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COMPARATIVE PERFORMANCE OF SIX AROMATIC RICE (*Oryza sativa*) VARIETIES UNDER CONVENTIONAL AND SRI METHOD OF CULTIVATION

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ABSTRACT

A field experiment was carried out at BCKVV, West Bengal (India) during *kharif* 2011 and 2012 to assess the performance of 6 rice varieties under conventional and SRI methods of cultivation with respect to growth, yield and quality parameters. The results revealed that the method of crop production significantly affected plant height and root length, whereas varieties exerted significant impact on dry matter accumulation, LAI, root length and root dry weight. The SRI method produced 58.6 and 21.8% higher grain and straw yields, respectively, than conventional system. The rice quality was unaffected by change in cultivation method. Rice variety 'Dehrdun' gave better response with respect to kernel length and L:B ratio than other varieties under SRI method.. The physico-chemical properties of soil after harvest was appreciable improved. Among the different varieties 'Badsha bhog' gave higher gross return, net return and B: C ratio under SRI method.

Key words: Aromatic rice, SRI, organic cultivation, quality, yield

INTRODUCTION

The global consumers presently show inclination towards health cautiousness with respect to their day-to-day diet. Food crops grown using organic input involving less or no chemicals are preferred over conventionally produced foods by the end users. Organic foods have a good market in developed and developing countries. The application of organic manure not only improves soil organic carbon for sustaining the soil physical quality but also increases soil nitrogen (Shukla and Tyagi, 2009). The total organic matter content in soil is a key attribute of soil quality since it profoundly influences physical, chemical and biological properties of a soil. However, the changes in the contents of organic carbon and total nitrogen are relatively slow and are not indicated tangibly over the short period. Rice cultivation through ósystem of Rice Intensificationô (SRI) is considered a new technology which deviates from conventional method of cultivating irrigated paddy in many ways (Reddy *et al.,* 2005). Five kg seed ha^{-1} is sufficient in SRI as against 50-60 kg ha^{-1} in conventional method. SRI method is of interest owing to its potential to achieve higher yield at lower production cost along with a saving of 40% water (Rao *et al.*, 2005; Anonymous, 2009). Scented rice has played an important role in many regional economics and is the favourites of the elite of society. Most of the rice varieties are highly area-specific, hence each Indian state has its own special type of scented rice. In West Bengal the popular scented rice varieties Gobindabhog,

Badshabhog, Radhunipagal, Tulaipanji, Kalonunia, Kalojira, Radhatilak, Gopalbhog, Mohanbhog, Seetabhog, Tulsimanjari, etc. are popular for their medium yield potentiality and superior grain quality (Roy, 2013). The present study was aimed to compare the performance of different aromatic rice varieties under conventional and SRI methods of cultivation.

MATERIALS AND METHODS

A field experiment was carried out during *kharif* seasons of 2011 and 2012 at Model Organic Farm, BCKV, Mohanpur West Bengal [22.93°N latitude, 88.53°E longitude and 9.75 m amsl, sub-humid to tropical climatic condition]. The experimental soil was *Entisol* having clay loam texture with 57.7% sand, 21.9% silt, 17.5% clay, 0.6% organic carbon and 148.4, 16.1 and 155.0 kg ha^{-1} available N, P and K, respectively. The experiment was laid out in a split plot design with two cropping practices (SRI and conventional) in main plot and six rice varieties (Gobindabhog, Kalonunia, Badsabhog, Jhugal, Kerala Sundari and Dehradun) in sub-plots. Each treatment was replicated three times. The seedlings were raised in nursery beds with a seed rate of 6 kg ha^{-1} for SRI and 50 kg ha^{-1} for conventional method. In SRI method, 10 day old seedlings were transplanted in main field with one seedling $hill^{-1}$ while one month old seedlings were transplanted in conventional method of cultivation. Rice was transplanted in 3rd week of July with a plant spacing of 25 cm x 25 cm in SRI and 20 cm x 15 cm in conventional method. Both the crop establishment methods received uniform fertilization i.e. 50 kg N, 30 kg P_2O_5 and 30 kg K_2O ha^{-1} as basal dose, except that 50% N was applied as basal doze in the form of mustard cake, farm yard manure (FYM) and rest N was top dressed as vermicompost or liquid manure spray (thrice at monthly interval). All other agronomic management practices followed were as per the package of practices recommended for the area.

Liquid manure was prepared by mixing 1 kg fresh cow dung and 1 L cow urine with 20 L water in a drum. Molasses and chickpea flour, 200 g each, were also added to hasten decomposition process (Harshavardhan *et al.,* 2014). The mouth of drum was covered and kept in open for 20 days. The water in drum was stirred every morning by a stick. After 20 days period (there was no bad odour, and the colour of the liquid changed to light tea liquor), the concentrated liquid was diluted 5 times. The diluted liquid was then sprayed on the foliage of plant. The NPK content in vermicompost was 1.5, 0.5 and 1.2%, respectively, and in farm yard manure 0.39, 0.10 and 0.32%, respectively. The NPK content in mustard cake was 5.0, 1.5 and 1.0%, respectively, and in liquid manure 1.0, 0.5 and 1.0%, respectively. The crop was harvested when 80% panicles with 80% grains in each panicle were mature. Grains and straws yields of each plot were assessed separately. The observations on plant height, root length, root dry weight $hill^{-1}$, number of tiller m^{-2}, panicle length, number of filled grain $panicle^{-1}$, number of unfilled grains $panicle^{-1}$,and dry matter accumulation (DMA) were recorded immediately after harvest. However, 1000 grain weight, grain yield and straw yield were also recorded. Leaf area index and harvest index were estimated as per the methods of Watson (1947) and Donald and Humblin (1976), respectively. Also, bulk soil samples were collected from five points across the each plot with the help of a spiral augur, at depth of 0-15 cm to determine various soil physic-chemical properties. The soil fertility was assessed in terms of available N as per modified macro-Kjeldahlôs method, available P as per Olsenôs method (Jackson, 1973), available K by flame photometric method and EC and pH by Beckmanôs method. The economics of cultivation was calculated on the basis of prevailing market prices.

The data was analyzed as per the analysis of variance (Cochran and Cox, 1963). The significance of different sources of variation was tested by ñerror mean square methodò of Fisher Snedecorôs ôFô test at probability level 0.05. The standard error of means and critical difference were estimated to compare the differences between the means.

RESULTS AND DISCUSSION

SRI method resulted in better plant growth and vigour as revealed by better height, leaf area index, dry matter accumulation, root length and root dry weight hill^{-1} showing 9.7, 4.6, 10.9, 1.6 and 22.1% increase, respectively, over conventional method (Table 1 and 2). Thakur *et al.* (2010) reported that SRI practices through optimum spacing minimize competition among rice plants for various growth factors. SRI method significantly improved plant height and root length. SRI and varieties resulted in significant improvement in plant height, LAI, root length and root dry weight (Table 1). Planting younger seedlings with SRI in their 2nd or 3rd phyllochron stage did not disturb rapid tillering and rooting which begins at the 4th phyllochron stage (Berkelar, 2001). Rice seedlings planted at younger stage under SRI might have recovered fast due to less transplantation shock and absorbed nutrients and water at faster rate to support its growth, and hence gave higher dry matter. Similarly, higher shoot dry matter production with planting of younger seedlings than with older seedlings has been reported by Berkelar (2001), Barison (2002) and Sarath and Thilak (2004). Planting younger seedlings at wider spacing might have resulted in more robust roots having more penetration so harnessing more nutrients and water and resulting in increased number of tillers, shoot and root dry matter.

SRI method gave higher number of tillers, longer panicles and more field grains panicle^{-1} and 1000 grain weight in various rice varieties than in conventional method (Table 2). Shrirame *et al.* (2000) reported that the number of functional leaves, leaf area and total number of tillers hill^{-1} were higher at wider spacing with increased photosynthetic rate leading to higher plant height. Similarly, higher effective tillers hill^{-1} by planting younger seedlings has been reported by Sarath and Thilak (2004). No much variation in panicle length was noticed with change in method of cultivation among different varieties. The number of filled grains panicle^{-1} and 1000-grain weight were significantly influenced by the methods of crop production but different varieties showed significant effects on all the yield attributes. Interaction between the methods of cultivation and rice varieties was significant for yield attributing characters under organic nutrient management.

Higher grain yield was observed by planting younger seedlings with control over water (SRI) than by planting older seedlings under submergence (conventional). The grain and straw yield of rice were significantly influenced by the conventional method (Table 3). Significantly higher grain and straw yield was obtained from SRI method. The SRI method produced 58.6 and 29.2% higher

Table 1: Effect of method of crop production and varieties on growth parameters of rice (pooled data of two years)

Varieties	Plant height at harvest (cm)			Dry matter accumul--ation at harvest (g m^{-2})			Leaf area index at 60 DAT			Root length at harvest (cm)			Root dry weight at harvest (g hill^{-1})		
	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean
Gobindabhog	134.1	109.9	122.0	543.8	561.9	552.9	2.46	2.44	2.45	13.05	12.45	12.75	3.83	1.73	2.78
Kalonunia	131.5	107.8	119.6	500.0	652.7	576.4	2.58	3.06	2.82	13.15	12.90	13.03	2.14	1.02	1.58
Badsabhog	119.0	110.6	114.8	692.1	592.2	642.1	4.48	3.08	3.78	12.18	14.15	13.17	1.52	2.30	1.91
Jhugal	119.9	117.6	118.7	556.8	513.1	535.0	3.81	3.27	3.54	12.04	10.92	11.48	1.61	1.60	1.61
Kerala sundari	138.2	119.4	128.8	870.9	620.2	745.5	2.60	2.31	2.45	11.71	12.60	12.15	2.45	2.15	2.30
Dehradun	119.2	129.1	124.1	382.5	450.2	416.3	1.69	1.75	1.72	14.54	12.42	13.48	2.02	1.79	1.90
Mean	127.0	115.7	-	591.0	565.0	-	2.94	2.65	-	12.78	12.57	-	2.26	1.76	-
	SEm±	$CD_{0.05}$		SEm±	$CD_{0.05}$		SEm±	$CD_{0.05}$		SEm±	$CD_{0.05}$		SEm±	$CD_{0.05}$	
Method (M)	0.62	3.77		33.13	ns		0.25	Ns		0.49	2.96		0.12	ns	
Variety (V)	3.69	11.34		60.28	177.8		0.33	0.98		0.48	1.41		0.37	1.10	
M x V	5.23	15.39		85.25	ns		0.47	1.39		0.68	1.99		0.53	1.55	

ns = Non-significant, SRI = System of rice intensification method, CT = Convention method

Table 2: Effect of method of crop production and varieties on yield attributes of rice (Pooled data of two years)

Varieties	No. of tiller m^{-2}			Panicle length (cm)			No. of filled grains $panicle^{-1}$			No. of unfilled grains $panicle^{-1}$			1000-grain weight (g)		
	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean
Gobindabhog	180.3	172.2	176.2	26.8	23.0	24.9	204.2	167.7	186.0	34.6	20.4	27.5	14.50	13.95	14.23
Kalonunia	198.3	175.3	186.8	26.0	22.9	24.4	209.0	166.5	187.8	35.2	31.2	33.2	10.57	16.07	13.32
Badsabhog	216.0	190.6	203.3	23.5	24.1	23.8	216.0	126.6	171.3	29.5	54.5	42.0	18.41	15.50	16.95
Jhugal	211.7	157.0	184.3	24.7	28.0	26.3	164.4	218.0	191.2	37.3	44.7	41.0	17.08	14.85	15.96
Kerala sundari	169.0	196.7	182.8	24.6	25.3	24.9	98.8	147.8	123.3	36.3	33.5	34.9	19.34	15.14	17.24
Dehradun	188.3	167.2	178.0	23.9	26.1	25.0	220.2	138.0	179.1	21.1	60.1	40.6	15.65	14.59	15.12
Mean	193.9	176.6	-	24.9	24.9	-	185.4	160.8	-	32.4	40.7	-	15.93	15.02	-
	SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$	
Method (M)	5.50	ns		0.32	ns		2.30	14.01		4.08	ns		0.10	0.62	
Variety (V)	9.66	28.51		0.72	2.13		13.70	40.42		4.78	14.09		1.14	3.35	
M x V	13.67	40.32		1.02	3.02		19.38	57.16		6.76	19.93		1.61	ns	

ns = Non-significant, CT = Convention, V = Variety, M = Method of cultivation

grain and straw yield, respectively, over conventional method. Rice variety ôBadsabhogô produced significantly higher number of filled grains $panicle^{-1}$ than other varieties. Straw yield followed similar trend. Many researchers have reported increased grain and straw yield by planting younger seedlings than older seedlings (Randriamiharisoa, 2002, Randriamiharisoa and Uphoff, 2002, Sarath and Thilak, 2004, Singh *et al*., 2013).

Rice quality parameters i.e. kernel length, kernel breadth and L:B ratio before cooking of rice were not affected by the cultivation method (Table 4). The highest kernel length, L:B ratio before cooking of rice was in ôDehradunô variety. Similar trend was observed in kernel length, kernel breadth and L:B ratio after cooking of rice, but both the parameters improved after cooking of rice. Similar observations have been reported by Quyen *et al.* (2003). Singh and Singh (1987) opined that length-wise expansion upon cooking without increase in girth is a desirable trait in high quality rice.

The residual soil fertility in SRI system was better with respect to pH, EC, organic carbon and available N, P and K contents over conventional method, but the difference was insignificant, except for soil EC (Table 5). Alternate wetting and drying appears to have improved the soil aeration and thus enhanced root activity to take up more nutrients under SRI. Increase in growth

Table 3: Effect of method of crop production and varieties on grain yield, straw yield, harvest index of rice (pooled data of two years)

Varieties	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})			Harvest index (%)		
	SRI	CT	Mean	SRI	CT	Mean	SRI	CT l	Mean
Gobindabhog	3.41	2.5	2.96	10.54	7.81	9.18	24.44	24.25	24.35
Kalonunia	3.38	2.06	2.72	8.75	6.59	7.67	27.86	23.82	25.84
Badsabhog	4.85	2.34	3.60	11.61	7.73	9.67	29.47	23.24	26.36
Jhugal	3.11	2.29	2.70	8.05	5.75	6.90	27.87	28.48	28.18
Kerala sundari	3.74	2.34	3.04	7.08	5.39	6.24	34.57	30.27	32.42
Dehradun	4.22	2.81	3.52	8.85	5.63	7.24	32.29	33.29	32.79
Mean	3.79	2.39	-	9.15	6.48	-	29.42	27.22	-
	SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$	
Method (M)	0.54	ns		0.44	2.67		1.56	ns	
Variety (V)	0.72	2.13		0.70	2.05		2.65	7.81	
M x V	1.02	3.02		0.98	2.90		3.74	11.05	

ns = Non-significant, CT = Convention, V = Variety, M = Method of cultivation

Table 4: Effect of method of crop production and varieties on quality parameters of rice (Pooled data of two years)

Variety	KLBC (mm)		KBBC (mm)		LBBC		KLAC (mm)		KBAC (mm)		LBAC	
	SRI	CT	SRI	CT	SRI	CT	SRI	CT	SRI	CT	SRI	CT
Gobindabhog	4.60	4.55	2.12	2.09	2.15	2.24	6.17	6.11	2.53	2.47	2.45	2.48
Kalonunia	5.16	5.09	1.82	1.79	2.83	2.59	6.50	6.47	2.11	2.07	3.08	3.13
Badsabhog	3.96	3.92	2.18	2.16	1.84	2.08	5.50	5.48	2.71	2.67	2.03	2.05
Jhugal	6.60	6.63	2.68	2.65	2.55	2.65	8.23	8.15	2.98	2.95	2.75	2.76
Kerala sundari	5.59	5.56	2.78	2.75	2.45	2.39	7.18	7.10	3.28	3.25	2.19	2.22
Dehradun	7.10	7.05	1.85	1.82	3.48	3.42	10.7	10.69	2.62	2.60	4.11	4.24
Mean	5.50	5.47	2.24	2.21	2.55	2.56	7.38	7.33	2.71	2.67	2.77	2.81
	SE±	$CD_{0.05}$	SE±	$CD_{0.05}$)	SE±	$CD_{0.05}$	SE±	$CD_{0.05}$	SE±	$CD_{0.05}$	SE±	$CD_{0.05}$
Method (M)	0.06	ns	0.01	ns	0.03	ns	0.01	ns	0.02	ns	0.01	ns
Variety (V)	0.08	0.25	0.07	0.22	0.22	0.66	0.04	0.10	0.06	0.16	0.04	0.12
M x V	0.12	ns	0.10	ns	0.32	ns	0.05	ns	0.08	ns	0.05	0.16

ns = Non-significant, CT = Convention, V = Variety, M = Method of cultivation;
KLBC = Kernel length before cooking, KBBC = Kernel breadth before cooking, LBBC = L/B ratio before cooking, KLAC = Kernel length after cooking, KBAC = Kernel breadth after cooking, LBAC = L/B ratio after cooking.

and yield attributes might be due to higher availability of biological N, P and K (Meena and Shivay, 2010). SRI appears to have provided more favourable soil conditions for plant growth, whereas higher N loss might have occurred under conventional method through denitrification and leaching. Milka *et al.* (2000) revealed that N losses from nearly saturated soil were 14% lower than from the flooded soil. Uphoff and Randriamiharisoa (2002) observed that SRI provides soil conditions conducive for mycorhizal fungal and microbiota growth, which enhances the nutrient uptake in rice.

Table 5: Effect of method of crop production and rice varieties on residual soil fertility (Pooled data of two years)

Varieties	pH			EC (dS m^{-1})			Organic carbon (%)			Available N (kg ha^{-1})			Available P (kg ha^{-1})			Available K (kg ha^{-1})		
	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean
Gobindabhog	7.4	7.2	7.3	0.29	0.28	0.28	0.68	0.66	0.67	155	185	170	14.5	15.5	15.0	143	180	161
Kalonunia	7.3	7.1	7.2	0.26	0.25	0.25	0.62	0.57	0.60	153	157	155	13.2	13.1	13.1	162	195	178
Badsabhog	7.3	7.4	7.3	0.30	0.32	0.31	0.64	0.68	0.66	195	156	176	19.5	18.6	19.1	178	199	189
Jhugal	7.4	7.3	7.3	0.23	0.29	0.26	0.65	0.64	0.64	193	172	182	25.2	16.9	21.1	206	122	164
Keralasundari	7.0	7.2	7.1	0.29	0.27	0.28	0.59	0.54	0.57	153	163	158	22.2	19.4	20.8	196	119	157
Dehradun	7.4	7.3	7.4	0.30	0.27	0.28	0.83	0.66	0.75	179	151	165	26.9	21.8	24.3	255	219	237
Mean	7.3	7.3	-	0.28	0.28	-	0.67	0.62	-	171	164	-	20.3	17.5	-	196	166	-
	SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$		SE±	$CD_{0.05}$	
Method (M)	0.05	ns		0.01	0.02		0.01	ns		5.5	ns		0.33	ns		5.1	Ns	
Variety (V)	0.07	ns		0.01	0.03		0.03	0.09		10.5	ns		0.89	2.63		7.8	22.9	
M x V	0.10	ns		0.01	0.04		0.04	0.12		14.9	ns		1.26	3.71		11.0	32.4	

ns = Non-significant, CT = Convention, V = Variety, M = Method of cultivation

Different cultivation method, varieties and their interaction exerted significant impact on gross and net return as well as on benefit: cost ratio, and the values were higher in SRI method than conventional method with maximum in variety ôBadshabhogô (Table 6). The cost of cultivation ha^{-1} was higher in conventional method than SRI method, while the net return realized was much higher in SRI (₹ 85,666) than in conventional method (₹ 40,200). This was mainly due to higher gross return (₹ 1,21,433) in SRI method, and this may be due to higher paddy yield. The results are in agreement with Basvaraja *et al.* (2008). The returns per rupee spent in conventional method were (₹1.00) against (₹ 2.40) in SRI method. The differences in the use of most of the inputs between

Table 6: Effect of method of crop production and varieties on economics of rice (pooled data)

Varieties	Gross return (₹/ha)			Net return (₹/ha)			B: C ratio		
	SRI	CT	Mean	SRI	CT	Mean	SRI	CT	Mean
Gobindabhog	120900	89050	104975	85133	49033	67083	2.38	1.23	1.82
Kalonunia	111350	74150	92750	75583	34133	54858	2.11	0.85	1.48
Badsabhog	155050	85450	120250	119283	45433	82358	3.34	1.14	2.24
Jhugal	102450	74550	88500	66683	34533	50608	1.86	0.86	1.36
Kerala sundari	110200	73750	91975	74433	33733	54083	2.08	0.84	1.44
Dehradun	128650	84350	106500	92883	44333	68608	2.60	1.11	1.86
Mean	121433	80216	-	85666	40200	-	2.40	1.00	-

CT = Convention, V = Variety, M = Method of cultivation

two methods were evident. Conventional method demands more input like FYM and labour. On the other hand SRI required less seed and fertilizers. Hence, it can be concluded that SRI method of crop production with ôBadshabhogô variety under organic nutrient management under Bengal conditions may have potential benefit in respect of grain yield, net return and soil health.

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