Influence of different methods of rice (Oryzae sativa.l) cultivation – SRI vs NTP on microbes, soil health and grainyeild

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Key words: System of Rice Intensification (SRI), rice productivity, soil health, microbial activity

Abstract

System of Rice Intensification (SRI) developed in Madagascar, a systems approach to increasing rice productivity with less reliance on expensive external inputs, is gaining momentum all over the world including India. IIRR has conducted a long term experiments in sandy clay loam soils (2008-09 to 2010-11) to compare the organic and inorganic sources of nutrients for its productivity and soil health in SRI vs Best Management Practice (BMP) of Normal puddled Transplanted rice. The superior performance of SRI with higher microbial biomass corbon (17.2 %) coupled with higher dehydrogenase activity (ug TPFg-1soil 24h-1) with SRI (182) as compared to BMP indicating soil health improvement. SRI method with organic and inorganic nutrient application yielded 15.66 to 22.76 %mean higher grain yield in wet and dry seasons respectively as compared to BMP indicating a major factor contributing to positive SRI crop results is that its practices (young seedling, wider spacing, inter cultivation with weeder, saturation of soil use of organics) respectively taken together, create conditions in which beneficial microbes prosper due to well aeration and improves the soil health.

Introduction

Rice is the principal staple food for 65 % of the population of India cultivated in largest area 42 with a productivity of 106 m tonnes M ha (2015-16) and demand for rice is expected to rise due to increase in population (1.6 % per year), with reduced area and inputs in the next 15–20 years . The System of Rice Intensification (SRI) has been promoted for more than a decade as a set of agronomic management practices for rice cultivation that enhances yield (Senthil Kumar *et al.,* 2008), which also reduces water requirements. SRI was also found more accessible to small land holders (Stoop *et al.,* 2002) and is more honorable for the environment than conventional transplanting with its continuous flooding and leaving reliance on inorganic fertilisation (Uphoff, 2003). Increased and indiscriminate use of chemical fertilizers and pesticides since the onset of the green revolution during seventies resulted in several harmful effects on soil, water and air. This has also reduced the productivity of the soil by deteriorating soil health in terms of soil fertility and biological activity. Remarkable progress in the last 50 years in agricultural production and self-sufficiency in food of many countries including India has been attained at the cost of soil health.

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Imbalanced nutrient management and decreased soil organic matter are the key responsible factors for this decline. Therefore, emphasis should be laid on reducing the use of chemical inputs and to improve their use efficiency. Microbial-based indicators of soil quality are generally more dynamic than those of physical and chemical properties. Microbial communities are important determinants

of soil organic matter decomposition rates, and thereby the nutrient turnover and their availability in agricultural soils. Microbial soil characteristics are attaining an increased interest as sensitive indicators of soil health because of the relationships between microbial diversity, soil and plant quality and ecosystem sustainability. Although grain yield under organic farming is often lower than under conventional farming, it is feasible to have increased rice yields under the former.

The information on organic farming in rice under SRI and its comparison with Best management practices with regard biological activity and productivity of rice in Indian soils is very scanty. Hence, the present experiment was conducted to investigate growth parameters, root characters , soil microbial populations, and yield attributes and grain yield by comparing the plants grown with different crop establishment methods (SRI – organic, SRI with organic + inorganic) *vs* Best management practices (BMP with organic+ inorganic) maintained with flooded irrigation

Material and methods

The studies were conducted at Indian Institute of Rice Research Farm located at ICRISAT Patancheru (17°.53'N latitude, 78°.27'E longitude, 545 m altitude) in sandy clay loam soils (2008-09 to 2010-11) for three consecutive wet (*kharif*) and dry (*rabi*) seasons to investigate effect on grain yield by comparing the plants grown with different crop establishment methods (SRI – organic, SRI with organic and inorganic) vs Transplanted Rice (BMP with organic+ inorganic). Mean maximum and minimum temperatures there are 32°C and 20°C, respectively,and mean annual precipitation is 750 mm. Trials were managed during six seasons: *Kharif (3* wet season) 2008-10, *Rabi* (3 dry seasons) 2008–09 -2010-11, on an integrated rice agro ecosystem in an undisturbed field lay-out with permanent bunds around each plot. All the plots were surrounded by 1.5 m wide bunds to prevent lateral water seepage and nutrient diffusion between plots. Soils at the experimental site are classified as sandy clay loam, alkaline (pH 8.5–9.4), non-saline (EC 0.32 dS m^{-1}) and contained 1.01% organic carbon, 795 ppm total N, 58 ppm available phosphorus (Olsen and Sommers,1982), and 190 ppm available potassium.

The experiment was laid out in a plot size of 105 m^2 for each treatment. The three methods of crop establishment (SRI-organic, SRI-organic + inorganic, and BMP) were the main treatments done with three replications each. The rice variety Sampada with bold grain quality, which matures normally in 135 days, was tested during both *Kharif* and *Rabi* seasons. In the SRI-organic + inorganic and BMP treatments, the inputs applied were the same (50% organic + 50% inorganic), while in SRI-organic, the total nutrients were supplied through organic sources such as farm yard manure, vermicompost and green manure (*Gliricidia sepium*, a leguminous N_2-fixing tree). The recommended doses of inorganic fertilizers were given at the rate of 100–60–40 kg N_2, P_2O_5 and K_2O ha^{-1} during *Kharif* season, and 120–60–40–20 kg N_2, P_2O_5, K_2O and Zn ha^{-1} during *Rabi* season, applied through urea, single super phosphate, muriate of potash, and zinc sulphate, respectively. Nitrogen was given in three equal splits at basal, maximum tillering, and panicle initiation stages, while P, K and Zn were given as basal doses. For SRI-organic treatments, the N dose was adjusted to the recommended level based on the moisture content and total N concentration of the organic sources. The average nutrient content of the organic fertilizers that were applied is shown in Table 1 and the standard management of SRI and BMP were adopted.

Table 1: Average nutrient content of organic fertilizers

Organic source*	N (%N)	P ($\%P_2O_5$)	K ($\%K_2O$)

Compost	1.4	1.8	2.2
Gliricidia	2.4	0.1	1.8
Rice-straw	0.8	0.2	1.8

*Organic fertilizers incorporated one week before transplanting rice; N = nitrogen; P = phosphorous; K = potassium
SRI method and recommended management was practiced as per the standard procedure

Results

Grain yield

Grain yield was found to be significantly higher in SRI-organic + inorganic (11.72 −23.07% and 3.81−35.04 % more in *kharif* (wet) and *rabi* (dry) seasons, respectively) compared to BMP in all six tested seasons, while with the SRI-organic treatment, yield was found to be higher (4−34%) only in the *Rabi* seasons . The mean grain yield ranged between 3.39 and 9.37 t ha^{-1} for SRI-organic, and 5.24 and 10.67 t ha^{-1} for SRI-organic + inorganic as compared to 4.29–8.47 t ha^{-1} in BMP (**Table 2**). The divergence in grain yield between SRI and BMP was more attributable to differences in Harvest Index than to dry matter production.

Table 2: Grian yield of the SRI vs BMP as influenced by nutrient management in different seasons

Treatments	**Grain yeild (t/ha)**							
	Kharif				*Rabi*			
	2008	**2009**	**2010**	**Mean**	**2008**	**2009**	**2010**	**Mean**
SRI-Organic	3.39	3.70	5.29	4.12	5.45	8.12	9.37	7.65
SRI (Org +inorganic)	5.24	5.28	5.65	5.39	5.44	8.17	10.67	8.09
BMP	4.69	4.29	4.99	4.66	5.24	6.05	8.47	6.59
L.S.D (0.05%)	0.57	0.67	0.7	0.65	NS	0.63	0.35	0.49
Mean				4.72				7.44

In the present investigation, it was also observed that the plants grown in SRI had more open architecture, with wider spread of tillers, covering more ground area, and more erect leaves hich avoided mutual shading of leaves. With higher light interception, this would lead to more photosynthesis and higher grain yield in SRI compared to BMP. A number of previously published reports on SRI have shown enhancement in rice yield with these methods (Sato and Uphoff 2007; Thakur et al. 2009).

In the present investigation, grain yield was found higher in *Rabi* seasons 57 per cent compared to *Kharif* seasons probably due to bright sunshine and favorable weather for the crop and also less pest and disease attack. Seshu and Cady (1984) reported that the 30% higher radiation during the *Rabi* season over *Kharif* season on the rice crop correlated positively with economic yield. This increase could also be attributed in part to soils during *Rabi* being less saturated (less hypoxic), which would favor larger concentrations of more beneficial aerobic soil organisms in the rhizosphere.

Nutrient, biological and microbiological properties of the rhizosphere soil from SRI vs BMP

The total N and %OC were found to be significantly higher in SRI-organic (16−22% and 12−20%, respectively) and SRI-organic + inorganic (3−13% and 5−10%, respectively) treatments over BMP (Table 3). Not much difference in total P was observed, however, in either SRI-organic or SRI-organic + inorganic treatments compared to BMP (Table 3). Soil dehydrogenase and microbial biomass carbon (MBC) were also found to be significantly higher in SRI-organic (11−18% and 34−38%, respectively) and SRI-organic + inorganic (9−50% and 6−34%, respectively) treatments over BMP in all seasons.

Table.3. Comparison of soil biological activity and nutrient status as influenced by SRI-organic, SRI-organic + inorganic and best management practices (BMP)

Season	Treatment	Dehydrogenase	MBC	Total N	Total P	%OC	
		(µg g^{-1}+soil	(µg g^{-1}+soil	(ppm)	(ppm)		
		24 h^{-1})	24 h^{-1})				
Kharif	SRI-org	188.0	672.0	*	108.0	1.14	
season	SRI-org + inorg	186.0	643.0	*	96.0	1.15	
(2008)	BMP	170.0	500.0	*	93.0	1.13	
	LSD (5%)	13.6	120.7		12.5	0.02	
Kharif	SRI-org	97.0	623.0	1674.0	94.0	1.38	
season	SRI-org + inorg	110.0	605.0	1549.0	91.0	1.27	
(2009)	BMP	82.0	450.0	1375.0	91.0	1.15	
	LSD (5%)	14.8	151.0	73.2	3.0	0.01	
Rabi season		SRI-org	*	*	*	*	*
(2008–09)	SRI-org + inorg	326.0	1218.0	1103.0	134.0	1.20	
	BMP	267.0	1153.0	1083.0	130.0	1.19	
	LSD (5%)	26.2	19.5	2.6	1.8	0.02	
Rabi season		SRI-org	*	*	1497.0	122.0	1.25
(2009–10)	SRI-org + inorg	274.0	781.0	1328.0	122.0	1.17	
	BMP	183.0	706.0	1287.0	120.0	1.12	
	LSD (5%)	89.5	4.3	206.6	2.4	0.07	

MBC – microbial biomass carbon; N = nitrogen; P = phosphorous; OC = organic carbon; ppm = parts per million; org = organic; inorg = inorganic; * = not analyzed; LSD = least significant difference

The microbial populations (total bacteria, fungi and actinomycetes) were found to be always higher in SRI-organic and SRI-organic + inorganic treatments over BMP (Table 4). It should be noted, however, that the approach of quantifying microbial population through plate-count techniques estimate probably less than 10% of the total microflora in the soil (Nannipieri et al. 1994). Therefore, molecular quantification (a more reliable method) needs to be done in future studies.

Table 4: Comparison of microbial population as influenced by SRI-organic, SRI-organic + inorganic and best management practices (BMP)

Year	Treatment	Total bacteria	Total actinomycetes	Total fungi
Kharif	SRI-org	5.79	4.60	5.59
season	SRI-org + inorg	5.79	4.66	5.71
(2008)	BMP	5.77	4.41	5.42
	LSD (5%)	0.01	0.11	0.10

Kharif season (2009)	SRI-org	5.97	5.00	3.81
	SRI-org + inorg	6.08	4.90	3.81
	BMP	5.80	4.73	3.78
	LSD (5%)	0.08	0.200	0.02
Rabi season (2008–09)	SRI-org	*	*	*
	SRI-org + inorg	6.94	5.56	5.72
	BMP	6.81	5.52	5.59
	LSD (5%)	0.16	0.10	0.13
Rabi season (2009–10)	SRI-org	6.88	6.04	4.88
	SRI-org + inorg	6.76	5.84	4.99
	BMP	6.76	5.69	4.68
	LSD (5%)	0.01	0.13	0.04

org = organic; inorg = inorganic; * = not analyzed;
LSD = least significant difference; Microbial populations were expressed in Log_{10} values

Discussion

In the present investigation, revealed that the grain yield found to be significantly higher in the SRI-organic + inorganic trials, as compared to BMP. Grain yield was found to be significantly higher in SRI-organic + inorganic (11.72 −23.07% and 3.81−35.04 % more in *Kharif* and *Rabi* seasons, respectively) compared to BMP in all six tested seasons, while with the SRI-organic treatment, yield was found to be higher (4–34%) only in the *Rabi* seasons. This is clear evidence that SRI management is not only a seed-saving (5kg /ha over 30 kg /ha) method but also enhances the productivity of the rice.

It can be concluded that SRI practices create conditions for beneficial soil microbes to prosper and for increasing grain yield. The role of soil microbes in enhancing rice plant productivity, even affecting the expression of genetic potentials, is just beginning to be studied (Chi et al., 2010). Further, long-term research studies at different locations will be useful to quantify each component of SRI, for enhancing resource conservation, wide-scale adoptability, and molecular assessment of microbial populations in the soil and the effects of symbiotic endophytes to assess positive soil–plant–microbial interactions.

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