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Genetic yield potential of rice (*Oryza sativa*) through water saving and high-yielding SRI technology*

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The system of rice intensification (SRI) that evolved in the 1980s in Madagascar is also gaining popularity in India. SRI saves not only the seed (a seed rate of 5–7 kg/ha as against 25–30 kg/ha for normal) but also saves water (35–40%) as the fields are not inundated continuously. It leads to higher ripening ratio and increases yield by 10–25%. The varietal response to SRI and conventional cultivation is wide. Varieties differed in their genetic potential and all the varieties are not promising for SRI cultivation. There is need to develop/ identify varieties that give better response to SRI cultivation. Therefore, the present investigation on comparative evaluation of rice genotypes for yield and its components under SRI and conventional system was undertaken to identify suitable cultivars for SRI.

The experimental materials consisted of 20 genotypes (released varieties and elite lines), including aromatic and hybrids. These were evaluated in two methods, viz SRI and conventional during rainy (*kharif*) season 2009 at CCSHAU, rice research station, Kaul situated at 29^0 51' N, 76^0 39' E and 230.87 m above msl in sub-tropical region of North India. The SRI method consisted of reduced seed rate of 5 kg/ha, young seedling (15-day old) transplanted with one seedling/hill in wide spacing of 25 + 25 cm and irrigation at five days interval up to 45 days after transplanting (DAT). In SRI the required dose of chemical fertilizers was supplemented with farmyard manure (as organic source) @ 15 tonnes/ha applied 30 days before transplanting. Conventional method comprised seed rate of 25 kg/ha, 25 days old seedlings transplanted with 2 seedlings/hill in narrow spacing of 15 + 15 cm and irrigation at 3 days interval up to 45 DAT with all the required nutrients (150 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha) supplied through inorganic fertilizers. After 54 DAT the irrigations were applied at 3 days interval in both the methods. Accordingly, the SRI and conventional method received 24 and 30 irrigations, respectively during the crop season (up to 90 DAT). Nursery of all genotypes was sown on 31 May for conventional cultivation and on 10 June for SRI while seedlings of both practices were transplanted on 26 June 2009. The experiment was laid out in a randomized complete block design (RBD) with two replications. Different combinations of spacing and seedling number per hill of each method were created termed as micro-environments (Luthera *et al.* 1974) (Table 1) to evaluate genotypes. Plot size was 1 m^2/genotype/replication. Observations were recorded on days to 50% flowering and days to 75% maturity from the whole plot, while observations on grain yield/plant and biological yield/plant were recorded from five randomly selected plants in each plot. The data were analyzed statistically using the method suggested by Panse and Sukhatme (1967) and pooled G × E interaction analysis was done following Eberhart and Russell (1966) model.

The analysis of variance revealed significant mean squares due to genotypes for all the characters studied indicating that genotypes differed among themselves and there existed considerable variability. Pooled analysis revealed

Table 1 Description of environments

Production system	Environment designation	Spacing (cm^2)	Number of seedling/ hill	Age of the seedling (days)
SRI	E1	25 × 25	1	15
SRI	E2	25 × 25	2	15
SRI	E3	15 × 15	1	15
SRI	E4	15 × 15	2	15
Normal	E5	25 × 25	1	25
Normal	E6	25 × 25	2	25
Normal	E7	15 × 15	1	25
Normal	E8	15 × 15	2	25

*Short note

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significant differences among environments and interaction of genotypes with environments. Trait-wise, genotypes responded differently for days to 50% flowering and 75% maturity in each planting method. Within SRI environments almost all genotypes had taken equal number of days to flower and same was the case within conventional planting environments and hence the data were averaged over the environments . This indicated that neither spacing nor seedling number/hill but the age of seedling was the key factor influencing flowering behaviour of genotypes. The genotypes flowered 1.5–14.5 days earlier in SRI than conventional method (Table 2). This could be attributed to transplanting of younger seedlings in SRI, which might have established quickly in the field and started growing at a faster rate. These findings are in conformity to those of Raju *et al*. (1989), Biradarpartil (1999) and Krishna *et al.* (2008). Govind was the earliest to flower in 76 days, followed by HKRH-1094 while Punjab Bas 2 and Pusa Basmati 1 were the last to flower taking maximum number of days (107–109 days) in SRI. However, genotypes took more days to mature in SRI than conventional system. In general, all genotypes matured late in SRI than in normal. Maximum lateness was shown by Haryana Basmati 1 (9.8 days), followed by HKR 46 (9.3 days). This may probably be due to greater tillering capacity of plants in SRI resulting in prolonged high synthesis of photosynthates and their translocation from source to sink. This was in contrast to what Uprety (2005) and Ganesh *et al.* (2006) who found that SRI methods shorten the growing cycle of rice by 1–3 weeks and six days, respectively. Govind was earliest to mature, followed by HKRH 1094 while Taraori basmati was the latest in both the production environments (Table 2).

A majority of genotypes (16) resulted in higher biological yield in conventional production system than SRI. The results were in conformity to those of Sheehy *et al*. (2003) who reported that SRI has no inherent advantage over conventional system and the response among the cultivars varied in SRI method indicating all cultivars were not suitable for SRI. Accordingly, four genotypes namely HKR 46, IR 64, HKRH 1094 and Pusa 1121 gave higher (5.29 to 10.70%) biological yield/plant in SRI (Table 3). The probable reason could be that SRI capitalizes on existing genetic potentials within the rice genome that have been suppressed by sub-optimizing management practices. Hence, transplanting normal seedlings

Table 2 Mean performance of rice genotypes for days to 50% flowering and days to 75% maturity in SRI and normal production system

Traits	Days to 50% flowering			Days to 75% maturity		
Environment/ Genotype	SRI**	Conventional*	Deviation	SRI**	Conventional*	Deviation
HKR 47	104.2	106.2	–2.0	129.3	123	–6.3
HKR 126	102.7	104.2	–1.5	129.5	124	–5.5
HKR 127	105.2	108.7	–3.5	130.3	124.1	–6.2
PR 114	107.2	110	–2.8	131.5	125.0	–6.5
HKR 120	107.1	112.5	–5.4	131.7	124.5	–7.2
IR 64	99.8	99	0.8	128.3	123.7	–4.6
Govind	76.1	85.1	–9.0	116.2	114.5	–1.7
HKR 48	92.2	97.3	–5.1	126.5	123.5	–3.0
HKR 46	94.62	98.5	–3.8	132	122.7	–9.3
PAU 201	103.3	101.7	1.6	130.5	124.5	–6.0
Pusa 1121	105.6	111.3	–5.7	131.2	126.2	–5.0
Pusa Bas 1	107.6	113	–5.4	131.1	126.6	–4.5
CSR 30	104.8	119.3	–14.5	135	129.3	–5.7
Haryana Bas 1	106.1	103.8	2.3	133.3	123.5	–9.8
Basmati 370	107.3	112.6	–5.3	133.5	127.3	–6.7
Punjab Bas 2	107.7	113.6	–5.9	134	128.8	–5.2
Taraori Bas	105.5	118.2	–12.7	135.6	128.7	–6.9
HKRH 1094	79.12	86.62	–7.5	117.2	116.2	–1.0
HSD 1	103.5	101.2	2.3	131.1	123.7	–7.4
HSD 2	106.2	106.87	–0.67	132.3	125.1	–7.2
Mean	103.45		127.31			
C.D (5%)	4.35		4.49			
CV	2.15		1.79			

Table 3 Mean performance of genotypes over different environments for biological yield/plant (g)

Genotypes	SRI method					Normal transplanting method					Per cent change
	E1 Mean	E2 Mean	E 3 Mean	E 4 Mean	Mean	E 5 Mean	E 6 Mean	E7 Mean	E 8 Mean	Mean	
HKR 47	73.920	58.700	33.430	27.500	48.38	76.700	74.300	33.700	37.200	55.47	–12.78
HKR 126	93.350	72.340	41.400	28.700	58.94	96.400	87.500	48.250	34.950	66.77	–11.73
HKR 127	60.630	72.900	46.700	32.920	53.28	77.300	92.300	58.500	29.300	64.35	–17.20
PR 114	64.000	68.620	39.250	33.880	51.43	94.100	84.600	36.800	36.300	62.95	–18.30
HKR 120	68.300	68.950	36.550	44.480	54.57	78.200	96.400	42.500	37.100	63.55	–14.13
IR 64	70.800	80.050	32.120	40.480	55.86	72.000	67.800	38.300	26.700	51.2	9.10
Govind	43.150	30.390	18.400	25.370	29.32	38.250	28.100	27.420	27.350	30.28	–3.17
HKR 48	68.680	44.100	31.300	42.800	46.72	68.500	64.700	30.480	31.700	48.84	–4.34
HKR 46	72.700	54.050	37.950	24.400	47.27	63.000	57.300	24.000	26.500	42.7	10.70
PAU 201	70.500	58.740	30.750	28.440	47.10	98.400	69.200	45.800	31.900	61.32	–23.19
Pusa 1121	67.500	78.250	33.950	46.500	56.55	53.000	77.850	45.900	38.100	53.71	5.29
Pusa Bas 1	60.400	45.900	29.650	35.400	42.83	65.800	88.700	37.400	32.400	56.07	–23.61
CSR 30	71.400	73.740	35.050	29.650	52.46	90.350	76.600	44.000	41.250	63.05	–16.80
Haryana Bas 1	53.600	57.150	43.700	40.280	48.68	78.000	64.600	31.200	27.700	50.37	–3.36
Basmati 370	61.780	65.790	43.700	45.100	54.09	93.400	86.600	53.200	36.600	67.45	–19.81
Punjab Bas 2	53.100	75.680	40.750	37.280	51.70	111.40	75.950	54.400	36.200	69.48	–25.59
Taraori Bas	85.600	72.820	45.700	32.000	59.03	108.70	84.550	42.900	46.500	70.66	–16.46
HKRH 1094	46.900	49.100	29.335	32.120	39.36	40.850	55.100	23.940	28.950	37.21	5.78
HSD 1	81.650	75.400	37.930	43.300	59.57	108.90	73.850	41.400	33.400	64.38	–7.47
HSD 2	84.400	84.720	52.250	45.650	66.75	113.85	93.600	39.300	41.000	71.93	–7.20
Mean	67.61	64.36	36.99	35.81	51.19	81.35	74.98	39.96	34.05	57.58	
CD	3.761	4.923	6.493	8.442		7.353	12.581	6.355	6.731		12.23*
CV	2.638	3.627	8.324	11.180		4.287	7.958	7.541	9.374		11.47*

*Pooled CV and CD values at 5% level of significance

singly or double in wide spacing was found to be the best. Uphoff (2009) reported that results with SRI practices differed from place to place, between seasons, and across varieties.

When averaged over the environments majority of genotypes (15) gave higher grain yield/plant in conventional production system than SRI. Only five genotypes, viz IR 64 (24.31%) HKRH 1094 (15.21%), Pusa 1121 (12.54%), HKR 46 (11.78%) and CSR 30 (2.34%) yielded higher in SRI over conventional (Table 4). This indicated that response among the cultivars varied due to planting method and all cultivars were not suitable for SRI. In general, wide spacing, irrespective of method of planting and seedling number/hill yielded almost two times than narrow spacing in both the production systems. Therefore, conventional production system of transplanting two seedlings per hill with spacing 25 cm × 25 cm ranked better for realization of higher grain yield/plant. Sheehy *et al*. (2003) reported that SRI has no inherent advantage over conventional system and the response among the cultivars varied in SRI method.

Results with SRI practices differed from place to place, between seasons, and across varieties (Uphoff 2009). Ganesh et al. (2006) showed 25% higher grain yield when SRI was adopted for seed production purpose. Singh (2007) reported an average 50% increase in yield with 40–50% less requirement for water in experiments conducted over three years in SRI environments. Mishra *et. al*. (2009) observed 16.6% higher grain yield in SRI over normal transplanting.

SUMMARY

In this investigation 20 rice genotypes were evaluated for yield and other traits under SRI and conventional system to identify suitable cultivars for SRI. In general, genotypes flowered earlier but matured late in SRI than conventional method. A majority of the genotypes attained more biological yield and grain yield/plant in conventional over SRI method. However, four genotypes namely; IR 64 (24.31%) HKRH 1094 (15.21%), Pusa 1121 (12.54%), and HKR 46 (11.78%) yielded higher in SRI over conventional. IR 64 is a widely adapted cultivar grown over a number of countries including India, whereas HKR 46 has been released for and cultivated in Haryana state. Pusa Basmati 1121 was released for commercial cultivation in 2003 for Haryana state but it's occupying about 60% of the total basmati area in northern India and contributed foreign exchange to the tune of INR

Table 4 Mean performance of genotypes over different environments for grain yield/plant (g)

Genotype	SRI method					Normal transplanting method					% change
	E1 Mean	E2 Mean	E 3 Mean	E 4 Mean	Mean	E 5 Mean	E 6 Mean	E7 Mean	E 8 Mean	Mean	
HKR 47	33.700	30.500	12.000	10.800	21.75	37.200	35.100	15.200	15.200	25.67	–15.27
HKR 126	43.000	36.200	17.700	10.400	26.82	54.700	43.600	23.900	14.800	34.25	–21.69
HKR 127	21.330	35.800	18.200	12.700	22.01	30.600	42.600	34.000	12.300	29.87	–26.31
PR 114	33.500	29.500	14.100	12.900	22.5	44.000	39.600	16.200	14.700	28.62	–21.38
HKR 120	26.200	29.850	14.900	11.100	20.51	31.800	37.200	13.500	13.700	24.05	–14.72
IR 64	44.900	40.500	12.800	19.000	29.3	35.000	30.200	17.100	12.000	23.57	24.31
Govind	19.800	14.700	6.600	9.400	12.62	16.300	16.300	12.300	14.050	14.73	–14.32
HKR 48	33.000	15.600	14.200	23.500	21.57	33.200	32.200	15.800	13.400	23.65	–8.79
HKR 46	37.600	27.600	17.650	11.300	23.53	33.300	30.800	9.600	10.500	21.05	11.78
PAU 201	38.500	30.300	13.550	12.400	23.68	56.800	38.200	24.300	15.900	33.8	–29.94
Pusa 1121	26.900	29.800	11.550	14.800	20.76	18.200	26.600	14.900	12.400	18.02	15.21
Pusa Bas 1	22.100	18.600	9.600	11.700	15.5	22.000	31.700	14.900	13.100	20.42	–24.09
CSR 30	19.900	26.300	10.550	8.000	16.18	26.350	17.500	11.000	8.400	15.81	2.34
Haryana Bas 1	26.100	17.100	14.800	13.700	17.92	29.400	25.600	11.700	8.200	18.72	–4.27
Basmati 370	17.800	19.800	11.800	9.900	14.82	28.400	26.500	17.500	12.200	21.15	–29.93
Punjab Bas 2	14.700	20.200	10.000	8.500	13.35	38.000	23.200	18.400	10.200	22.45	–40.53
Taraori Bas	18.400	13.600	9.700	7.300	12.25	29.300	18.000	7.500	9.500	16.07	–23.77
HKRH 1094	23.200	21.700	12.000	16.700	18.4	16.000	24.400	9.900	15.100	16.35	12.54
HSD 1	35.900	34.900	15.500	17.200	25.87	49.100	42.600	19.700	15.300	31.67	–18.31
HSD 2	38.000	38.300	21.800	18.550	29.16	59.100	43.600	16.600	18.600	34.47	–15.40
Mean	28.72	26.54	13.45	12.99	20.42	34.43	31.27	16.2	12.97	23.71	–13.87
CD	4.929	4.770	6.457	4.664		6.075	5.843	3.782	5.247		6.16*
CV	8.137	8.523	22.769	17.025		8.366	8.860	11.073	19.175		14.31*

*Pooled CV and CD values at 5% level of significance

5000/crores annually (www.icar.org.in 2009). These genotypes identified superior for grain and biological yield could be tested over macro-environments of space and time and recommended for cultivation in SRI production system.

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