Madras Agric. J., 99 (7-9): 538-544, September 2012
https://doi.org/10.29321/MAJ.10.100134

Influence of Time of Planting, Spacing, Seedling Number and Nitrogen Management Practices on Productivity, Profitability and Energetics of Rice (*Oryza sativa*) in Island Ecosystem

V. Damodaran*, B.K. Saren, N. Ravisankar and N. Bommayasamy
Central Agricultural Research Institute,
Port Blair - 744 101, Andaman & Nicobar Islands

Field experiments were conducted during wet season of 2007 and 2008 at Central Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands in order to evaluate the practices of System of Rice Intensification (SRI) in Island ecosystem. Time of planting, spacing and nitrogen management practices significantly influenced the growth and yield attributes while number of seedlings/ hill did not exert any influence on these parameters. Planting in second fortnight of June with 20 x 20 cm spacing recorded higher number of tillers (18.3), DMP (17.6), panicles/m$_2$ (9.2) and filled grains/panicle (9.1). As a result of better growth and yield components, higher grain yield (4,678 kg/ha), net returns (Rs. 31,768/ha), net return per rupee invested (1.47) and energy ratio (14.5) were recorded in the early planting. Application of 100 % Recommended Dose of Nitrogen (RDN) through urea recorded more number of tillers with higher DMP, number of panicles, more number of filled grains and highest grain yield of 4,465 kg/ha but it was comparable with 50 % RDN through *Gliricidia* + 50 % RDN through urea and 75 % RDN through *Gliricidia* + 25 % RDN through urea. Though the net return was slightly higher (Rs. 29,002/ha) with application of 100 % RDN through urea, but net return per rupee invested was higher (1.40) with application of 50 % RDN through *Gliricidia* + 50 % RDN through urea. Thus, planting in second fortnight of June with 20 x 20 cm spacing using single seedling combined with application of 50 % N through *Gliricidia* and 50 % N through urea can be recommended for achieving higher productivity, profitability and energetic of rice in island ecosystem.

Key words: Rice, productivity, profitability, energetics, island ecosystem

*Corresponding author email: damuvijayan@yahoo.co.in

Rice (*Oryza sativa* L.) is the most important staple food for nearly half of the world's population, which is grown under wide range of latitudes and altitudes with the challenges of climate change (Swaminathan, 2006). Rice is cultivated in 8,549 ha with annual production and productivity of 26,249 t and 2,200 kg/ ha, respectively, necessitating an import of about 27,188 t of rice from the Indian mainland (A&N Administration, 2009). Shrinking of land, water, labour, capital and energy are found to be a challenge in the Island ecosystem, thus requiring innovative research and technologies which can increase the unit area production of rice. Uphoff (2003) found that the SRI has ability to increase rice production by 26 % or more. Studies at many places of India revealed that planting single seedling resulted in 15 to 16 % higher yield than planting two to three seedlings/hill. Around 40 kg of seeds are used in conventional planting while rice can produce higher yield with single seedling (5 kg seeds/ha) or two seedlings (10 kg seeds/ha), thus saving grains of 30-35 kg/ha. Due to inadequate and imbalanced fertilizer application, farmers are not able to harness the full yield potential of rice in the islands. Practices of SRI such as number of seedling and spacing developed elsewhere would not be suitable for Island ecosystem as it receives annual average rainfall of 3070 mm with higher intensity. Hence, this study.

Materials and Methods

Field experiments were carried out during wet season of 2007 and 2008 at Field crops research farm, Bloomsdale of Central Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands. The soil was clay loam in texture having slightly acidic pH (6.2), normal EC (0.2 dS/m), medium in organic carbon (0.6%), low in available Nitrogen (245 kg/ ha), medium in Phosphorus (11.2 kg/ha) and low in available Potassium (128 kg/ha). The experiment was laid out in split plot design having time of planting and spacing in main plot (Second fortnight of June with 20 x 20 cm (M_1), Second fortnight of June with 25 x 25 cm (M_2), Second fortnight of July with 20 x 20 cm (M_3) and Second fortnight of July with 25 x 25 cm (M_4)) and seedling number (One (H_1), Two (H_2)) and nitrogen management (100 % of recommended dose of N through *Gliricidia* (N_1), 100 % RDN through urea (N_2), 50 % RDN through

Gliricidia + 50 % RDN through urea (N_3) and 75 % RDN through *Gliricidia* + 25 % RDN through urea (N_4)) in subplot and replicated thrice. Seedlings of rice variety Bhavani were raised in MAT nursery and 15 day old seedlings were transplanted as per the treatments. Fertilizer dose of 90: 60: 40 kg N, P_2O_5 and K_2O/ha was adopted and accordingly 100 % P_2O_5 and 50% K_2O were applied as basal and remaining 50 % K_2O was applied at panicle initiation stage through inorganic sources as per the treatment. The quantity of P_2O_5 supplied by *Gliricidia* (*Gliricidia sepium*) was estimated and the remaining quantity was supplemented with in organic sources. *Gliricidia* contained 2.9 % N, 0.5 % P_2O_5 and 2.8 % K_2O on fresh weight basis. However, no addition of K from inorganic source was done as *Gliricidia* leaf incorporation met the entire K requirement. Nitrogen in the form of Urea, Phosphorus in the form of Single Super Phosphate and Potassium in the form of Muriate of potash was used as inorganic sources. Criss –cross conoweeding was carried out on 10, 25 and 40 DAT. Observations on growth and yield parameters were recorded as per standard procedure. Root volume was measured by displacement method and expressed in cubic centimeter (cc). Grains from individual net plot were sun dried, cleaned and weighed and yield was expressed at 14 per cent moisture basis while straw was sun dried for 4 days and weighed separately. Economic evaluation was done by calculating the gross return, net return, cost of cultivation and Net return per rupee invested (NRPRI) based on the prevalent market rate. Cultural energy (Mega Joules) used through various inputs in the cropping period was computed as described by Mittal *et al*. (1985) and the energy use efficiency (energy ratio) was worked out using the formula of Energy output divided by Energy input and Specific energy was calculated in terms of energy required to produce a kilogram of economic yield and expressed in MJ/kg. All the observed data were subjected to statistical analysis as per the prescribed standard procedures for the similar kind of study.

Results and Discussion

Growth parameters

Time of planting, spacing, number of seedlings/ hill and N management practices did not significantly influence the plant height at flowering stage of rice in both the years. However, it had significant difference on number of tillers m^{-2}, Leaf Area Index (LAI) and dry matter production (DMP) of rice (Table 1) . Early planting in June second fortnight with 20 x 20 cm spacing recorded 18.3, 6.9, and 7% higher tiller m^{-2} LAI and DMP respectively compared to delayed planting (July second fortnight with 20 x 20 cm spacing). The magnitude of increase was about 22.8, 10.2 and 9.3 % in terms of tiller m^{-2}, LAI and DMP respectively compared to same time of planting with wider spacing (25 x 25 cm). Higher tillers in early planting with closer spacing can be attributed to long time of growth before flowering and optimum population. Nayak *et al*. (2003) also reported early planting exhibited maximum number of tillers in hybrid rice compared to delayed planting. Further closer spacing of 20 x 20 cm recorded the highest LAI compared to wider spacing of 25 x 25 cm. This might be due to more number of leaves which occupied the same land area and consequently trapped more light and CO_2 resulting in higher photosynthesis and producing more dry matter. This corroborates with the findings of Salem (2006). DMP is the product of the influence of growth characters like plant height, number of tillers, LAI and efficiencies of the crop to capture available resources. Higher DMP in closer spacing may be because of higher

Table 1. Influence of management practices on growth parameters of rice at flowering stage

Treatment	Plant height (cm)			No. of tillers/m^2			Leaf Area Index			DMP (kg/ha)		
	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
Time of planting & spacing												
M_1 - June second fortnight + 20 x 20 cm	102.0	97.0	99.5	477	439	458	5.82	5.38	5.60	5400	5250	5325
M_2 - June second fortnight + 25 x 25 cm	97.7	92.3	95.0	394	352	373	5.32	4.84	5.08	4981	4766	4873
M_3 - July second fortnight + 20 x 20 cm	101.5	94.6	98.1	410	363	387	5.45	5.04	5.24	5018	4938	4978
M_4 - July second fortnight + 25 x 25 cm	93.5	87.7	90.6	344	207	275	4.87	3.74	4.31	4407	4194	4300
SEm±	1.5	1.6	1.5	6	6	6	0.08	0.08	0.08	83	77	80
CD (*P*=0.05)	NS	NS	NS	22	20	21	0.28	0.26	0.27	289	266	276
Number of seedling $hill^{-1}$												
H_1 - One seedling	96.9	93.4	95.2	398	337	368	5.31	4.65	4.98	4935	4822	4878
H_2 - Two seedling	100.4	92.5	96.4	415	343	379	5.42	4.84	5.13	4968	4752	4860
SEm±	1.5	1.4	1.5	6	5	6	0.08	0.07	0.08	74	72	73
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management												
N_1- 100 % RDN through *Gliricidia*	96.2	89.3	92.8	327	304	315	5.03	4.11	4.57	4560	4503	4532
N_2- 100 % RDN through urea	100.8	95.2	98.0	442	359	401	5.51	5.03	5.27	5199	4975	5087
N_3- 50 % RDN through *Gliricidia* + 50 % RDN through urea	99.7	93.8	96.7	434	353	394	5.46	4.89	5.18	5041	4841	4941
N_4- 75 % RDN through *Gliricidia* + 25 % RDN through urea	97.9	93.3	95.6	422	344	383	5.45	4.96	5.21	5005	4828	4917
SEm±	2.1	2.0	2.1	9	7	8	0.11	0.09	0.11	105	102	103
CD (*P*=0.05)	NS	NS	NS	25	21	23	0.32	0.29	0.30	298	288	291

RDN= Recommended dose of Nitrogen; Interaction not significant plant population as compared to the wider spacing. Number of seedlings/hill did not show much variation in the growth parameters and it clearly indicates that use of extra seedling in a hill do not provide any extra benefit.

Among the nitrogen management practices N_2 (100 % RDN through urea) recorded higher tiller production (401/m2), LAI (5.27) and it was at par with N_3 (50 % RDN through *Gliricidia* + 50 % RDN through urea) and N_4 (75 % RDN through *Gliricidia* + 25 % RDN through urea). This might be attributed to slow and steady release of N by the *gliricidia* green leaf manure on its decomposition resulting in efficient utilization indicating that supplementing the inorganic fertilizer with organic source which improved the general soil environment, physico-chemical and biological conditions favouring the increased availability of macro and micro nutrients (Sengar *et al*., 2000) thereby helped in improving the rice growth. Similar finding was also reported by Singh *et al*. (2002).

Root characteristics

Root length, volume and weight were influenced by the time of planting, spacing and N management practices while number of seedlings/hill did not exert any pronounced effect. Maximum root length (25.9 cm), higher root volume (62.3cc) and more dry weight (26.5 g/hill) was recorded under June second fortnight planting with 20 x 20 cm spacing followed by July second fortnight planting with 20 x 20 cm (Fig.1). In the present findings, it was observed that

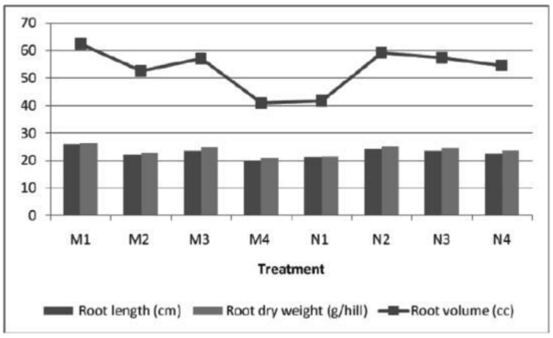

Fig. 1. Influence of management practices on root characteristics of rice at flowering stage

early planting in June second fortnight with 20 x 20 cm recorded longer roots since higher plant density increases the length of roots due to competition for uptake of water and nutrients from the soil. Further, the better root characteristics may be attributed due to the effect of cono weeding which resulted in formation of more number of roots as well pruning of some of the upper roots and thus encouraged deeper root growth thereby increasing the root length and volume (Uphoff, 2002). Among the nitrogen management practices, lengthier roots (24.3 cm) with higher volume (59.1 cc) and dry weight (25.2 g) were recorded with N_2 (100 % RDN through urea) but, it was at par with N_3 (50 % RDN through *Gliricidia* + 50 % RDN through urea). This can be due to the large amount of N supplied to leaves from roots which enhanced the photosynthesis and secured the supply of carbohydrates to roots (Osaki *et al*., 1997). The higher root dry weight may be due to cumulative effect of lengthier roots and higher root volume due to number of roots and root thickness.

Yield attributes

The yield attributes *viz*, panicles/m2, panicle length and filled grains/panicle was significantly influenced by the time of planting, spacing and N management practices while number of seedlings/ hill did not show much variations on the yield attributes (Table 2).

Early planting in June second fortnight with 20 x 20 cm spacing recorded 9.1 % higher panicles/m2, lengthier panicle with higher number of filled grains/ panicle (108) compared to the same time of planting in 25 x 25 cm. The number of panicles/ m2 was higher at increased plant density and decreased with wider spacing. This may be due to greater plant population per unit area rather than more tillers/ plant. Similar results were earlier reported by Choudhury *et al*. (2007). Among the nitrogen management practices, N_2 (100 % RDN through urea) recorded the higher number of panicles (218) and filled grains/panicle but the same was at par with N_3 (50 % RDN through *Gliricidia* + 50 % RDN through urea) and N_4 (75 % RDN through *Gliricidia* + 25 % RDN through urea). This may be due to the conjunctive use of inorganic fertilizer with organic source which inturn improved the general soil environment, physico-chemical and biological conditions. Similar findings were earlier reported by Natarajan *et al*. (2005).

Yield

Early planting in June second fortnight with 20 x 20 cm (25 hills/m2) recorded significantly higher grain and straw yield in both the years (Table 3 & 3.1).

The increase in grain yield was 461 kg/ha in 2007 and 470 kg/ha in 2008 and 30 % and 26 % higher straw yield in the corresponding years as compared to the same time of planting with wider spacing of 25 x 25 cm (16 hills/m2). At the same time one month delay in planting (July second fortnight) accounted 357 and 368 kg/ha reduction in yield with same density of population. This can be attributed to better growth and yield components due to efficient utilization of resources which in turn improved the yield attributes and thereby increased the yield. It clearly indicates that early planting enabled the plants to have longer time for growth before flowering and had potential for higher source capacity from which more dry matter could be produced for storage in the economic organs. Further due to more number of panicles/m2 produced in the early planting with closer spacing must have contributed to higher grain yield. Similarly Gill *et al*. (2006) also

Table 2. Influence of management practices on yield components of rice

Treatment	No. of panicles/m2			Panicle length (cm)			Filled grains/panicle		
	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
Time of planting & spacing									
M_1 - June second fortnight + 20 x 20 cm	247	230	239	23.4	22.6	23.0	112	103	108
M_2 - June second fortnight + 25 x 25 cm	220	217	219	21.5	20.8	21.2	104	94	99
M_3 - July second fortnight + 20 x 20 cm	224	218	221	22.1	21.4	21.8	106	97	101
M_4 - July second fortnight + 25 x 25 cm	156	154	155	20.2	19.3	19.8	97	87	92
SEm±	3	3	3	0.3	0.3	0.3	2	1	2
CD (*P*=0.05)	11	11	11	1.2	1.1	1.2	6	5	5
Number of seedling hill-1									
H_1 - One seedling	207	203	205	21.6	20.9	21.2	104	95	99
H_2 - Two seedling	216	207	211	22.0	21.3	21.6	105	96	100
SEm±	3	3	3	0.3	0.3	0.3	2	1	1
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management									
N_1- 100 % RDN through *Gliricidia*	198	188	193	20.1	19.7	19.9	97	87	92
N_2- 100 % RDN through urea	222	214	218	22.9	21.8	22.3	109	101	105
N_3- 50 % RDN through *Gliricidia* + 50 % RDN through urea	215	208	212	22.3	21.5	21.9	108	97	102
N_4- 75 % RDN through *Gliricidia* + 25 % RDN through urea	212	209	210	21.9	21.3	21.6	105	96	101
SEm±	5	4	4	0.5	0.4	0.5	2	2	2
CD (*P*=0.05)	13	12	13	1.3	1.3	1.3	6	6	6

RDN= Recommended dose of Nitrogen; Interaction not significant

reported that delayed transplanting in July compared to June resulted in sharp reduction in grain yield due to reduction in favourable growing period. Further wider spacing may increase yield per plant but may often lead to a decrease in grain yield per unit area due to less plant population. This is true in the present findings. Closer spacing gave higher yield in comparison with wider spacing. Karmakar *et al*. (2004) reported that closer spacing gave higher yield in comparison with wider spacing. Number of seedlings hill-1 had no significant effect on yield. Though planting two seedlings/hill recorded numerically higher grain and straw yield but it was in close comparison with one seedling/ hill. Similar findings were reported by Latif *et al*. (2009).

Table 3. Influence of management practices on grain yield (kg/ha) of rice

M x H x N	N_1			N_2			N_3			N_4			Mean		Mean
	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	
Grain yield (2007)															
M_1	4385	4684	4535	5135	4385	4760	4606	5748	5177	5059	4516	4788	4796	4833	4815
M_2	3529	4135	3832	4955	4992	4974	3979	4169	4074	3966	5104	4535	4107	4600	4354
M_3	4020	4363	4192	5500	3802	4651	5054	4572	4813	4563	3789	4176	4784	4132	4458
M_4	3498	4259	3878	3716	4246	3981	4214	3873	4043	3657	4324	3991	3771	4175	3973
Mean	3858	4360	4109	4826	4356	4591	4463	4590	4527	4311	4433	4372	4365	4435	
Grain yield (2008)															
M_1	4170	4231	4200	4995	4157	4576	4262	5076	4669	5037	4404	4721	4616	4467	4542
M_2	3231	3748	3489	4678	4805	4741	3472	4147	3810	3593	4892	4242	3743	4398	4071
M_3	3668	3972	3820	5202	3734	4468	4432	4518	4475	4141	3721	3931	4361	3986	4174
M_4	3341	3621	3481	3434	3711	3573	3967	3709	3838	3382	3718	3550	3531	3690	3610
Mean	3602	3893	3748	4577	4102	4340	4033	4363	4198	4038	4184	4111	4063	4135	
Pooled															
M_1	4278	4457	4368	5065	4271	4668	4434	5412	4923	5048	4460	4754	4706	4650	4678
M_2	3380	3941	3661	4817	4898	4857	3725	4158	3942	3780	4998	4389	3925	4499	4212
M_3	3844	4168	4006	5351	3768	4559	4743	4545	4644	4352	3755	4054	4573	4059	4316
M_4	3420	3940	3680	3575	3978	3777	4090	3791	3941	3519	4021	3770	3651	3933	3792
Mean	3730	4127	3928	4702	4229	4465	4248	4477	4362	4175	4309	4242	4214	4285	

M x H x N	2007		2008		Pooled	
	SEm±	CD (*P*=0.05)	SEm±	CD (*P*=0.05)	SEm±	CD (*P*=0.05)
M	69	237	66	231	68	234
H	66	NS	61	NS	64	NS
N	93	263	86	244	90	254
M at H	91	NS	86	NS	89	NS
M at N	175	512	163	481	169	496
H at N	102	NS	98	NS	100	NS
N at M	186	526	173	489	179	507

Application of 100 % RDN through urea recorded the highest grain (4,591 and 4,340 kg/ha) and straw yield (6,015 and 5,524 kg/ha) in 2007 and 2008 but it was on par with 50 % RDN through *Gliricidia* + 50 % RDN through urea and 75 % RDN through *Gliricidia* + 25 % RDN through urea. The interaction effect indicates that early planting in June second fortnight with closer spacing responded well for the integrated N management practices as compared to RDN through urea alone and accordingly higher

Table 3.1 Influence of management practices on straw yield (kg/ha) of rice

M x H x N	N1			N2			N3			N4			Mean		Mean
	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	Mean	H_1	H_2	
Straw yield (2007)															
M_1	5488	5902	5695	8154	7195	7675	8151	6411	7281	6222	7783	7003	7004	6823	6913
M_2	4964	5050	5007	5658	6053	5855	5168	4841	5005	5535	5390	5463	5331	5333	5332
M_3	4822	4983	4902	6380	5448	5914	5547	5193	5370	5219	5946	5582	5492	5393	5442
M_4	4900	4495	4698	4234	5000	4617	5566	5201	5384	5125	4721	4923	4956	4854	4905
Mean	5043	5107	5075	6107	5924	6015	6108	5412	5760	5525	5960	5743	5696	5601	
Straw yield (2008)															
M_1	4380	5641	5011	7890	6011	6950	7683	5569	6626	6194	6523	6358	6537	5936	6236
M_2	4844	4719	4781	4787	5880	5334	4586	4603	4594	4682	5379	5030	4725	5145	4935
M_3	4689	4667	4678	5427	5319	5373	4924	5466	5195	4390	5573	4982	4858	5256	5057
M_4	4846	3744	4295	4020	4857	4439	5011	4829	4920	4821	4533	4677	4675	4491	4583
Mean	4690	4693	4691	5531	5517	5524	5551	5117	5334	5022	5502	5262	5198	5207	
Pooled															
M_1	4934	5772	5353	8022	6603	7312	7917	5990	6954	6208	7153	6680	6770	6379	6575
M_2	4904	4884	4894	5223	5966	5595	4877	4722	4799	5109	5384	5246	5028	5239	5134
M_3	4755	4825	4790	5904	5384	5644	5236	5330	5283	4804	5759	5282	5175	5324	5250
M_4	4873	4119	4496	4127	4929	4528	5289	5015	5152	4973	4627	4800	4816	4673	4744
Mean	4867	4900	4883	5819	5720	5770	5830	5264	5547	5274	5731	5502	5447	5404	

M x H x N	2007		2008		Pooled	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
M	86	298	83	286	84	292
H	85	NS	78	NS	81	NS
N	120	340	110	313	115	326
M at H	114	NS	108	NS	111	NS
M at N	225	658	209	611	217	634
H at N	121	NS	116	NS	119	NS
N at M	240	680	221	626	231	653

grain yield (4,923 kg/ha) was recorded with the application of 50 % RDN through *Gliricidia* + 50 % RDN through urea and it was at par with 75 % RDN through *Gliricidia* + 25 % RDN through urea. *Gliricidia* green leaf manuring might have not only attributed steady and uninterrupted supply of nutrients throughout the crop growth period, but also increased the fertilizer use efficiency and improved the physical, chemical and biological properties of soil thereby paving the way for better utilization of nutrients resulting in similar trend in yield as compared to RDN only through urea. Moreover, higher yield under SRI can also be attributed to conoweeding as it minimizes the weeds besides increasing the soil aeration and root pruning.

Economics

The economic analysis revealed marked variation in cost of cultivation due to spacing (Table 4). Higher cost was incurred under the closer spacing (20x 20 cm) which reduced correspondingly with further widening in plant spacing (25 x 25 cm). This may be due to higher labour cost involved for transplanting and harvesting. Early planting in second fortnight of June at 20 x 20 cm recorded higher net returns (Rs. 31,768/ha) and net return per rupee invested (1.47). Two seedlings/hill recorded marginally higher net return (564/ha) over single seedling/ hill. Among the N management practices, though the net return was marginally higher (Rs. 327/ha) with the application of 100 % RDN through urea compared to application of 50 % RDN through *Gliricidia* + 50 % RDN Urea (N_3), the later resulted in higher net return per rupee invested (1.40) which indicates the positive effect of organics and fertilizer nitrogen on the grain yield.

Table 4. Influence of management practices on economics of rice

Treatment	Cost of cultivation			Gross return			Net return			Net return per rupee invested		
	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
Time of planting & spacing												
M_1 - June second fortnight + 20 x 20 cm	21,588	21,588	21,588	55,061	51,652	53,356	33,473	30,063	31,768	1.55	1.39	1.47
M_2 - June second fortnight + 25 x 25 cm	19,560	19,560	19,560	48,868	45,642	47,255	29,308	26,082	27,695	1.50	1.33	1.42
M_3 - July second fortnight + 20 x 20 cm	21,589	21,589	21,589	50,022	46,792	48,407	28,433	25,204	26,818	1.32	1.17	1.24
M_4 - July second fortnight + 25 x 25 cm	19,561	19,561	19,561	44,639	40,687	42,663	25,078	21,126	23,102	1.28	1.08	1.18
Number of seedling hill^{-1}												
H_1 - One seedling	20,521	20,521	20,521	49,343	45,826	47,585	28,822	25,305	27,064	1.40	1.23	1.32
H_2 - Two seedling	20,628	20,628	20,628	49,952	46,560	48,256	29,324	25,932	27,628	1.42	1.26	1.34
Nitrogen management												
N_1- 100 % RDN through *Gliricidia*	20,138	20,138	20,138	46,167	42,168	44,168	26,029	22,029	24,029	1.29	1.09	1.19
N_2- 100 % RDN through urea	21,422	21,422	21,422	51,929	48,919	50,424	30,507	27,497	29,002	1.42	1.28	1.35
N_3- 50 % RDN through *Gliricidia* + 50 % RDN through urea	20,496	20,496	20,496	51,027	47,314	49,171	30,531	26,818	28,675	1.49	1.31	1.40
N_4- 75 % RDN through *Gliricidia* + 25 % RDN through urea	20,242	20,242	20,242	49,466	46,372	47,919	29,224	26,130	27,677	1.44	1.29	1.37

RDN= Recommended dose of Nitrogen   * Data not statistically analysed

Energetics

Early planting in second fortnight of June at closer spacing of (20 x 20 cm) recorded significantly higher output energy (1,509 x 10^3 MJ/ha) followed by planting in second fortnight of July with 20 x 20 cm (Table 5). Among the N management practices, though N_2 (100 % RDN through urea) recorded the higher output energy (1,377 x 10^3 MJ/ha), it was at par with N_3 (50 % RDN through *Gliricidia* + 50 % RDN through urea) and N_4 (75 % RDN through *Gliricidia* + 25 % RDN through urea). Energy output depends on grain and straw yield. In the present investigation, the higher output energy recorded in early planting in second fortnight of June at closer spacing of 20 x 20 cm and application of 100 % RDN through urea (N_2) and N_3 (50 % RDN through *Gliricidia* + 50 % RDN through urea) confirms that it was mainly due to higher grain and straw yield obtained in the respective treatments.

Table 5. Influence of management practices on energetics of rice

Treatment	Output energy (10^3 MJ/ha)			Specific energy (MJ/kg)			Energy ratio		
	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
Time of planting & spacing									
M_1 - June second fortnight + 20 x 20 cm	1,571	1,447	1,509	2.27	2.40	2.34	15.1	13.9	14.5
M_2 - June second fortnight + 25 x 25 cm	1,306	1,215	1,260	2.53	2.73	2.63	12.7	11.8	12.2
M_3 - July second fortnight + 20 x 20 cm	1,335	1,245	1,290	2.50	2.66	2.58	12.9	12.0	12.5
M_4 - July second fortnight + 25 x 25 cm	1,197	1,103	1,150	2.74	3.01	2.87	11.6	10.7	11.1
SEm±	20	20	20	0.04	0.03	0.04	0.2	0.2	0.2
CD (*P*=0.05)	71	69	70	NS	NS	NS	0.8	NS	NS
Number of seedling $hill^{-1}$									
H_1 - One seedling	1,353	1,247	1,300	2.54	2.74	2.64	13.1	12.1	12.6
H_2 - Two seedling	1,352	1,258	1,305	2.48	2.66	2.57	13.0	12.1	12.6
SEm±	20	18	19	0.09	0.11	0.11	0.5	0.5	0.5
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen management									
N_1 - 100 % RDN through *Gliricidia*	1,238	1,137	1,187	2.76	3.02	2.89	11.7	10.7	11.2
N_2 - 100 % RDN through urea	1,426	1,328	1,377	2.39	2.53	2.46	14.0	13.1	13.5
N_3 - 50 % RDN through *Gliricidia* + 50 % RDN through urea	1,385	1,283	1,334	2.18	2.35	2.27	14.5	13.5	14.0
N_4 - 75 % RDN through *Gliricidia* + 25 % RDN through urea	1,360	1,262	1,311	2.71	2.90	2.80	12.0	11.2	11.6
SEm±	28	26	27	0.14	0.16	0.15	0.7	0.6	0.7
CD (*P*=0.05)	80	74	77	0.41	0.44	0.42	2.0	1.8	1.9

RDN= Recommended dose of Nitrogen; Interaction not significant

In contrast, specific energy and energy ratio was not significantly influenced by time of planting, spacing and number of seedlings/hill, but it was influenced by N management practices. Specific energy, a measure of energy required to produce one kilogram of paddy was higher (2.89 MJ/Kg) with application of 100 % RDN through *Gliricidia* (N_1) was mainly due to lesser grain yield coupled with more energy intake in terms of inputs. Similar findings were reported earlier by Ravisankar *et al*. (2008). Similarly the energy ratio indicates the ratio in terms of energy between output and input, which was higher under N_3 (50 % RDN through *Gliricidia* + 50 % RDN through urea). This might be due to the combined effect of reduced energy consumption and more output in terms of grain and straw yield. This is in agreement with the findings of Balakrishnan *et al*. (2010).

Thus, it can be concluded that early planting in June second fortnight using single seedling in 20 x 20 cm spacing with application of 50 % N through *Gliricidia* and 50% N through urea can be recommended for achieving higher yield and net return of rice under SRI practice in Island ecosystem.

References

Anchal Dass, Sudhishri, S. and Lenka, N. K. 2009. Integrated nutrient management for upland rice in eastern ghats of Orissa. *Oryza,* **46**: 220-226.

Andaman & Nicobar Administration. 2009. Basic statistics-2. *Directorate of Econ and Stat*., p 8-12.

Balakrishnan, M., Ravisankar, N., Swarnam, T.P. and Din, M. 2010. Influence of prickly sesban (*Sesbania cannabina*) intercropping in wet-seeded rice (*Oryza sativa*) on productivity, profitability, energetic and nitrogen balance under island ecosystem. *Indian J. Agric. Sci.,* **80**: 21-23.

Choudhury, B. U., Anil Kumar Singh, Bouman, B.A.M. and Jagdish Prasad, 2007. System of Rice Intensification and irrigated transplanted rice: Effect on crop water productivity. *J. Indian Soc. Soil Sci.,* **55**: 464.470.

Gill, M.S., Ashwani Kumar and Pardeep Kumar, 2006. Growth and yield of rice (*Oryza sativa*) under various methods and times of sowing. *Indian J. Agron.,* **51**: 123-127.

Karmakar, B., Ali, M.A., Mazid, M. A., Duxbury, J. and Meisner, C.A. 2004. Validation of System of Rice Intensification (SRI) practices through spacing, seedling age and water management. *Bangladesh Agron J.,* **10**: 13-21.

Latif, M.A., Ali, M.Y., Islam, M.R., Badshah, M.A. and Hasan, M. S. 2009. Evaluation of management principles and performance of the system of rice intensification (SRI) in Bangladesh. *Field Crops Res.,* **114**: 255-262

Mittal, V.K., Mittal, T.P. and Dhawan, K.C. 1985. Research bulletin on energy requirements in agriculture sector. *Punjab Agric Uni.*, Ludhiana.p 20-23.

Natarajan,S., Kuppuswamy, G., Arivahagan, K and Thirukumaran, K. 2005. Effect of organic manure application in rice. *Oryza* **42**: 319-320.

Nayak, B.C., Dalei, B.B. and Choudhury, B.K. 2003. Response of hybrid rice (*Oryza sativa*) to date of planting, spacing and seedling rate during wet season. *Indian J. Agron.,* **48**: 172-174.

Osaki, M., Shinano, T., Matsumoto, M., Zheng, T. and Tadano T. 1997. A root-shoot interaction hypothesis for high productivity of field crops. *Soil Sci and Plant Nutri.,* **43**: 1079-1084.

Ravisankar, N., Raja, R., Din, M., Elanchezhian, R., Swarnam, T. P., Deshmukh, P. S and Ghoshal Chaudhuri, S. 2008. Influence of varieties and crop establishment methods on production potential, economics and energetic of wet-seeded rice (*Oryza sativa)* under Island ecosystem. *Indian J. Agric Sci.,***78** : 807 – 809.

Salem, A. K .M. 2006. Effect of Nitrogen levels, plant spacing and time of Farm Yard Manure application on the productivity of rice. *J. Applied Sci Res.,* **2**: 980-987

Sengar, S. S, Wade, I. J., Baghel, S. S., Singh, R. K and Singh G. 2000. Effect of nutrient management on rice in rainfed low land of southeast M.P. *Indian J. Agron.,* **45**: 315-322.

Singh, G, Kumar, T., Kumar, V., Singh, R. G and Sharma R B. 2002. Effect of integrated nutrient management on transplanted rice (*Oryza sativa*) and its residual effect on succeeding wheat (*Triticum aestivum*) crop in rainfed lowlands. *Indian J. Agron.,* **47**: 311-317.

Swaminathan, M.S. 2006. Science and shaping the future of rice. *In Proc 2nd Int. Rice Cong.*, New Delhi. p .1.

Uphoff, N. 2002. System of Rice Intensification (SRI) for enhancing the productivity of land, labour and water. *J. Agric. Res. Management,* **1**: 43-49.

Uphoff, N. 2003. SRI – Higher yields with fewer external inputs? The system of rice intensification and potential contributions to agricultural sustainability. *Int. J. Agricultural Sustainability,* **1**: 38-50.

Received: February 15, 2012; Accepted: May 23, 2012