS

The experiment was conducted during *kharif*, 2008 and 2009 at Seed Research and Technology Centre, Rajendranagar, Hyderabad using the most popular rice cultivar, Swarna (MTU 7029). Experiment was laid out in a split plot design with age of seedlings (12, 14, 16 and 28 days old seedlings) as main treatments and spacing schedule as sub treatments (30 × 30 cm, 25 × 25 cm and 20 × 20 cm). Therefore, there are twelve treatment combinations replicated thrice for the experimentation. The treatment combinations are 12 days / 30 × 30 cm, 12 days / 25 × 25 cm, 12 days/ 20 × 20 cm, 14 days / 30 × 30 cm, 14 days / 25 × 25 cm, 14 days / 20 × 20 cm, 16 days / 30 × 30 cm, 16 days / 25 × 25 cm, 16 days / 20 × 20 cm, 28 days / 30 × 30 cm, 28 days / 25 × 25 cm and 28 days / 20 × 20 cm.

Integrated crop management practices are followed to raise a healthy crop. Observations were taken at regular intervals for yield and yield attributing characters and seed quality characters. Important parameters like plant height, number of tillers per hill, ear bearing tiller per hill, filled spikelets per plant, spikelet fertility, 100 grain weight and grain yield were recorded on five randomly selected plants from each replication for assessing treatment effects on crop growth and performance. The seeds obtained from all the treatments were tested for laboratory germination (paper towel method) as per the ISTA rules (1985). After final germination count, ten normal seedlings were selected at random in each replication for recording seedling length in centimeters (cm) and the same seedlings were oven dried at 80°C for 17 h and weighed (g) for recording seedling dry weight. Seedling vigour indices I and II were calculated by multiplying germination percent with seedling length and seedling dry weight, respectively (Abdul-Baki and Anderson, 1973).

RESULTS AND DISCUSSION

Pooled data over two years (Tables 1 and 2) revealed significant differences due to the age of seedlings, spacing schedule and interaction effects for yield, yield components and seed quality parameters. Data presented on plant height revealed non-significant differences among the age of seedling and spacing schedule. 12 days old seedlings produced more height of the plant (70.0 cm) followed by 16 days (69.8 cm) and 28 days aged seedlings (69.2 cm). Seedlings planted at a spacing of 20 × 20 cm (69.6 cm) resulted in more height followed by the seedlings planted at 30 × 30 cm (69.4 cm) and 25 × 25 cm (68.6 cm). Plant height at maturity was maximum for the 12 days aged seedlings planted at 30 × 30 cm spacing (71.5 cm) followed by 16 days aged seedlings planted at a spacing of 25 × 25 cm (70.7 cm), 16 days aged seedlings planted at 20 × 20 cm (70.6 cm) and 28 days seedlings planted at 30 × 30 cm (70.0 cm) and were significantly different from 14 days seedlings planted at 25 × 25 cm (66.7 cm).

Significant differences were observed in total number of tillers per hill which is due to age of seedlings and spacing schedule. 28 days old seedlings produced more tillers per hill (43.5) followed by 16 days (39.8) and 12 days aged seedlings (39.3) and are significantly different from the 14 days old seedlings. Seedlings planted at 30 × 30 cm produced more tillers (44.9) as compared to the seedlings planted at 25 × 25 cm (40.0) and 20 × 20 cm (35.4) and are significantly different from each other. 28 days old seedlings planted at wider spacing of 30 × 30 cm produced more productive tillers per hill (46.9) followed by 14 days with 30 × 30 cm spacing (45.8) and 28 days seedlings planted at 25 × 25 cm spacing (44.4). All these treatments are statistically on par with each other and with other treatments, that is, 12 / 30 × 30 cm (43.5), 16 / 30 × 30 cm (43.5) and 16 / 25 × 25 cm (41.8). Krishna and Biradir Patil (2009) substantiated that planting in square method with wider spacing of 40 × 40 cm 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 number with 12 days aged seedlings planted at 30 × 30 cm under SRI method

There was a significant difference in ear bearing tillers per hill observed due to the age of seedlings, spacing and their interaction effects. 28 days old seedlings produced more number of productive tillers/hill (29.3) as compared to the 12 days old seedlings (27.2) and 16 days old seedlings (26.6). However, these are significantly different from 14 days old seedlings (25.1). Krishna et al. (2008) reported highest number of tillers with twelve day old seedlings. Seedlings planted at 30 × 30 cm resulted in more number of productive tillers per hill (29.6) as compared to the seedlings planted at 25 × 25 cm (27.5) and are significantly different from the seedlings planted at 20 × 20 cm (24.1). Manhan and Siddique (1990) and Das et al. (1988) recorded significantly higher number of productive tillers with wider spacing of 40 × 40 cm as compared to the closer spacing. Similarly Reddy (2002) reported decline in tiller number with closer spacing. Older seedlings (28 days) planted at a wider spacing of 30 × 30 cm resulted in more number of ear bearing tillers per hill (31.7) followed by 28 days seedlings planted at 25 × 25 cm (30.3), 12 days seedlings planted at 30 × 30 cm spacing (29.8) and 14 days seedlings planted at 30 × 30 cm (29.7). The other treatments which are statistically on par with these treatments are 12 / 25 × 25 cm (28.1), 16 / 25 × 25 cm (27.8) and 16 / 30 × 30 cm (27.2).

Yield attributing characters *viz.,* filled spikelets per panicle, spikelet fertility and 100 grain weight directly contributed to higher grain yield. 16 days old seedlings resulted in more number of filled spikelets per panicle (106.7) followed by 28 days old seedlings (104.7) and are on par with the other two treatments. The seedlings planted at a wider spacing of 30 × 30 cm resulted in more number of filled spikelets per panicle (104.5)

Table 1. Mean data for various yield and yield attributing characters of rice variety, Swarna (MTU 7029) under SRI.

Treatment	Plant height at maturity (cm)	Total number of tillers hill^{-1}	Ear bearing tillers hill^{-1} (no)	Number of filled spikelets panicle^{-1}	Spikelet fertility (%)	Seed yield plot^{-1} (kg)	Seed yield (q/ha)	100 seed weight (g)
28 days	69.2	43.5	29.3	104.7	81.3	8.73	43.6	16.20
12 days	70.0	39.3	27.2	101.7	88.6	10.64	53.2	16.82
14 days	67.8	37.8	25.1	100.5	81.5	9.79	49.0	17.28
16 days	69.8	39.8	26.6	106.7	82.4	10.23	51.2	16.44
S.E.	1.89	3.1	2.7	7.245	1.92	0.53	2.64	0.08
C.D.	2.29	4.64	3.82	14.14	4.70	1.29	12.96	0.42
30 × 30 cm	69.4	44.9	29.6	104.5	86.5	9.47	47.3	16.58
25 × 25 cm	68.6	40.0	27.5	103.3	82.7	9.44	47.2	16.68
20 × 20 cm	69.6	35.4	24.1	102.4	82.5	10.63	53.2	16.80
S.E.	1.52	2.13	1.29	5.96	1.53	0.48	2.40	0.16
C.D.	1.85	4.52	3.27	11.77	3.23	0.65	3.25	0.05
28/30 × 30 cm	70.0	46.9	31.7	112.0	85.0	8.64	43.2	16.42
28/25 × 25 cm	67.9	44.4	30.3	106.0	82.3	8.66	43.3	16.50
28/20 × 20 cm	69.6	39.2	26.1	96.0	80.2	8.88	44.4	15.68
12/30 × 30 cm	71.5	43.5	29.8	101.0	93.5	10.25	51.2	16.51
12/25 × 25 cm	69.0	38.9	28.1	99.0	87.8	10.43	52.2	16.78
12/20 × 20 cm	69.4	35.7	23.7	105.0	84.7	11.25	56.2	17.18
14/30 × 30 cm	67.8	45.8	29.7	100.0	82.8	9.76	48.8	17.35
14/25 × 25 cm	66.7	34.8	23.8	103.0	80.7	8.93	44.6	16.96
14/20 × 20 cm	68.9	32.8	22.0	98.5	81.1	10.69	53.4	17.54
16/30 × 30 cm	68.1	43.5	27.2	105.0	83.3	9.23	46.1	16.04
16/25 × 25 cm	70.7	41.8	27.8	105.0	80.0	9.75	48.8	16.48
16/20 × 20 cm	70.6	34.1	24.9	110.0	84.0	11.73	58.6	16.81
G. Mean	69.2	41.4	28.1	102.2	83.9	5.68	49.2	16.69

	S.E	C.D	S.E	C.D	S.E	C.D	S.E	C.D	S.E	C.D	S.E	C.D	S.E	C.D	S.E	C.D
Sub at same level of main	3.0	3.68	4.26	4.73	3.08	2.31	10.94	20.93	3.05	6.47	0.65	0.65	3.28	3.25	0.32	0.69
Main at same or different level of sub	3.09	3.69	5.01	6.82	4.28	5.44	12.13	22.23	3.24	7.26	0.80	3.95	4.01	7.89	0.28	0.62

followed by seedlings planted at 25 × 25 cm spacing (103.3) and 20 × 20 cm spacing (102.4). Non significant differences were noticed among the interaction effects and 28 days old seedlings planted at a wider spacing of 30 × 30 cm recorded highest number of filled spikelets per panicle (112). Percent spikelet fertility was highest with wider spacing of 30 × 30 cm when planted at 12 days (93.5) and is statistically on par with the 12 days aged seedlings planted at 25 × 25 cm (87.8). Further, seedlings planted at 30 × 30 cm recorded significantly higher number of total tillers (44.9) and productive tillers / hill (29.6) when compared to narrow spacing of 25 × 25 cm (40.0 and 27.5, respectively) and 20 × 20 cm (35.4 and 24.1, respectively).

With respect to grain yield per hectare, 12 days old seedlings resulted in maximum grain yield (53.2 q/ha) and is statistically on par with 16 days (51.2 q/ha), 14 days (49.0 q/ha) but significantly different from 28 days old seedlings (43.6 q/ha). Similarly, seedlings planted at narrow spacing of 20 × 20 cm significantly increased the grain yield (53.2 q/ha) of rice. Thus, the seedlings planted at 20 × 20 cm spacing recorded maximum yield compared to planting at 30 × 30 cm (47.3 q/ha) and is significantly different from each other and with the seedlings planted at 25 × 25 cm (47.2 q/ha). 16 days seedlings planted at 20 × 20 cm recorded highest grain yield of 58.6 q/ha followed by 12 days / 20 × 20 cm (56.2 q/ha) and 14 days / 20 × 20 cm (53.4 q/ha) and 12 days / 25 × 25 cm (52.2 q/ha) and 12 days/ 30 × 30 cm (51.2 q/ha) and significantly different from the rest of the treatments. Biradir Patil (1999) attributed the reduction in grain yield with 20 and 30 days old seedlings to low productive tillers per plant.

Krishna and Biradir Patil (2009) attributed high grain yield ha^{-1} under 30 × 30 cm spacing to

Table 2. Seed quality characters of Swarna (MTU 7029) under SRI during kharif, 2008 and 2009.

Treatment		Germination %	Total seedling length (cm)	Seedling dry weight (g)	Seedling vigour Index I	Seedling vigour Index II
28 days		99.2	24.8	0.016	2461	1.644
12 days		99.8	25.0	0.015	2499	1.456
14 days		99.7	24.5	0.017	2442	1.656
16 days		99.5	24.8	0.017	2466	1.639
S.E.		0.41	1.07	0.002		
C.V.		0.62	6.56	16.62		
30 × 30 cm		99.4	25.2	0.017	2508	1.629
25 × 25 cm		99.3	24.7	0.017	2452	1.695
20 × 20 cm		100.0	24.4	0.015	2441	1.472
S.E.		0.36	0.83	0.002		
C.V.		0.63	5.92	14.64		
28/30 × 30 cm		98.6	25.8	0.016	2548	1.589
28/25 × 25 cm		99.3	24.5	0.018	2432	1.830
28/20 × 20 cm		99.8	24.1	0.015	2404	1.512
12/30 × 30 cm		99.6	24.6	0.017	2454	1.680
12/25 × 25 cm		99.9	25.3	0.013	2523	1.316
12/20 × 20 cm		100.0	25.2	0.014	2521	1.371
14/30 × 30 cm		99.7	25.4	0.016	2528	1.597
14/25 × 25 cm		99.3	24.5	0.019	2431	1.907
14/20 × 20 cm		100.0	23.7	0.015	2368	1.465
16/30 × 30 cm		99.8	25.1	0.017	2503	1.648
16/25 × 25 cm		98.6	24.6	0.018	2423	1.727
16/20 × 20 cm		100.0	24.7	0.015	2472	1.541
G. Mean		99.5	24.9	0.016	2475	1.599
Interaction	S.E	0.51	1.18	0.003		
	C.V.	0.60	5.90	21.60		

optimum levels of plant population coupled with better yield parameters. Similar finding were also reported by Cessay and Uphoff (2003) and Zhang et al. (2004). 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.

The data revealed no significant differences among the 12 treatments for seed germination due to age of seedlings, spacing schedule and their interactions. However, seed produced with 20 × 20 cm spacing showed percent germination with three different aged seedlings, that is, 12, 14 and 16 days aged seedlings. 28 days old seedlings planted at 30 × 30 cm spacing resulted in longer seedlings (25.8 cm) with high seedling vigour Index I (2548). Similarly, 14 days aged seedlings with 30 × 30 cm spacing also resulted in highly vigorous seedlings w.r.t seedling length (25.4 cm) and seedling vigour Index I (2528) was also significantly higher. On the other side, 14 days seedlings planted at 25 × 25 cm were found vigorous w.r.t seedling dry weight (0.019 g) and seedling vigour Index II (1.907) followed by 28 days seedlings planted at 25 × 25 cm (0.018 g of dry matter and 1.830 SVI II, respectively). Krishna and Biradir Patil (2009) reported non-significant differences for seed germination due to age of seedlings and spacing. And further reported high vigour Index I with 12 days old seedlings planted under wider spacing (40 × 40 cm).

Twelve, fourteen and sixteen days seedlings planted at 20 × 20 cm and 12 days seedlings planted at 25 × 25 cm and 30 × 30 cm recorded highest grain yield per hectare. Of all the five treatments, 12 days aged seedlings besides recording highest grain yield were also found superior for spikelet fertility and ear bearing tillers per hill. Though non significant differences for seed germination due to age of seedlings and spacing is reported, 12 days old seedlings planted at 25 × 25 cm recorded percent germination with longer seedlings and high seedling vigour Index I.

Thus, on the whole grain quality may be improved by providing wider spacing which in turn gives good aeration to the plants. This can be attributed to the inhibition of pathogen growth and development in the grain by exposure to sunlight. Krishna and Biradir Patil (2009) and Manonmani and Jacquilin (1995) attributed better grain quality under wider spacing to higher test weight values.

Conflict of Interest

The authors have not declared any conflict of interest.

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