EFFECT OF PLANTING GEOMETRY AND SEEDLING DENSITY ON GROWTH AND YIELD OF SCENTED RICE UNDER SRI BASED CULTIVATION PRACTICES

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Abstract: The experiment was carried out at Research Cum Instructional Farm of the Indira Gandhi Krishi Vishwavidalaya, Raipur (C.G.) during *kharif* season 2012. The treatment 25 cm X 25 cm with 2-3 seedlings (T_2) produced the significantly highest grain yield (38.20 q ha^{-1}) and straw yield (77.91 q ha^{-1}). However, few treatments were found at par, but on the basis of economics the same treatment was produced the highest net return (Rs. 59,426 ha^{-1}) and B:C ratio (2.4). The lowest net return (Rs. 41,894 ha^{-1}) B:C ratio (1.7) and maximum cost of cultivation (Rs. 25,305 ha^{-1}) were found with 20 cm x 10 cm + S_{2-3} (T_{14}).

Keywords: Growth, Scented rice, SRI Based, Spacing

INTRODUCTION

Rice is a vital food material for more than half the world's population. Among cereals rice is more nutritious and about 40% of world population consumes it as a major source of calorie (Banik, 1999). Rice is the most important cereal food crop of the world providing major source of the food energy for more than half of the human population. More than 90 per cent of the world's rice is produced and consumed in Asia where it is an integral part of culture and tradition. In world the total production of rice is 463.3 million tonnes (milled basis) in 2011–12 (Anonymous, 2012a). India is second largest producer after china and has an area of over 42.2 million hectares and production of 104.32 million tonnes with productivity of 2372 kg ha^{-1}. Rice production in India has shown a steady upward trend during the period 2005–06 to 2008–09 reaching a record level of 99.18 million tonnes in 2008–09. Production declined to 89.09 million tonnes in 2009–10 due to a severe drought gripping in most parts of the country but rebounded to 96 million tonnes in 2010–11 and further with a record production of 104.32 million tonnes in 2011–12 (Anonymous, 2012b). Rice occupies a pivotal place in Indian agriculture and it contributes to 15 per cent of annual GDP and provides 43 per cent calorie requirement for more than 70 per cent of Indians. It is accounts for about 42 per cent of total food grain production and 55 per cent of cereal production in the country.

In India, supply of fine and fine scented rice is very less; therefore its market is comparatively high. Most of the fine scented traditional varieties are tall, low productive, low input responsive, long duration and susceptible towards the insect, pest and diseases. Due to this, farmers are unable to make their cultivation a profitable enterprise in this region. It is therefore important to achieve high yield with good quality from scented rice varieties through proper agronomic manipulation. The crop plants growing depends largely on temperature, root volume, moisture and soil fertility for their growth and nutritional requirements. An unsuitable population crop may have limitation in the maximum availability of these factors. It is, therefore necessary to determine the optimum density of plant population per unit area for obtaining maximum yield. Wider spacing had linearly increasing effect on the performance of individual plants. The plants grown with wider spacing had more solar radiation to absorb for better photosynthetic process and hence performed better as individual (Baloch *et al*., 2002).

The optimum seedlings per hill ensure the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation, water and nutrients (Miah *et al.*, 2004). When the planting densities exceed the optimum level, competition among plants becomes severe and consequently the plant growth slows and the grain yield decreases. As the tiller production in scented rice is very low and most of them are low yielding. So, it is essential to determine suitable spacing and number of seedlings for scented rice varieties to maximize their yield. So, it is necessary to improve its cultural practices like optimum sources and doses of nutrients, seedlings per hill and optimum spacing.

MATERIAL AND METHOD

The experiment was carried out at Research Cum Instructional Farm, I.G.K.V., Raipur (C.G.) during *Kharif* 2012. The soil of experiment field was '*Inceptisols*' (sandy loam) which is locally known as '*Matasi*'. The soil was neutral in reaction and medium in fertility having low N, medium P, high K Climate of this region is sub- humid with an average annual rainfall of about 1200-1400 mm and the crop received 1315.9 mm of the total rainfall during its crop growth. The weekly average maximum and minimum temperature varied in between 25.8^{0}C – 31.9^{0}C and 12.75^{0}C – 25.8^{0}C, respectively. The experiment was laid out in randomized block design (RBD) with three replication, fourteen treatments and one variety '*Dubraj'* and the treatments *viz.* 25 cm x 25 cm + S_1 (T_1), 25 cm x 25 cm + S_{2-3} (T_2), 25 cm x 25 cm +S_{4-5} (T_3), 25 cm x 20 cm + S_1 (T_4), 25 cm x 20 cm + S_{2-3} (T_5), 25 cm x 20 cm + S_{4-5} (T_6), 25 cm x 15 cm + S_1 (T_7), 25 cm x15 cm + S $_{2-3}$(T_8), 25 cm x 15 cm + S_{4-5} (T_9), 25 cm x 10 cm + S_1 (T_{10}), 25 cm x 10 cm + S $_{2-3}$ (T_{11}), 25 cm x 10 cm + S_{4-5} (T_{12}), 20 cm x 20 cm + S_2 (T_{13}), 20 cm x 10 cm + S_{2-3} (T_{14}).

Transplanting of one, two, three and four seedlings hill^{-1} here used for S_1, S_2, S_{2-3} and S_{4-5} for respective treatment. Crop was transplanted on 23. 07. 2012 and harvested on 02.12.2012. Recommended dose of nutrient was 60 kg N + 40 kg P_2O_5 + 30 kg K_2O ha^{-1}. The fertilizers were applied as per the treatments. Entire quantity of phosphorus and FYM was applied before transplanting. Nitrogen, Phosphorus and potassium applied through urea, single super phosphate and muriate of potash respectively. Nitrogen was applied in 3 splits (basal, tillering and panicle initiation stage @ 50:25:25%). Among the quality characteristics aroma is considered as most important quality parameter to high quality rice. Aroma developed by both genetic factor and environment. The major aromatic compound responsible for aroma is considered is 2-acetyl-1-pyrroline (Buttery *et al*. 1983). The plants of outer row and the extreme ends of the middle rows were excluded to avoid border effect. Five hills were randomly selected from each treatment for recording observations on plant height, total tillers/hill, dry matter accumulation, root volume, root dry weight, panicle length and weight, filled grains panicle^{-1}and 1000-grain weight. Grain yield, straw yield, and harvest index were recorded at harvest. The straws were sun dried and the yield of grain and straw/plot were converted to q ha^{-1}. Collected data were analyzed statistically following ANOVA technique and the mean differences were adjudged by Duncan's multiple Range lest (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

Effect on Growth of scented rice

Data for plant height, No. of tillers and dry matter accumulation were presented in Table 1. The plant height was progressively increased with advancement of the age of crop. Among the treatments the treatment 25 cm x 25 cm + S $_{2-3}$ (T_2) produced significantly highest plant height which was found to be at par with the treatments 25 cm x 25 cm +S_1 (T_1) , 25 cm x 25 cm + S_{4-5} (T_3), 25 cm x 20 cm + S_1 (T_4), 25 cm x 20 cm + S_{2-3} (T_5), 25 cm x 20 cm + S_{4-5} (T_6), 25 cm x 15 cm +S_1 (T_7) and 25 cm x 15 cm +S_{2-3} (T_8). Kumar *et al.* (2011) and Singh *et al*. (2012) also found similar results. It is due to Younger seedling, optimum seedling density, seedling age and wider spacing helped to attain higher plant height due to fact that early transplanting preserves potential for crop growth and wider spacing provides efficient use of nutrients with less competition. Treatment 25 cm x 25 cm + S $_{2-3}$ (T_2) produced maximum no. of tillers hill^{-1} and the treatments 25 cm x 25 cm +S_1 (T_1), 25 cm x 25 cm + S_{4-5} (T_3), 25 cm x 20 cm + S_1 (T_4), 25 cm x 20 cm + S $_{2-3}$ (T_5), 25 cm x15 cm +S_1 (T_7), 25 cm x 15 cm +S $_{2-3}$ (T_8) and 25 cm x 15 cm + S_{4-5} (T_9) were found to be at par with the same treatment. The lowest number of tillers was observed in treatment 20 cm x 10 cm + S_{2-3} (T_{14}) *i.e.* farmers practice of scented rice. These findings are in accordance with Balsubramanian *et al.* (2005). Younger seedlings (10-12 days old) with wider spacing also helped to attain higher number of tillers due to fact that early transplanting preserves potential for tillering and wider spacing provides efficient use of nutrients with less competition. The results are also in consonance with the findings of Singh and Singh (2005). Dry matter accumulation is directly related to the growth pattern of the crop, which linearly influences the biological yield. Dry matter accumulation increased with the advancement of crop age. Treatment 25 cm x 25 cm + S_{2-3} (T_2) recorded significantly higher dry matter accumulation and it was accumulated more over all the treatments except treatment 25 cm x 25 cm + S_1 (T_1) which was statistically similar with the highest dry matter produced treatment 25 cm x 25 cm + S $_{2-3}$ (T_2). This result is in accordance with Sridevi, V. and Chellamuthu (2007). The higher value of dry matter accumulation might be due to higher availability and translocation of nutrients during growth and development stages. It depends upon the photosynthesis and respiration rate which finally increase the plant growth with respect to plant height, tillers etc. Irrespective of planting methods and crop geometry, plant dry biomass was significantly higher under two seedlings hill^{-1}. Similar result was also found by Verma (2009).

Effect on root volume and dry weight

Data recorded for root volume (ml) and root dry weight (g) at 30 and 60 DAT presented in Fig. 1 and Fig. 2. The significantly highest root volume and dry weight was observed in 25 cm x 25 cm + S $_{2-3}$ (T_2) treatment, however root volume at 60 DAT, treatment 25 cm x 25 cm + S_1 (T_1), 25 cm x 25 cm + S_{4-5} (T_3) and 25 cm x 20 cm + S_{4-5} (T_6) were found at par with 25 cm x 25 cm + S $_{2-3}$ (T_2). In case of root dry weight (g) 25 cm x 25 cm + S_1 (T_1) and 25 cm x 20 cm + S_{2-3} (T_5) were at par with 25 cm x 25 cm + S $_{2-3}$ (T_2). The significantly lowest value was observed with treatment 20 cm x 10 cm + S_{2-3} (T_{14}) in case of root volume and root dry weight, except root dry weight at 60 DAT. Vertical and horizontal distribution decides the size of the root system. It might to be due to younger seedlings, it sustained least injury to the roots because they quickly established after transplanting, wider spacing and use of mechanical weeding enhance the root system, the root growth and its activity. Similar finding's observed by Sridhara *et al*. (2011). It might be due to increased plant height, ultimately plant get sufficient space to grow and increased light interception in the canopy leads to increase root : shoot ratio.

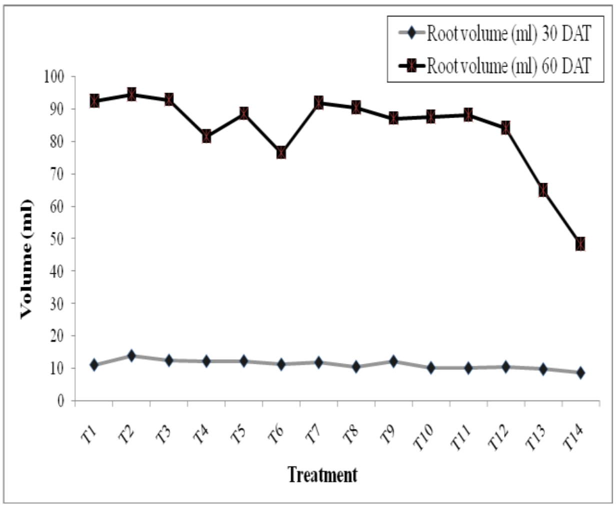

Fig. 1: Root volume at different growth stages of scented rice as influenced by planting geometry and seedling density under SRI based cultivation practices

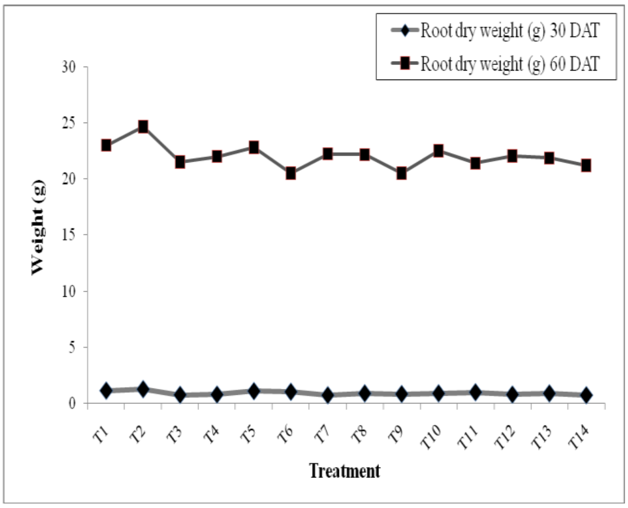

Fig. 2: Root dry weight at different growth stages of scented rice as influenced by planting geometry and seedling density under SRI based cultivation practices

Effects on yield attributes and yield of scented rice

The treatment 25 cm x 25 cm + $S_{2\text{-}3}$(T_2) produced significantly higher number of effective tillers m^{-2}, which was found to be superior with all other treatments. Panicle length and weight are one of the important yields attributing character, which influenced the yield directly. Data pertaining to length and weight of panicle are presented in Table 1. It revealed that length and weight of panicle varied significant due to different treatments. The highest panicle length and weight was recorded under the treatment 25 cm x 25 cm + $S_{2\text{-}3}$ (T_2) which was found to be at par in case of panicle lenth with the treatments 25 cm x 25 cm + S_1 (T_1), 25 cm x 25 cm + $S_{4\text{-}5}$ (T_3), 25 cm x 20 cm +S_1 (T_4), 25 cm x 20 cm + $S_{2\text{-}3}$ (T_5), 25 cm x 15 cm + S_1 (T_7), 25 cm x 15 cm + $S_{2\text{-}3}$ (T_8) ,25 cm x 10 cm + $S_{2\text{-}3}$ (T_{11}) and 20 cm x 20 cm + $S_{2\text{-}3}$ (2S) (T_{13}). However in case of panicle weight treatments 25 cm x 25 cm + S_1 (T_1), 25 cm x 20 cm +S_1 (T_4), 25 cm x 20 cm + $S_{2\text{-}3}$ (T_5), 25 cm x 20 cm + $S_{4\text{-}5}$(T_6), 25 cm x 15 cm + S_1 (T_7) and 20 cm x 20 cm + $S_{2\text{-}3}$ (2S) (T_{13}) were found to be at par with the same treatment 25 cm x 25 cm + $S_{2\text{-}3}$(T_2). The number of filled grains $panicle^{-1}$ and test weight of sound grains are another important yield attributing characters, which directly affecting the grain yield of crop. Number of filled grains $panicle^{-1}$ and test weight were significantly influenced due to different treatments (Table 1). The highest no. of filled grains and test weight was recorded significant under the treatment 25 cm x 25 cm + $S_{2\text{-}3}$ (T_2). Whereas it is found to be at par with treatment 25 cm x 25 cm + S_1 (T_1), 25 cm x 25 cm + $S_{4\text{-}5}$ (T_3), 25 cm x 20 cm +S_1 (T_4), 25 cm x 20 cm + $S_{2\text{-}3}$ (T_5) and 25 cm x 15 cm + S_1 (T_7) in case of filled grains $panicle^{-1}$. However in case of test weight, treatment 25 cm x 25 cm + S_1 (T_1) was found to be at par with the same treatment i.e. 25 cm x 25 cm + $S_{2\text{-}3}$ (T_2). The increased plant spacing considerably resulted in vigorous plant growth and caused a significant increase in test weight. The results are in accordance with Luikhm (2008). The panicle length and number of grains per panicle were obtained higher with the wider spacing compared to narrow spacings. Ramaswamy and Babu (1997) also found reduction in yield contributing characters under increased plant density.

The grain yield and straw yield ha^{-1} was significantly higher with 12 days old seedlings (Table 1). The per cent increase in the grain yield and straw yield by 12 days old seedlings was 21.56 per cent over 25 days old seedlings. The reduction in grain yield and straw yield with 25 days old seedlings was attributed to the lower productive tillers m^{-2} was reported by Biradarpatil (1999) in rice. Significantly higher grain yield and straw yield ha^{-1} was noticed with a spacing of 25 x 25 cm compared to other spacing's. The optimum level of plant population coupled with better yield parameters might have resulted in higher grain and straw yield ha^{-1} under treatment 25 x 25 cm spacing. These findings are in conformity with findings of Ceesay and Uphoff (2003) and Zhang et al. (2004). The grain, straw yield and harvest index were significantly influenced due to different treatments. From the data presented in Table 1, treatment 25 cm x 25 cm + $S_{2\text{-}3}$ (T_2) produced the significantly highest grain yield (38.20 q ha^{-1}) and straw yield (77.91 q ha^{-1}), which was statistically similar with the treatments 25 cm x 25 cm + S_1 (T_1), 25 cm x 20 cm + S_1 (T_4), 25 cm x 20 cm + S $_{2-3}$ (T_5), 25 cm x 15 cm + S_1 (T_7) and 20 cm x 20 cm + S $_{2-3}$ (2S) (T_{13}) in case of grain yield. Whereas in case of straw yield it was found to be at par with the treatment 25 cm x 25 cm + S_1 (T_1). However, lowest grain yield and straw yield produced in the treatment 20 cm x 10 cm + S_{2-3} (T_{14}).

Effect on economic of scented rice

The treatment 25 cm x 25 cm + S_{2-3} (T_2) produced the highest net return (Rs.59,426 ha^{-1}) and B: C ratio (2.4) followed by 25 cm x 25 cm + S_1 (T_1) (Table 1). The lowest net return (Rs.41,896 ha^{-1}), B:C ratios (1.7) and maximum cost of cultivation (Rs. 25,305 ha^{-1}) were found with the treatment 20 cm x 10 cm + S_{2-3} (T_{14}). Karki (2009) found that net return and B: C ratio were significantly different in 15 days of seedlings and 25 cm x 25 cm crop geometry and found more profitable.

Table 1: Growth, yield attributing characters and yield of scented rice as influenced by planting geometry and seedling density under SRI based cultivation practices

Treatment	Plant height (cm)	No. of tillers (hill^{-1})	Effective tillers (m^{-2})	Dry matter accumulation (g hill^{-1})	Panicle length (cm)	Panicle weight (g)	Filled grains panicle^{-1}	Sterility (%)	Test weight (g)	Grain Yield (q ha^{-1})	Straw yield (q ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net Return (Rs ha^{-1})	B:C Ratio
T_1: 25x25cm^2+S_1	128.74	15.27	187.02	99.20	24.75	5.29	221.13	5.93	18.17	36.91	75.04	24645	56679	2.3
T_2: 25x25cm^2+S_{2-3}	129.64	15.70	196.19	102.65	24.85	5.69	223.87	6.10	18.57	38.20	77.91	24765	59426	2.4
T_3: 25x25cm^2+S_{4-5}	124.72	14.83	164.92	93.55	23.76	4.39	206.33	5.69	17.22	34.35	71.97	24945	50952	2.0
T_4: 25x20cm^2+S_1	123.90	14.27	166.68	91.01	24.15	4.58	213.20	5.63	17.52	35.98	65.56	24645	53871	2.2
T_5: 25x20cm^2+S_{2-3}	126.34	14.87	174.87	96.14	24.83	5.43	197.13	5.80	17.7	36.84	72.33	24765	56148	2.3
T_6 : 25x20cm^2+S_{4-5}	122.59	12.62	144.85	86.63	22.83	4.45	188.60	6.62	17.6	33.10	65.23	24945	47778	1.9
T_7 : 25x15cm^2+S_1	121.31	13.10	170.84	88.06	23.59	5.02	194.33	7.09	17.57	36.40	66.40	24645	54795	2.2
T_8 : 25x15cm^2+S_{2-3}	125.95	13.61	156.78	92.58	23.76	4.14	177.60	7.79	17.38	33.88	62.96	24765	49291	2.0
T_9 : 25x15cm^2+S_{4-5}	120.66	12.63	148.39	82.97	22.95	3.83	176.93	7.12	17.54	33.51	60.36	24945	48111	1.9
T_{10} :25x10cm^2+S_1	118.88	11.07	160.81	74.71	23.45	4.33	170.93	5.88	17.69	34.25	64.95	24645	50350	2.0
T_{11} :25x10cm^2+S_{2-3}	119.38	12.11	136.47	80.51	23.65	4.11	166.87	6.65	17.00	32.89	59.81	24765	46996	1.9
T_{12}: 25x10cm^2+S_{4-5}	114.84	9.99	132.82	69.35	23.10	4.10	164.20	7.91	17.27	32.58	57.42	24945	45957	1.8
T_{13}:20x20cm^2+S_2 (2S)	119.20	11.07	165.45	78.61	24.06	4.73	183.60	6.01	17.64	35.59	64.68	24765	52883	2.1
T_{14}: 20x10cm^2+S_{2-3}	115.59	8.60	145.09	63.96	22.87	3.84	146.80	5.74	16.69	30.79	56.21	25305	41896	1.7
SEm ±	2.89	1.05	2.03	2.21	0.47	0.38	10.39	0.59	0.23	1.28	2.18	-	-	-
CD(P=0.05)	8.42	3.07	5.90	6.43	1.38	1.28	30.22	NS	0.68	3.74	3.09	-	-	-

*S – seedlings

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