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Evaluation of Crop Establishment Methods for their Productivity, Nutrient Uptake and Use Efficiency under Rice-Rice System

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Abstract

A field experiment was conducted in *kharif* (wet) and *rabi* (dry) seasons of 2010-11 at the Indian Institute of Rice Research (formerly Directorate of Rice Research)- Ramachandrapuram farm on sandy clay loam soil to study the influence of different methods of crop establishment *viz*., System of Rice Intensification (SRI), Eco-SRI and conventional method on rice productivity, nutrients uptake, their use efficiency and soil nutrient status. Three cultivars each in *kharif* and *rabi* were tested. During *kharif*, grain yield was significantly higher in SRI than conventional method and Eco-SRI by 10.3 and 33.4 per cent, respectively. Whereas, SRI and conventional method were on par and superior to Eco-SRI in *rabi*. Among the cultivars, Swarna and DRRH 2 were significantly superior to other varieties in *kharif* and *rabi*, respectively. SRI and conventional method were on par and significantly superior to ECO-SRI with respect to N, P and K uptake in both the seasons. Though the nutrients uptake remained same, the nutrient use efficiency was marginally higher in SRI (by 8, 8 and 12 per cent for N, P and K, respectively during *kharif* and 5 per cent for N during *rabi*) compared to conventional rice. Soil analysis data indicated similar available nutrient status in SRI and conventional methods after two seasons of experimentation.

Key words: Crop establishment methods, conventional method, Eco-SRI, SRI, productivity, nutrient use efficiency

Introduction

Low land rice is being grown under flooded conditions for millennia and such situation may result in several drastic adaptations in the root system of rice such as formation of aerenchyma and subsequent degeneration of root system to the extent of 70 per cent by the time of flowering. Further, the hypoxic condition leads to a reduced soil condition that creates low availability of some nutrient ions and high availability of certain other nutrients. System of Rice Intensification (SRI), originated through participatory on farm experimentation conducted in Madagascar during 1980s by Fr. Henri de Laulanie represents an integrated and ecologically sound approach to irrigated rice cultivation and the productivity is higher in SRI compared to conventional rice farming. A well developed and healthy root system in SRI plays an important role in uptake and translocation of nutrients from the soil than conventional system (Uphoff, 2005) and this ultimately results in healthy plant growth, better tillering, higher biomass and higher yields. Increased yields in SRI compared to conventional method were reported by several authors (Thiyagarajan *et al*., 2005; Uphoff, 2005). Under conditions of modern, high yield rice culture, nutrient removal in double cropping areas is more and continuous cropping under high levels of N and high yield will sooner or later exhaust the phosphate and potash reserves of any soil (Von Uexkull, 1976). Though use of organics alone in SRI has been considered as an important component, non availability of organic manures in large quantities forced the farmers to follow Integrated Nutrient Management (INM). The information on yield, nutrient use efficiency and soil nutrient status under different crop establishment methods is very limited. Keeping this in view, three methods of crop establishment *viz*., SRI-organic (Eco-SRI), SRI-INM (SRI) and conventional method were evaluated for their productivity, nutrient uptake, use efficiency and soil nutrient status during 2006-07 in rice-rice system.

Materials and Methods

The field experiment was conducted in *kharif* (wet) and *rabi* (dry) seasons of 2006-07 at the Indian Institute of Rice Research (formerly Directorate of Rice Research)-Ramachandrapuram farm in ICRISAT campus in a sandy clay loam soil. Initial soil samples were collected from three depths and were analysed for important properties using standard procedures. The soil was alkaline [pH 8.50 - 9.45 in surface (0-15 cm) and sub surface (30-60 cm) depths, respectively]; non-saline (EC- 0.47-0.67 in surface and sub surface depths, respectively); with high organic carbon (0.76-1.27%) content. Available N was medium (291kg/ha); available P_2O was high (268 kg/ha) and available K_2O was high (527 kg/ha) in surface layer.

The experiment was laid out in a split-plot design with cultivars as main plots (BPT 5204, Swarna & DRRH 2 in *kharif;* MTU 1010, Shanti & DRRH 2 in *rabi*) and methods of crop establishment (ECO-SRI, SRI and Conventional method) as sub-plot treatments in four replications. In SRI and conventional methods, the recommended dose of N @ 100 kg/ha during *kharif* and 120 kg/ha during *rabi* was applied through 50% organics (FYM) + 50% inorganics (urea). P_2O_5 and K_2O @ 60 and 40 kg/ha were given through single super phosphate and muriate of potash, respectively, in both seasons. Whereas, in ECO-SRI method, total nutrients were supplied through organic source, FYM only. Twelve days old seedlings in Eco-SRI and SRI at a spacing of 25x25cm and 30 day old seedlings in conventional method at 20x15cm spacing were transplanted. Water management and other cultural practices were followed as per the principles of SRI in SRI and Eco-SRI and paddy straw was used as mulch in Eco-SRI. Grain and straw yields were recorded at harvest. Further, grain, and straw samples were collected at harvest and were analysed for N, P and K. Plant nutrient uptake was calculated and nutrient use efficiency was computed using grain yield and total nutrient uptake. Soil samples were collected at the end of two seasons and were analyzed for important soil parameters using standard procedures. All the data were analyzed using standard statistical methods (Gomez and Gomez, 1984).

Results and Discussion

Grain and straw yields

Grain yield data presented in Table 1 indicated the superiority of SRI (5.27 t/ha) over conventional method (4.78 t/ha) and Eco-SRI (3.95 t/ha) during *kharif* season by 10.3 and 33.4 per cent, respectively. Whereas, during *rabi*, SRI (3.34 t/ha) and conventional method (3.46 t/ha) were on par and both were significantly superior to Eco-SRI (1.66 t/ha). Among the varieties, grain yield differences were significant where Swarna (5.33 t/ha) during *kharif* and DRRH 2 (4.12 t/ha) during *rabi* were significantly superior to other varieties recording maximum grain yield. The expected higher yields in SRI could not be attained especially, during *rabi* due to sub-soil alkalinity and delayed planting. Plant growth on saline soils is mainly affected by high levels of soluble salts causing ion toxicity, ionic imbalance and impaired water balance and rice is very sensitive during early growth stage (Dobermann and Fairhurst, 2000). Sensitivity of rice to salinity at 1-2 leaf stage and again at flowering stage was also reported by Yoshida (1981). Transplanting at 2 leaf stage and damage caused to the root system due to salt accumulation in the root zone by the upward movement under non-flooded conditions could be the probable reasons for not attaining the potential yield in SRI especially during *rabi* season. The dilution effect due to the advantage of flooding in conventional rice might not have resulted in greater yield reduction. In the arid and semi arid regions, salt accumulation in the root zone of soils with high pH due to upward water movement was reported by Yoshida (1981). Eco-SRI with 100 per cent organics did not perform well because in the initial years of organic farming, yield reduction is expected due to slower release of nutrients and mismatch of nutrient release from organics and crop demand.

In case of straw yields, SRI and conventional method were on par and both systems were significantly superior to Eco-SRI in both seasons. Among the varieties, DRRH 2 recorded maximum straw yield in both seasons.

Nutrients uptake

The major nutrients (NPK) uptake data is presented in Table 2. Total nitrogen uptake ranged from 51.4-109.3 and 29.5-100.1 kg/ha during *kharif* and *rabi* seasons, respectively. In case of methods of cultivation, SRI (103.8 and 73.0 kg/ha in *kharif* and *rabi*) and conventional (100.6 and 82.9 kg/ha in *kharif* and *rabi*) methods were on par and significantly higher than Eco-SRI (72.7 and 42.0 kg/ha in *kharif* and *rabi*) in both the seasons. Among the varieties, Swarna (104.1 kg/ha) in *kharif* and DRRH 2 (82.6 kg/ha) in *rabi* recorded maximum N uptake. Total P uptake ranged from 11.4 – 17.3 and 6.8-18.0 kg/ha during *kharif* and *rabi,* respectively. SRI (15.2 and 12.2 kg/ha in *kharif* and *rabi*) and conventional (14.9 and 12.4 kg/ha in *kharif* and *rabi*) method were on par and superior to Eco-SRI (12.6 and 8.2 kg/ha in *kharif* and *rabi*) in both the seasons. Among the varieties, all varieties were on par during *kharif* (13.3-15.9 kg/ha) and DRRH 2 (15.0 kg/ha) recorded significantly higher P uptake than other varieties during *rabi*. With regard to K uptake, total K uptake ranged from 58.2-101.7 and 36.1-103.6 kg/ha during *kharif* and *rabi*, respectively. SRI and conventional method were on par (81.9-91.9 and 84.1-90.0 kg/ha in *kharif* and *rabi*) and recorded significantly higher K uptake over ECO-SRI (63.9 and 55.9 kg/ha in *kharif* and *rabi*). Varieties did not differ significantly (76.2-84.7 and 70.3-88.1 kg/ha in *kharif* and *rabi,* respectively) in total K uptake.

Nutrients use efficiency

Among the methods of cultivation, in *kharif*, SRI recorded maximum use efficiency in case of N, P and K with 52, 347 and 63 kg grain/kg NPK uptake, respectively (Figure

1) and it was marginally higher than conventional method (48, 320 and 56 kg grain/kg NPK uptake respectively). Whereas, during *rabi,* SRI recorded maximum nutrient use efficiency in case of N alone (44 kg grain/kg N uptake) than conventional method (41 kg grain/kg N uptake) and ECO-SRI (38 kg grain/kg N uptake). P and K use efficiencies were same in SRI and conventional methods but, both were higher than Eco-SRI. Thus, though there was no significant difference in nutrients uptake, the nutrient use efficiency was marginally higher in SRI compared to other systems when grain yield was on par in *rabi* (for N) or significantly higher in *kharif* (for N, P, K) than conventional rice. Similar results were reported by Barison (2002). Among the varieties, Swarna during *kharif* and DRRH2 during *rabi* were superior to other varieties in their nutrient use efficiency of all nutrients (Figure 2).

Soil properties after two crop seasons

Soil properties measured after two seasons of the study indicated no significant treatment differences in pH, EC, organic carbon and available N either due to methods of cultivation (Table 3) or due to different varieties. Available P_2O_5 was same in SRI and conventional method and these two systems were superior to Eco-SRI. Whereas, there was a significant increase in available K_2O in Eco-SRI compared to other two systems which could be attributed to the paddy straw mulching in case of Eco-SRI in both seasons. The increase in soil available K due to paddy straw application was also reported by Ponnamperuma (1984) and Dobermann *et al*. (1998). This indicated that SRI did not exhaust the soil available nutrients after two seasons of experimentation.

Conclusion

From the present study, it can be concluded that SRI resulted in higher yield during *kharif*, non-significant nutrient uptake and marginally higher nutrient use efficiency without depleting the soil available nutrients compared to conventional transplanting, at least up to two seasons. During *rabi*, the expected higher yields could not be achieved due to alkalinity problem. However, long term studies on nutrient uptake and available nutrient status under highly productive SRI in different soils are needed.

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Table 1. **Grain and straw yeilds (t/ha) as influenced by different methods of crop establishment**

	Grain yield (t/ha)							
	kharif				*rabi*			
Treatments	BPT 5204	Swarna	DRRH 2	Mean	MTU 1010	Shanti	DRRH 2	Mean
Eco-SRI	3.38	4.83	3.63	3.95	1.30	0.87	2.90	1.69
SRI	5.05	6.00	4.75	5.27	3.32	1.75	4.96	3.34
Conventional	4.52	5.17	4.65	4.78	3.39	2.53	4.45	3.46
Mean	4.32	5.33	4.34		2.67	1.69	4.12	
C.D (0.05)								
Main	0.32				0.58			
Sub	0.15				0.60			
MXS	NS				NS			

	Straw yield (t/ha)							
	kharif				*rabi*			
	BPT 5204	**Swarna**	**DRRH 2**	**Mean**	**MTU 1010**	**Shanti**	**DRRH 2**	**Mean**
Eco-SRI	5.48	4.83	3.68	4.66	2.71	3.81	4.99	3.84
SRI	6.31	6.52	7.47	6.77	6.08	5.36	6.92	6.12
Conventional	5.82	7.07	7.47	6.79	6.45	6.60	6.05	6.37
Mean	5.87	6.14	6.21		5.08	5.26	5.99	
C.D (0.05)								
Main	NS				0.63			
Sub	1.57				1.24			
MXS	NS				NS			

Table 2. **Total nutrient uptake (kg/ha) as influenced by different treatments**

	Kharif (wet season)													
	N uptake					**P uptake**					**K uptake**			
	BPT 5204	**Swarna**	**DRRH 2**	**Mean**		**BPT 5204**	**Swarna**	**DRRH 2**	**Mean**		**BPT 5204**	**Swarna**	**DRRH 2**	**Mean**
Eco-SRI	71.4	95.3	51.4	72.7	Eco-SRI	11.4	14.0	12.4	12.6	Eco-SRI	59.1	74.4	58.2	63.9
SRI	100.2	109.3	101.8	103.8	SRI	14.7	17.3	13.5	15.2	SRI	87.2	101.7	86.8	91.9
Conventional	91.4	107.6	102.9	100.6	Conventional	13.7	16.5	14.6	14.9	Conventional	84.3	77.9	83.5	81.9
Mean	87.7	104.1	85.4		Mean	13.3	15.9	13.5		Mean	76.9	84.7	76.2	
C.D (0.05)					C.D(0.05)					C.D(0.05)				
Main	NS				Main	NS				Main	NS			
Sub	25.67				Sub	3.94				Sub	23.5			
MXS	NS				MXS	NS				MXS	NS			

	Rabi (dry season)													
	N uptake					**P uptake**					**K uptake**			
	MTU 1010	**Shanti**	**DRRH 2**	**Mean**		**MTU 1010**	**Shanti**	**DRRH 2**	**Mean**		**MTU 1010**	**Shanti**	**DRRH 2**	**Mean**
Eco-SRI	29.5	38.4	58.2	42.0	Eco-SRI	7.0	6.8	10.9	8.2	Eco-SRI	36.1	51.9	78.6	55.5
SRI	63.1	55.7	100.1	73.0	SRI	10.8	7.9	18.0	12.2	SRI	83.3	65.2	103.6	84.1
Conventional	77.5	81.8	89.5	82.9	Conventional	11.2	10.1	16.0	12.4	Conventional	91.6	96.5	82.0	90.0
Mean	56.7	58.7	82.6		Mean	9.7	8.3	15.0		Mean	70.3	71.2	88.1	
C.D (0.05)					C.D(0.05)					C.D(0.05)				
Main	NS				Main	4.6				Main	NS			
Sub	12.23				Sub	2.9				Sub	15.7			
MXS	NS				MXS	NS				MXS	NS			

Table 3. Soil properties after 2 seasons as influenced by different crop establishment methods

Treatments	pH	EC (dS/m)	SOC (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Eco-SRI	8.51	0.50	1.10	247.0	204	674
SRI	8.43	0.51	1.25	272.0	258	638
Conventional	8.44	0.51	1.18	251.0	256	609
Mean	8.44	0.51	1.18	257	239	641
C.D (0.05)	NS	NS	NS	NS	26	34

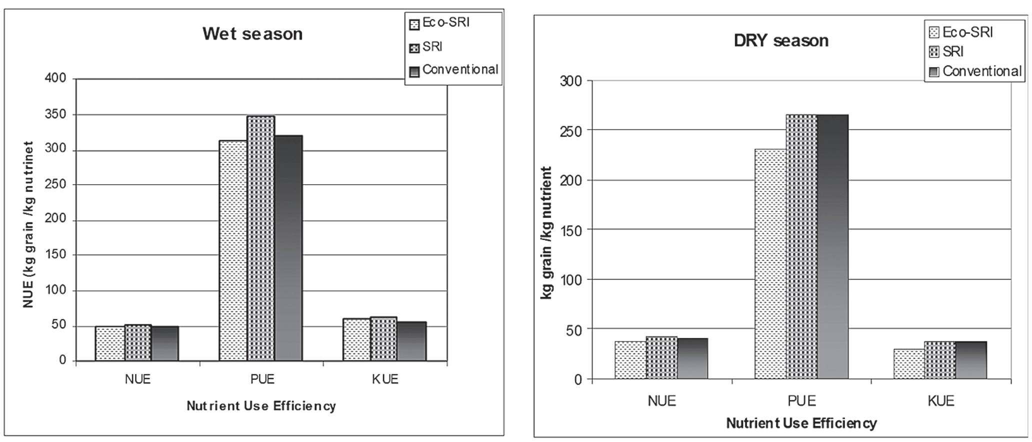

Fig.1. Nutrient use efficiency as influenced by methods of crop establishment

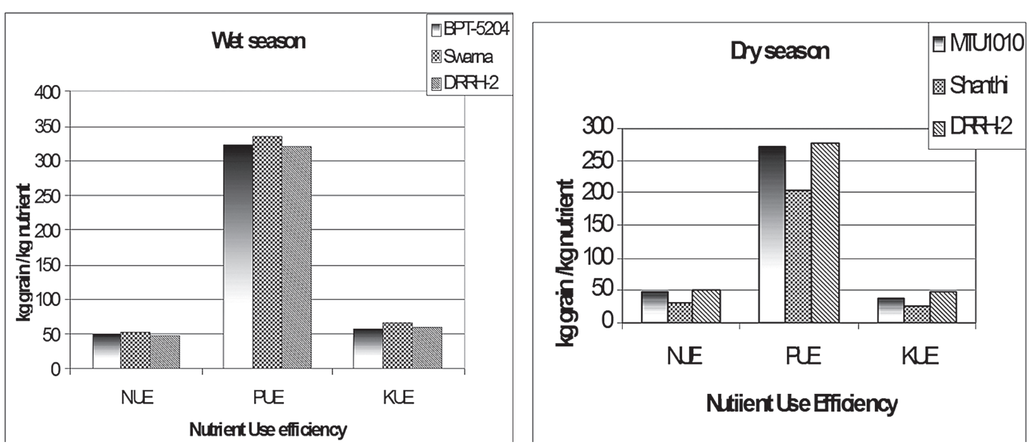

Fig. 2. Nutrient use efficiency as influenced by cultivars