



Nutrient management of rice (*Oryza sativa*) under system of rice intensification (SRI)

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Received: 31 March 2011; Revised accepted: 25 February 2013

ABSTRACT

Field studies were conducted at Agricultural Research Station, Gangavathi, during 2006 and 2007 to study the response of rice genotypes to different organics and NPK levels under system of rice intensification (SRI) and traditional transplanting. The findings revealed that growing rice under SRI with 100% NPK recorded significantly higher mean grain yield of 76.56 q/ha than traditional transplanting with a grain yield of 64.76 q/ha, resulting in an yield increase of 15 percent. Growing rice under SRI with purely organics did not result in higher grain yield. Among the genotypes the hybrid KRH 2 proved superior to BPT 5204 and Early Sona. More number of panicles per unit area, more filled grains per panicle and higher grain weight per plant have contributed to increased grain yield in the case of SRI as compared to traditional transplanting.

Key words: Brown plant hopper, Net returns, System of Rice Intensification, Water use efficiency

System of rice intensification (SRI) is a new technique of rice culture. Adoption of SRI practices like planting of 8-12 days aged seedlings at wider spacing, using of organic manures and keeping the soil moist without standing water during vegetative growth have resulted in significant yield improvement (Norman Uphoff 2006). However, there are some constraints for adoption of SRI as per the presently recommended practices like use of organic manures. The release of nutrients from organic manures is not only slow but often organic manures are in scarce supply and doubts have been raised whether organic manures alone can sustain high yield levels on long term basis under SRI. Many studies have reported in which SRI is modified according to agro-ecological conditions prevailing in different regions. Jianguo Zheng *et al.* (2004) reported that by modifying SRI practices like use of three seedlings and inorganic fertilizers to improve tillering, high yields have been realized. With this background information the present experiment was conducted to study the performance of rice cultivars to purely organic manure as well as NPK fertilizers under SRI.

MATERIALS AND METHODS

Field experiment was conducted during the rainy season

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of 2006 and 2007 at the Agricultural Research Station, Gangavathi, Karnataka. The soil was medium deep black clay, neutral to alkaline in reaction (pH 8.1 to 8.4) and low in electrical conductivity (0.60 to 0.80 dS/m). The soil was low in alkaline $\text{KMnO}_4\text{-N}$ (210 kg/ha), medium in Olsen's-P (12.7 kg/ha) and high in NH_4OAc extractable K_2O (504 kg/ha) in the surface 0-20 cm depth. The treatments consisted of combinations of establishment methods and organics and NPK fertilizers, viz. M_1 : SRI with 100% organic, M_2 : SRI with 50% NPK, M_3 : SRI with 100% NPK and M_4 : Traditional transplanting with 100% NPK as main plot treatments and different cultivars of rice, viz. S_1 : Early Sona, S_2 : BPT 5204 and S_3 : KRH 2 hybrid as sub plot treatments were tried in split-plot design with three replications. Field was puddled and levelled. A day after passing of leveller, cylindrical marker was drawn on the field where in lines were formed in both the directions at a spacing of 25 cm \times 25 cm. At the intersection of two lines single seedling of twelve days old rice was planted. In the case of traditional transplanting 27 days old seedlings were planted at a spacing of 20 cm \times 10 cm with 2-3 seedlings per hill. Planting was taken up on 2 August and 3 August during 2006 and 2007 respectively in the case of SRI and on 17 August and 18 August during 2006 and 2007 in the case of traditional transplanting. Irrigation was scheduled at 5-6 days interval (through Parshall flumes) and the soil was kept only moist (saturation) during vegetative growth followed by 2.5 cm water there onwards in the case of SRI. While in the traditional transplanting 5 cm standing

Table 1 Grain yield and yield parameters, WUE and root growth of rice cultivars under SRI and traditional transplanting

Planting methods	Grain yield			Yield parameters					
	2006	2007	Mean	Panicles/ m ²	Grains/ panicle	Grain weight/hill (g)	Mean WUE (kg/ha mm)	Root volume (cc)	Root dry weight (g)
M1: SRI-Organics	30.90	24.98	28.00	251	97	15.6	2.52	74.7	8.2
M2: SRI-50%NPK	48.34	67.08	57.71	349	113	31.4	5.20	84.0	9.2
M3: SRI-100%NPK	64.82	88.30	76.56	436	133	42.0	6.90	114.7	11.7
M4: Traditional transplanting	59.20	70.33	64.76	396	116	22.6	3.71	29.4	3.2
CD (P=0.05)	3.74	5.07	3.07	15.0	20.2	2.41	0.28	10.8	1.58
<i>Cultivars</i>									
V1: BPT 5204	46.97	63.72	55.38	360	137	29.6	4.46	95.1	9.4
V2: Early Sona	52.54	52.91	52.73	388	97	18.5	4.27	52.7	6.7
V3: KRH 2	52.94	71.39	62.16	325	110	35.7	5.01	79.3	8.0
CD (P=0.05)	3.18	3.90	2.65	14.4	11.7	3.1	0.18	7.0	0.77
<i>Interaction</i>									
M1V1	33.27	26.23	29.91	244	118	19.1	2.70	90	8.8
M1V2	27.90	20.17	24.03	296	81	8.74	2.16	54	7.3
M1V3	31.53	28.55	30.04	212	92	19	2.71	80	8.5
M2V1	39.23	74.05	56.64	366	140	34.7	5.10	100	11.1
M2V2	50.33	53.45	51.89	387	99	19.9	4.68	62	8.0
M2V3	55.47	73.75	64.61	294	101	39.7	5.82	90	8.5
M3V1	59.13	82.37	70.75	447	149	44.8	6.37	150	13.2
M3V2	70.63	83.30	76.96	444	116	30.3	6.93	74	9.6
M3V3	64.70	99.22	81.95	415	133	51.1	7.38	120	12.2
M4V1	56.23	72.23	64.23	382	141	19.8	3.68	40.3	4.7
M4V2	61.31	54.73	58.02	426	92	14.9	3.33	21	2.1
M4V3	60.07	84.02	72.04	380	116	33.2	4.13	27	2.9
SEm	2.12	2.60	1.77	9.61	7.85	2.1	0.12	4.7	0.51
CD (P=0.05)	6.36	7.8	5.29	28.8	NS	6.2	0.35	14.1	NS

SRI, System of rice intensification; WUE, water use efficiency

water was maintained from 10 days after transplanting (DAT) up to 10 days before harvest. The organic manure (farmyard manure with 0.6% N on dry weight basis) was applied on equivalent N basis (recommended 150 kg N/ha). The crop was fertilized @ 150:33:61 kg, N, P and K/ha with 50% N and full P and K at the time of planting and the remaining N in two equal split doses at active tillering and panicle initiation stage. For controlling of weeds in SRI cono weeder was passed between lines at 10 and 20 days after planting (DAT)

Table 2 Water requirement of rice as influenced by SRI and traditional transplanting

Methods	Water requirements (mm)			% saving in water (Mean)
	2006	2007	Mean	
Traditional	1 840	1 650	1 745	
SRI	1 180	1 040	1 110	36.3

followed by two hand weeding at 30 and 40 DAT. In the case of traditional transplanting butachlor @ 1 500g/ha was applied 5 DAT followed by one hand weeding at 30 DAT. Observations on water supplied, root growth, grain yield parameters and pest infestation such as brown plant hopper were recorded, the water use efficiency (WUE) and the economics was worked out.

RESULTS AND DISCUSSION

Grain yield

Growing rice under SRI with 100% recommended NPK recorded significantly higher grain yield than traditional transplanting during both 2006 and 2007 and also in the mean data. The treatment recorded a mean grain yield of 76.56 q/ha as against 64.76 q/ha in the case of traditional transplanting representing 15% higher grain yield. The data indicated that though equal amounts of nutrients were supplied to both the methods, yet yield increase was higher in SRI

Table 3 BPH population as influenced by SRI and traditional transplanting

Variety	BPH population (No./10 hills)				Mean
	SRI-Organics	SRI-50% NPK	SRI-100% NPK	Traditional	
BPT 5204	114	108	111	1 664	499
Early Sona	104	103	99	480	196.5
KRH 2	95	98	110	556	215
Mean	104	103	107	900	

than in traditional transplanting indicating the beneficial effects of early aged seedlings, wider spacing and keeping the soil under saturation during vegetative growth stage, the practices that are associated with SRI. These practices might have created better growth environment for proper root development such as good aeration, optimum moisture and better availability of nutrients that helped rice plant to express its full yield potential. Similarly, growing rice under SRI with 100% NPK was also significantly superior than growing rice either purely with organics or with 50% NPK under SRI. This indicated that application of organic manures alone do not meet the full nutrient requirement of rice for higher yield under SRI and that by modifying the nutrient management such as external application of NPK fertilizers, higher yields can be achieved. Similar higher yields under SRI in comparison to conventional transplanting have been reported by Jianguo Zheng *et al.* (2004), Vijaykumar *et al.* (2004), Thiyagarajan (2006), Krishna *et al.* (2008) and Geethalakshmi *et al.* (2009).

Rice cultivars exhibited significant difference for grain yield. The hybrid KRH 2 recorded a mean grain yield of 62.16 q/ha which was superior to BPT 5204 (55.38 q/ha) and Early Sona (52.73 q/ha). Interaction effect was significant. The hybrid KRH 2 with 100% NPK under SRI recorded higher mean grain yield of 81.95 q/ha as compared to the performance of the same hybrid under traditional transplanting (72.04 q/ha) and over other combinations. This clearly indicated that hybrids perform better than cultivars under SRI.

Analysing the yield parameters that have contributed to higher grain yield in the case of SRI, the data clearly indicated that the mean number of panicles per unit area was significantly higher under SRI with 100% NPK (436) than traditional transplanting (396). This indicated that 12 days seedlings under SRI have retained higher potential for tillering than 30 days aged seedlings and thus contributed to more number of panicles and higher grain yield. Earlier Krishna *et al.* (2008) and Virakthmath (2008) have reported higher grain yield in SRI mainly due to more number of panicles per unit area. The data also revealed that SRI practices with organics alone had recorded lower number of panicles when compared with SRI practices with 100% NPK indicating that the amount of nutrients supplied with organics particularly the nitrogen was insufficient to promote tiller growth. Among the cultivars Early Sona recorded higher no. of panicles (388) than BPT 5204 (360) and KRH 2 (325). Among the treatment combinations Early Sona and BPT under SRI with 100%NPK recorded higher no. of panicles (444 and 447 respectively).

Similarly, SRI with 100% NPK recorded more number

Table 4 Economics of rice as influenced by SRI

Treatments	Gross returns (₹/ha)			Cost of cultivation (₹/ha)			Net returns (₹/ha)		
	2006	2007	Mean	2006	2007	Mean	2006	2007	Mean
M1V1	27 424	23 196	25 310	20 015	20 015	20 015	7 408	3 181	5 295
M1V2	17 470	15 732	16 601	20 015	20 015	20 015	-1 082	-4 283	-3 413
M1V3	19 745	21 975	20 860	20 015	20 015	20 015	4 094	1 960	845
M2V1	32 374	64 148	48 261	16 765	16 765	16 765	16 143	47 383	31 496
M2V2	31 480	40 785	36 133	16 765	16 765	16 765	14 568	24 020	19 368
M2V3	34 693	56 298	45 495	16 765	16 765	16 765	22 921	39 532	28 730
M3V1	48 769	71 335	60 052	18 515	18 515	18 515	28 566	52 820	41 537
M3V2	44 163	63 760	53 961	18 515	18 515	18 515	24 284	45 245	35 446
M3V3	40 448	75 850	58 148	18 515	18 515	18 515	24 355	57 335	39 634
M4V1	46 336	62 210	54 273	17 600	17 600	17 600	24 700	44 610	36 673
M4V2	38 336	41 957	40 147	17 600	17 600	17 600	21 779	24 358	22 547
M4V3	37 560	63 967	50 764	17 600	17 600	17 600	13 267	46 368	33 164

M1: SRI-Organics, M2:SRI-50%NPK, M3:SRI-100%NPK, M4:Traditional transplanting, V1: BPT 5204, V2: Early Sona, V3: KRH 2

Cost of grain : BPT 5204 : ₹ 825 and ₹ 900/q in 2006 and 2007 respectively

Early Sona and KRH 2: ₹ 725 and ₹ 800/q in 2006 and 2007 respectively

Cost of straw: ₹ 250/tonne

of filled grains per panicle (133/panicle) than other methods including traditional transplanting (116) indicating beneficial effect of SRI on grain number. Among the cultivars BPT 5204 recorded more number of filled grains (137) than Early Sona (97) and KRH 2 (110). Among the treatment combinations higher number of filled grains were observed with BPT 5204 under SRI with 100% NPK(149).

The grain weight per hill was also significantly higher in the case of SRI with 100% NPK(42 g/hill) than other methods including traditional transplanting (22.6 g/hill). Among the cultivars KRH 2 recorded higher grain weight per hill of 35.7 g/hill than Early Sona (18.5 g) and BPT 5204 (29.6 g) indicating that higher grain yield in KRH 2 was attributed more to the heavier panicles than number of panicles. Interaction effect was also significant. KRH 2 under SRI with 100% NPK recorded higher grain weight per hill (51.1g).

Vigorous and profused root growth is another factor that is commonly attributed to the success of SRI. In the present study it was observed that the root growth as measured through root volume was significantly higher under SRI with 100% NPK (114.7 cc) than traditional transplanting (29.4 cc). Among the cultivars BPT 5204 recorded higher root volume than others. Among the treatment combinations BPT 5204 under SRI with 100% NPK had higher root volume (150 cc). Similar trend was observed in root weight.

Water requirements and water use efficiency (WUE)

Growing rice under SRI method required a mean quantity of 1 110 mm/crop/season as against traditional transplanting which required 1 745 mm/crop/season resulting in saving of 36.3% in water. Similar savings in water requirements under SRI have been reported by Jiaguo Zheng *et al.* (2004) and Geethalakshmi *et al.* (2009).

The mean WUE was significantly higher in the case of SRI with 100% NPK (6.9 kg/ha mm) than traditional transplanting (3.71 kg/ha mm) which indicated higher grain productivity per unit of water used in SRI when compared to traditional transplanting. These findings are in agreement with Geetha Lakshmi *et al.* (2009). Among the cultivars KRH 2 recorded significantly higher WUE than other cultivars indicating differential response of rice cultivars for WUE. Among the treatment combinations KRH 2 with 100% NPK under SRI recorded significantly higher WUE of 7.38 kg/ha mm followed by Early Sona and BPT 5204 with similar treatment combinations than other combinations.

Pest incidence

Among the cultivars BPT 5204 recorded higher mean brown plant hopper (BPH) population of 499/10 hill than

Early Sona (196.5/10 hill) or KRH 2 (215/10 hill). Among different methods growing of rice under SRI recorded lower BPH population (104 to 107 /10 hill) than traditional method which recorded highest BPH population of 900/10 hill indicating effective control of pests like BPH in SRI method.

Economics

The mean gross returns were higher with BPT 5204 under SRI with 100% NPK (₹ 60 052/ha) followed by KRH 2 under SRI with 100%NPK (₹ 58 148/ha). The mean net returns were higher with BPT 5204 under SRI with 100% NPK (₹ 41 537/ha) followed by KRH 2 under SRI with 100% NPK (₹ 39 634/ha). Growing of rice under SRI with purely organics resulted in lower net returns or negative returns due to both lower grain yield and higher cost of farmyard manure.

The two year data thus indicated that by suitably modifying the SRI practices such as use of inorganic fertilizers for supplying nutrients, higher grain yield and monetary benefits can be realized over traditional transplanting. SRI recorded lower incidence of pests such as BPH and resulted in considerable savings in water used. SRI improved the rice productivity by improving the root growth, panicle density per unit area as well as the grain weight per plant.

REFERENCES

- Geetha Lakshmi, Lakshmanan, Udaya Sekhar and Nagothu. 2009. Sustaining rice production amidst changing climate: Choices of cultivation system for increasing water and grain productivity. CLIMARICE Technical brief 1 March 2009.
- Jiaguo Zheng, Xianjun Lu, Xinlu Jiang and Younglu Tang. 2004. The system of rice intensification (SRI) for super high yields of rice in Siachuan Basin. (in) *Proceedings of 4th International Crop Science Congress*, 26 September–1 October 2004, Brisbane, Australia.
- Krishna A, Biradarapatil N K and Channappagoudar B B. 2008. Influence of system of rice intensification (SRI) cultivation on seed yield and quality. *Karnataka journal of Agricultural Sciences* 21(3): 369–72.
- Norman Uphoff. 2006. The system of rice intensification and its implications for Agriculture. *LEISA* 22.4.December
- Thiyagarajan T M. 2006. Adopting SRI in Tamilnadu, India. *LEISA* 22.4-December.
- Vijayakumar M, Sundar Singh S D, Prabhakaran N K and Thiyagarajan T M. 2004. Effect of SRI practices on the yield attributes, yield and water productivity of rice (*Oryza sativa* L.). *Acta Agronomica Hungarica* 52(4): 399–408.
- Virakthmath B C. 2008. Research on system of rice intensification (SRI) in India and priorities for future.(in) *3rd National Symposium on SRI*, 1–3 December 2008, Coimbatore.