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Influence of crop management practices on productivity and economics of rice in south Andaman Islands

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ABSTRACT

On-farm experiments were conducted during wet seasons of 2008 and 2009 in the farmer's field at Calicut and Manjery villages in South Andaman district to select best management practices for rice to increase the Island level productivity. In on-farm trials, four best treatments of on-station experiment along with the farmer's practice of cultivation were evaluated in farmer's field. Planting of rice at 20 x 20 cm with application of 50 % recommended dose (90 kg ha $^{-1)}$ of nitgen (RDN) through Gliricidia + 50 % RDN through urea resulted in better growth, uptake of nutrients and yield attributes which in turn led to higher grain, straw yield and monetary returns and was at par with application of 75 % RDN through Gliricidia + 25 % RDN through urea at same density. The increase in grain yield was 0.90 t ha^{-1} in Calicut village and 0.91 t ha^{-1} in Manjery compared to planting at 25 x 25 cm. The increases in grain yield at 20 x 20 cm spacing with organic-inorganic nutrient combination over farmers practice was 2.11 t ha^{-1} and 1.98 t ha^{-1} in Calicut and Manjery, respectively.

Key words: *system of rice intensification, on-farm evaluation, nutrient uptake, yield, economics*

In India, rice cultivation is a mean of livelihood for millions of rural households and it plays a vital role in our national food security as it is cultivated in an area of 42.3 million ha with annual production of 87.0 million tonnes and a productivity of little more than 3 t ha^{-1} (Krishna *et al*., 2008). The production increase by at least 2.5 million tonnes of rice every year to sustain the present level of self sufficiency is must for which farmer friendly scientific technologies are needed. In Andaman and Nicobar islands also, rice is important cereal crop grown in 8 549 ha with the annual production of 26 249 t and the productivity is much lower (2.2 t ha^{-1}) than the national average and every year around 27 000 t of rice is supplied from the mainland India. The low yield of rice in the islands is mainly due to mono cropping of lodging prone, photo sensitive traditional rice variety (C 14-8) with late planting (August) and low or no input management. The System of Rice Intensification (SRI) developed in Madagascar over a 20 year period and synthesized in the early 1980's (Uphoff, 2002) would be an appropriate practice to produce more yield with less input. Experience with SRI methods suggests that average rice yields can be about double the present world average without requiring a change in the cultivar or use of external inputs (Wang *et al*., 2002). The SRI has proven ability to increase rice production by 26 % or more depending on the extent of adherence to its basic principles *viz.,* transplanting young seedlings, at wider spacing in square pattern and keeping the soil moist and aerated during vegetative phase (Uphoff, 2003). SRI involves a number of specific techniques that are always required to be tested and adapted according to local conditions. The components of SRI have claimed substantial increase in rice productivity in different rice growing areas. The technology diffusion from on-station experiments to on-farm are rather very slow due to non-consideration or below realization of on-farm constraints in many of treatments designed at on-station. Hence, the approach of on-station and on-farm linked experiments were conducted by selecting four best treatments of SRI from on-station and evaluating in the on-farm to validate the performance of modified SRI practices under farmers field conditions in the Andaman Islands.

MATERIALS AND METHODS

The on-station field experiments were carried out during wet season of 2007 and 2008 at Bloomsdale farm, Central Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands. The on station experiment was laid out in split plot design with three replications. Time of planting (second fortnight of June; second fortnight of July) and spacing (20 x 20 cm; 25 x 25 cm) was assigned to main plot while number of seedlings hill^{-1} (one; two) and nitrogen management practices viz. (100 % of recommended dose (90 kg ha^{-1}) of N (RDN) through *Gliricidia,* 100 % RDN through urea, 50 % RDN through *Gliricidia* + 50 % RDN through urea and 75 % RDN through *Gliricidia* + 25 % RDN through urea, respectively) was assigned to sub plot. Based on the on station performance of SRI practices, four best management practices (treatments) *viz.,* 20 x 20 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, 20 x 20 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, 25 x 25 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea and 25 x 25 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea along with farmers practice (Conventional nursery with conventional planting involving closer spacing, 5-7 seedlings hill^{-1}, no organic or inorganic fertilizer application, no weeding) were evaluated in farmer's field at Calicut and Manjery villages of South Andaman in randomized block design with four replications in each farmers field during wet season of 2008 and 2009. The farmers preferred two seedlings hill^{-1} over single seedling hill^{-1}, in the on farm trial due to difficulty in separating the seedling and picking one seedling. Hence, two seedlings were used in the on-farm experiment though the grain yield of single and double seedlings were on par at on-station experiments. Similarly, as the rice farmers are applying limited quantity of fertilizers in the region, best treatments involving *Gliricidia* and inorganic nitrogen combinations were selected for on-farm trial. The soil was clay loam at Calicut and sandy loam at Manjery respectively with pH 6.2- 6.3, EC 0.2 dS m^{-1}, organic carbon 0.5- 0.6%, low in available Nitrogen (225 - 235 kg ha^{-1}), medium in Phosphorus (10.6 – 10.8 kg ha^{-1}) and low in available Potassium (114 - 126 kg ha^{-1}). 15 days old seedlings of rice cv. Bhavani raised in MAT nursery method were transplanted in the main field during second fortnight of June. The recommended dose of fertilizer 90, 60, 40 kg N, P and K ha^{-1} was adopted for rice as per the requirements of treatments. The quantity of N, P and K supplied by *Gliricidia* (*Gliricidia sepium*) was estimated (2.9 % N, 0.5 % P_2O_5 and 2.8 % K_2O on fresh weight basis) and the remaining quantity was supplemented with inorganics. No addition of K from inorganic source was done, since *Gliricidia* leaf incorporation met the K requirement. Nitrogen through inorganic sources was applied in three equal splits as basal, tillering and panicle initiation (PI) stage. Nitrogen in the form of urea, phosphorus in the form of single super phosphate and potassium in the form of muriate of potash was applied. Cono weeder was operated three times during the crop growth period in between the rows in both the directions at 10, 25 and 40 days after transplanting (DAT). The weeds were thus incorporated and the soil was stirred. The percent concentration of the nutrients was multiplied with the respective dry matter content and NPK uptake values were worked out. Soil samples collected after harvest of the crop was analyzed for available N, P and K.

RESULTS AND DISCUSSION

At on station, early planting in June second fortnight with 20 x 20 cm spacing recorded 9.1 % higher panicles m^{-2}, lengthier panicle with higher number of filled grains panicle^{-1} (108) compared to the planting 25 x 25 cm. As a result of better growth and yield components higher grain yield (4 678 kg ha^{-1}) was recorded in the early planting. Though application of 100 % recommended dose of nitrogen (RDN) through urea recorded more number of tillers with higher dry matter production (DMP), number of panicles, more number of filled grains and highest grain yield of 4.46 t ha^{-1} but it was comparable with 50 % RDN through *Gliricidia* + 50 % RDN through urea and 75 % RDN through *Gliricidia* + 25 % RDN through urea. At on farm also, spacing and nitrogen management practice under SRI exerted marked influence on the growth, yield attributes and yield of rice (Table 1). Planting of rice at 20 x 20 cm with application of 50 % RDN through *Gliricidia* + 50 % RDN through urea recorded highest DMP (10.64, 8.72 t ha^{-1}), more number of panicles m^{-2} (248, 213), panicle length (25.3, 22.1 cm) with maximum

Table 1. Effect of spacing and N management on growth and yield attributes of rice under SRI in farmer's field

Treatments	On farm trial at Calicut					On farm trial at Manjery				
	Plant height (cm)	DMP (t ha^{1})	No of panicle m^{-2}	Panicle length (cm)	Filled grains $panicle^{-1}$	Plant height (cm)	DMP (t ha^{-1})	No of panicle m^{-2}	Panicle length (cm)	Filled grains $panicle^{-1}$
T_1	102.7	10.64	248	25.3	117	100.1	8.73	213	22.1	101
T_2	104.2	9.96	235	23.3	112	100.5	8.01	206	21.0	96
T_3	101.2	8.00	206	20.7	94	98.7	6.44	183	20.2	87
T_4	99.9	7.35	204	19.7	88	98.8	5.67	177	19.4	84
T_5	98.4	5.61	173	16.6	72	96.6	3.66	158	16.5	71
CD (*P*=0.05)	NS	0.97	15	2.3	12	NS	0.93	18	1.7	10

T_1- 20 x 20 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_2- 20 x 20 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_3 - 25 x 25 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_4 - 25 x 25 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_5 - (Conventional nursery with conventional planting (closer spacing, 5-7 seedlings/hill, no organic or inorganic fertilizer application, no weeding), DMP - Dry matter Production.

number of filled grains $panicle^{-1}$ (117, 101) and higher grain (4.21 , 3.69 t ha^{-1}) and straw yield (6.19, 4.88 t ha^{-1}), respectively at Calicut and Manjery. However the same was at par with planting of rice at 20 x 20 cm with application of 75 % RDN through *Gliricidia* + 25 % RDN through urea. Conventional method of farmer's practice of rice cultivation recorded significantly lower DMP, least number of panicles m^{-2}, shorter panicle with less number of filled grains leading to low grain and straw yield in both the villages. Results obtained in the on station experiment was similar in on-farm experiments also. In general, higher yield was recorded in Calicut compared to Manjery village which was due to better soil nutrient status. Among the improved practices evaluated along with farmers practice, planting of rice at closer spacing of 20 x 20 cm and application of 50 % RDN through *Gliricidia* + 50 % RDN through urea resulted in better growth and yield attributes which in turn resulted in higher grain and straw yield (Table.2) at both the places. The increase in grain and straw yield was 0.90, 1.45 t ha^{-1} respectively in Calicut and 0.91, 1.36 t ha^{-1}, respectively in Manjery compared to planting with wider spacing of 25 x 25 cm and application of 50 % RDN through *Gliricidia* + 50 % RDN through urea while the increase in grain and straw yield was 2.11, 3.03 t ha^{-1} and 1.98, 2.82 t ha^{-1}, respectively in Calicut and Manjery village compared to the farmers practice. As compared to on station the yield was low (1.19, 1.72 t ha^{-1}) at Calicut and Manery. Increased grain yield under SRI can be mainly attributed to a

Table 2. Effect of spacing and N management on yield of rice under SRI in farmer's field

Treatments	On station		OFT-1 (Calicut)		OFT-2 (Manjery)		Yield gap in OFT (%)	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	OFT-1	OFT-2
T_1	5.41	5.99	4.21	6.19	3.69	4.88	28.3	46.5
T_2	4.99	5.38	3.94	5.70	3.40	4.39	26.7	46.7
T_3	4.46	5.87	3.31	4.74	2.78	3.52	34.6	60.4
T_4	4.15	4.72	3.03	4.30	2.56	3.07	36.9	62.1
T_5	-	-	2.10	3.16	1.71	2.06	-	-
CD (*P*=0.05)	0.49	0.63	0.42	0.62	0.54	0.53	-	-

T_1- 20 x 20 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_2- 20 x 20 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_3 - 25 x 25 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_4 - 25 x 25 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_5 - (Conventional nursery with conventional planting (closer spacing, 5-7 seedlings $hill^{-1}$, no organic or inorganic fertilizer application, no weeding), OFT - On farm trial greater number of lengthy and productive tillers with an increased number of filled grains panicle^{-1}. This is in agreement with the findings of Satyanarayana *et al* (2004) and Thiyagarajan (2006) who have also recorded yield advantage under SRI in the farmers' fields.

application of 75 % RDN through *Gliricidia* + 25 % RDN through urea. Similar trend was also recorded in Manjery. Closer spacing registered significantly higher nutrient uptake compared to wider spacing because of higher plant population per unit area, higher translocation rate and percentage of stored assimilates. Similarly application of 50 % RDN through *Gliricidia* + 50 % RDN through urea and 75 % RDN through *Gliricidia* + 25 % RDN through urea resulted in better uptake. This could be attributed to the increased supply of nutrients directly from the organic and inorganic sources, higher root activity and addition of organic matter from

Table 3. Effect of spacing and N management on N, P, K uptake (t ha $^{-1}$) and soil available N, P and K (t ha^{-1}) of rice under SRI in farmer's field

Treatments	OFT-1 (Calicut)						OFT-2 (Manjery)					
	Uptake of N, P and K (kg ha^{-1})			Soil available N, P and K (kg ha^{-1})			Uptake of N, P and K (kg ha^{-1})			Soil available N, P and K (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1	112.6	26.0	108.2	217.9	11.9	133.9	94.7	20.3	87.1	229.6	10.7	127.9
T_2	108.0	23.7	100.8	223.6	12.3	138.3	92.0	18.5	79.0	231.2	11.1	130.3
T_3	100.1	20.1	81.7	229.1	12.7	140.8	81.8	15.6	63.7	235.9	11.3	136.5
T_4	93.8	19.3	75.9	230.8	12.8	144.0	78.6	14.4	57.2	238.8	11.8	139.9
T_5	74.3	16.2	55.7	232.4	13.0	147.1	57.2	10.3	36.0	244.0	11.9	141.2
SEm±	2.6	0.8	3.8	3.9	0.3	3.4	2.9	0.7	2.8	3.6	0.4	4.0
CD (*P*=0.05)	7.9	2.4	11.7	12.0	0.8	10.4	8.8	2.1	8.5	11.2	1.1	12.5

T_1- 20 x 20 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_2- 20 x 20 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_3 - 25 x 25 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_4 - 25 x 25 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_5 - (Conventional nursery with conventional planting (closer spacing, 5-7 seedlings/hill, no organic or inorganic fertilizer application, no weeding), OFT - On farm trial

Spacing and N management practices under SRI had positive influence on the nutrient uptake (Table 3). Planting of rice at 20 x 20 cm with application of 50 % RDN through *Gliricidia* + 50 % RDN through urea resulted in highest uptake of N,P and K (112.6, 26.0 and 108.2 kg ha^{-1}, respectively) at Calicut and it was at par with same density of population coupled with

Table 4. Effect of spacing and N management on economics of rice under SRI in farmer's field (mean of 2 years)

Treatments	On station			OFT-1 (Calicut)			OFT-2 (Manjery)		
	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Net return per rupee invested	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Net return per rupee invested	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Net return per rupee invested
T_1	60 110	38 546	1.78	48 385	26 821	1.24	41 813	20 249	0.94
T_2	55 364	34 055	1.60	45 144	23 835	1.12	38 471	17 162	0.81
T_3	50 475	30 939	1.58	37 882	18 346	0.94	31 323	11 787	0.60
T_4	46 302	27 021	1.40	34 660	15 379	0.80	28 729	9 448	0.49
T_5	-	-	-	24 256	11 256	0.86	19 160	6 160	0.47

*Data statistically not analysed, T_1- 20 x 20 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_2- 20 x 20 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_3 - 25 x 25 cm + 50 % RDN through *Gliricidia* + 50 % RDN through urea, T_4 - 25 x 25 cm + 75 % RDN through *Gliricidia* + 25 % RDN through urea, T_5 - (Conventional nursery with conventional planting (closer spacing, 5-7 seedlings/hill, no organic or inorganic fertilizer application, no weeding), OFT - On farm trial

Cost of cultivation: T_1-₹ 21 564, T_2 - ₹ 21 309, T_3- ₹ 19 536, T_4- ₹ 19 281, T_5- ₹ 13 000, respectively the decomposition of *Gliricidia* leaves due to higher microbial activities which might have stimulated the mineralization process of N in the soil and resulted in continuous or phased release of N thereby leading to higher uptake of N. Similar findings were earlier reported by Yadav *et al*., (2005). Decomposition of organic matter results in more phosphatase activity that catalyses the native and applied P and thereby increases the available form of phosphorus which in turn resulted in higher P uptake by the crop. This is in line with findings of Pandey *et al.,* (2009).

The soil nutrient status was also significantly influenced by the spacing and N management practices under SRI in both locations (Table 3). Though conventional method of cultivation had resulted in higher soil available N, P and K planting of rice at 20 x 20 cm with application of 50 % RDN through *Gliricidia* + 50 % RDN through urea had comparatively lesser NPK content of soil owing to higher grain and straw yield. Baloch *et al*., (2006) opined available nutrient status gets depleted as a consequence of biomass production under optimum combination of non-monetary inputs.

Planting of rice at closer spacing (20 x 20 cm) and application of 50 % RDN through *Gliricidia* + 50 % RDN through urea realized higher net return (₹ 15 565 and ₹ 14 089 ha^{-1}) at Calicut and Manjery villages respectively (Table 4) compared to the farmers practice. At on station also the same treatment recorded higher net return (₹ 38546) and net return per rupee invested (1.78). This was mainly due to the yield advantage that resulted under SRI which in turn reflected in the net returns and net return per rupee invested. These results are in conformity with the earlier findings of Udayakumar, 2005. The cost of cultivation was less under farmers practice compared to modified SRI method.

Thus, it can be concluded that planting of rice at closer spacing (20 x 20 cm) and application of 50 % N through *Gliricidia* and 50 % N through urea can be recommended for achieving higher yield and net return of rice in south Andaman.

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