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Influence of non-monetary inputs on growth and yield of rice (*Oryza sativa*) under system of rice intensification (SRI)

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ABSTRACT

Field experiments were carried out from 2003 to 2005 at Agricultural College and Research Institute, Killikulam, Tamil Nadu to optimize the establishment techniques of System of Rice Intensification (SRI). The treatments consisted of types of nursery and age of seedling in main plot, three different plant geometry in sub-plot and two number of seedlings/ hill in sub sub-plot and replicated thrice. SRI and conventional nursery with 14-days-old seedlings had registered statistically similar yields as that of conventional nursery with 21 days old seedlings. However, conventional nursery recorded higher nutrient uptake leading to more depletion of soil fertility. Closer spacing (20 cm x 20 cm) had higher number of productive tillers/m^2 (491) but number of filled grains/ panicle (116.7) are lower resulting in significantly higher grain (8.0 t/ha) and straw yield (9.1t/ha). Number of seedlings/hill failed to exert any significant influence on either yield, nutrient uptake or residual soil fertility.

Key words: Density, Highlands, Lighting, Seedlings, Transmission, Yield

Rice (*Oryza sativa* L.) is the staple food for nearly 3 billion people, and demand continues to grow as population increases (Carriger and Vallee, 2007). In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 44.6 m ha (Mangala Rai, 2004) with a production of 132 m t of rice with average productivity of 2.96 tonne/ha. Rice production in India had increased in the past three decades continuously beginning with the green revolution, but has stagnated since 1999 (USDA, 2004). It is estimated that by 2020 at least 170 to 180 m t (115-120 m t milled rice) of rice is to be produced in India with an average productivity of 4.03 tonne/ha to maintain the present level of self sufficiency (Mishra *et al.*, 2006), which means, the productivity should go up by a tonne from the current level. With many constraints, producing more rice from the same land to feed additional population is a great challenge. The solar radiation requirement of rice crop differs from one growth stage to another stage. On an average about 75% of the incident radiation is absorbed by the plant canopy, about 15% is reflected and 10% is transmitted. Factors affecting the distribution of radiation are type of plants, age of the leaf, chlorophyll content, arrangement of leaves, angle of leaves and plant density. Manipulation of planting geometry appears to have a promising potential for increasing the rice yield, as it is assumed to have pronounced effect on tillering, interception and utilization of light which in turn influence the rice yield (Alexander *et al.,* 1988). System of rice intensification (SRI) needs to be compared with conventional method of cultivation in order to elucidate the parameters contributing for yield determination under system of rice intensification method. Hence, a study was conducted to find out the influence of non monetary inputs on growth and yield of rice under system of rice intensification.

MATERIAL AND METHODS

Field experiments were carried out during *rabi* 2003-04 to 2004-05 at Agricultural College and Research Institute, Killikulam (located at 8° 46' N latitude and 77° 42' E longitude at an altitude of 40 m above mean sea level), Tamil Nadu. The soil was sandy clay in texture medium in organic carbon (0.58%), available nitrogen (270.6 kg/ha), phosphorus (18.7 kg/ha) and potassium (224.0 kg/ha). Experiment was conducted in split-split plot design by assigning type of nursery with age of seedlings (system of rice intensification nursery at 14-days-old, conventional nursery at 14-days-old and conventional (SRI) nursery at 21-days-old) in to main plots while three spacing (20 cm x 20 cm, 25 cm x 25 cm & 30 cm x 30 cm) assigned to sub-plots. In sub-sub-plots, number of seedlings/hill (single and double) was assigned. The intensity of solar radiation

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falling above the canopy (Ia), middle and also below the canopy (Ib) in all directions was measured and worked out at flowering stages with lux meter. The Light Transmission Ratio (LTR) is worked out (Ib÷Ia x100) as per the procedure suggested by Yashida *et al*. (1972). The recommended dose of fertilizer (120: 38: 38 kg N:P:K/ha) was applied through urea, single super phosphate and muriate of potash. Nitrogen was applied in four splits at 10, 20, 30 and 40 days after planting (DAP) while entire phosphorus and 50% potassium were applied as basal. Remaining potassium was applied at 20 DAP. Paddy 'ADT 43', having a duration of 110 days, was used for the study. Land was prepared during second week of November while planting was taken up in first week of December in both the years. The crop was harvested during third week of March. The plots were irrigated to 2.5 cm depth after the formation of hairline cracks on the soil surface from planting to panicle initiation. Need based plant-protection measures were given whenever the incidences (leaf folder) were more than economic threshold level. Growth and yield parameters were recorded as per standard procedures. Economics was calculated based on the input and output prices.

RESULTS AND DISCUSSION

Growth attributes

Nursery type and age of seedlings did not exert any influence on plant height and leaf area index at flowering in both the years (Table 1). Light transmission ratio at flowering was significantly influenced by nursery type and age of seedlings in 2003-04. However, in 2004-05 they did not influence light transmission ratio which could be attributed to weather factors especially light availability during the year.

Closer spacing (20 cm x 20 cm) led to significantly taller plants (92.5 cm) and leaf area index (5.82) compared to other two spacing in both the years. Leaf area index at flowering was significantly influenced by spacing in 2003-04, however, it was not influenced by spacings during 2004-05 due to the weather factors limiting growth of leaf production. Leaf area index however, followed a reverse trend of plant height and was highest with 20 cm x 20 cm spacing where as 30 cm x 30 cm registered the least value. Similar trend was earlier reported by Long Xing and Shaokai (2002).

Number of seedlings had significant influence on plant height (Table 1). However, they failed to exert any influence on leaf area index. Single seedling/hill is better than double seedling for plant height. Similarly, LTR was significantly lower in double seedlings/ hill (45.56) when compared with single seedling/hill (47.05) Radha Krishna Murthy (2002) also reported similar findings.

Crop growth rate

Age of seedlings and nursery has significant influence on crop growth rate (CGR) at flowering to maturity in

Table 1. Effect of age and number of seedlings, nursery type and spacing on growth, yield parameters and crop growth rate (CGR) of rice

Treatment	Plant height (cm)		LAI at flowering		LTR at flowering		CGR (kg/ha/d) at flowering to maturity		Panicles/m^2		Filled grains /panicle	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Types of nursery and age of seedling (days)												
SRI and 14 days	87.0	84.6	5.81	5.30	46.85	45.91	172.1	178.3	437	431	126.8	121.8
Conventional and 14 days	86.1	88.6	5.95	5.56	49.56	44.61	172.5	181.2	449	449	118.5	129.1
Conventional and 21 days	87.6	86.1	5.81	5.44	44.83	45.23	163.3	180.1	424	436	129.0	127.9
SEm±	0.8	1.6	0.07	0.10	0.52	0.78	3.0	3.3	5	6	1.5	1.5
CD (P=0.05)	NS	NS	NS	NS	1.81	NS	10.3	NS	18	NS	5.2	NS
Spacing (cm x cm)												
20 x 20 cm	89.2	95.8	5.89	5.74	39.69	41.99	177.5	189.4	489	493	115.1	118.2
25 x 25 cm	86.1	84.8	5.85	5.46	49.67	45.26	165.1	180.3	419	433	125.2	126.9
30 x 30 cm	84.5	78.6	5.76	5.11	52.73	48.49	155.7	169.9	378	390	132.4	133.7
SEm±	0.8	1.0	0.04	0.06	0.36	0.47	2.6	2.0	4	4	0.9	1.2
CD (P=0.05)	2.3	3.0	NS	0.19	1.07	1.43	7.6	6.1	10	13	2.8	3.7
Number of seedlings/hill												
Single	88.2	88.7	5.84	5.48	48.06	46.03	164.5	177.4	428	436	123.4	125.5
Double	85.0	84.1	5.83	5.38	46.66	44.46	167.7	182.4	430	441	125.1	127.1
SEm±	0.7	0.9	0.04	0.06	0.33	0.44	2.2	1.9	2.8	3.5	0.8	1.0
CD (P=0.05)	2.0	2.7	NS	NS	0.94	1.30	NS	NS	NS	NS	NS	NS

2003 to 04 only (Table 1). Conventional nursery with 14 days old seedlings recorded 5.6% higher (CGR) than SRI nursery with 14-days-old seedlings. Among the spacing tested, 20 cm x 20 cm led to significantly higher CGR in both the years and 30 x 30 cm recorded the least CGR values. Number of seedlings/hill did not exert any influence on crop growth rate on both the years. This corroborates the findings of Goswami and Sujoy Dutta (2005).

Yield parameters

What was true of growth parameters is also true for yield parameters. In 2003-04, productive tillers/m^2 and filled grains/panicle was significantly influenced by age of seedlings and nursery type. Though conventional nursery with 14-days-old seedlings had registered higher productive tillers/m^2 (449) and filled grains/panicle (129.0) in 2003-04, however in 2004–05, all the treatments remained at par.

Spacings have significant effect on yield parameters of rice. Closer spacing of 20 cm x 20 cm had higher number of productive tillers/m^2 (491) but, it registered lower number of filled grains/panicle (116.7). The trend observed indicates that with increase in spacing, the productive tillers/m^2 decreased while filled grains/panicle increased. More number of productive tillers in closer spacing might be the cause for lower number of filled grains/panicle due to more competition for all resources, since; sink is divided between productive tillers and grains/panicle. Similarly number of seedlings/hill also failed to exert any significant influence on yield parameters.

Yield

Grain and straw yield was not influenced by type of nursery, age of seedlings and number of seedlings/hill. This could be attributed to little influence of these factors on CGR, nutrient uptake and consequently yield parameters and yield. Significantly higher grain (8.0 tonne/ha) and straw yield (9.15 tonne/ha) was recorded with 20 cm x 20 cm spacing followed by 25 cm x 25 cm. 30 cm x 30 cm spacing led to 11% yield reduction over 20 cm x 20 cm spacing. Higher yield under closer spacing was mainly due to more number of panicles/m^2 and grains/ panicle. It corroborates the findings of Singh and Singh (2005). Straw yield also followed similar trend as that of grain yield.

Nutrient uptake

Type of nursery and age of seedlings influenced N uptake at maturity. Fourteen-days-old seedlings from conventional type of nursery had higher N uptake compared to SRI method. However, nursery type and age of seedlings did not significantly influence P and K uptake. Higher N uptake in younger seedlings could be attributed to increased root length, root volume which might have enabled more absorption area. Rajesh and Thanunathan (2003) also reported similar results. Closer spacing registered significantly higher nutrient (N P K) uptake when compared with wider spacing which is probably due to more population in a unit area. A mean N, P and K uptake

Table 2. Influence of age and number of seedling, nursery type and spacing on nutrient uptake (kg/ha) and yield (tonne/ha) of rice

Treatment	Nitrogen		Phosphorus		Potassium		Grain yield		Straw yield	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Types of nursery and age of seedling (days)										
SRI and 14 days	112.9	115.6	38.61	39.60	133.0	136.2	7.6	7.7	8.6	8.6
Conventional and 14 days	116.8	118.2	39.68	40.25	137.5	139.2	7.8	7.8	8.5	8.8
Conventional and 21 days	107.4	116.2	36.82	39.86	126.6	137.0	7.3	7.8	8.1	8.7
SEm±	2.0	2.2	0.34	0.75	1.2	2.6	0.1	0.2	0.1	0.2
CD (P=0.05)	6.9	NS	1.17	NS	4.1	NS	0.5	NS	0.5	NS
Spacing (cm x cm)										
20 x 20 cm	118.5	124.8	40.25	42.37	139.4	146.9	7.8	8.2	9.0	9.3
25 x 25 cm	109.3	115.2	37.47	39.48	128.8	135.8	7.4	7.7	8.2	8.5
30 x 30 cm	102.2	109.9	35.19	37.86	120.6	129.8	7.0	7.3	7.8	8.4
SEm±	1.7	1.3	0.37	0.45	1.3	1.5	0.1	0.1	0.1	0.1
CD (P=0.05)	5.1	4.0	1.13	1.37	3.9	4.7	0.3	0.3	0.4	0.3
Number of seedlings/hill										
Single	109.5	115.5	37.42	39.36	128.8	135.9	7.4	7.6	8.4	8.6
Double	110.5	117.8	37.86	40.45	130.4	139.1	7.5	7.8	8.4	8.8
SEm±	1.4	1.2	0.30	0.42	1.0	1.5	0.1	0.1	0.1	0.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Soil nutrient status (kg/ha) after harvest of rice as influenced by age and number of seedlings, nursery type and spacing

Treatment	Available N		Available P		Available K	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Types of nursery and age of seedling (days)						
SRI + 14 days	208.9	222.6	15.7	14.1	212.7	239.4
Conventional + 14 days	200.0	213.6	15.1	13.7	205.6	231.6
Conventional + 21 days	219.5	218.7	16.5	13.9	221.5	235.8
SEm±	1.6	3.9	0.1	0.3	1.7	4.2
CD (P=0.05)	5.6	NS	0.4	NS	5.7	NS
Spacing (cm x cm)						
20 x 20	199.6	204.1	15.1	13.0	203.5	220.2
25 x 25	211.2	217.3	15.9	14.0	218.0	234.6
30 x 30	228.3	233.5	17.0	14.8	230.0	252.1
SEm±	2.0	2.3	0.2	0.2	2.0	2.4
CD (P=0.05)	5.9	6.9	0.5	0.5	6.0	7.5
Number of seedlings/hill						
Single	213.3	220.0	16.1	14.1	220.4	237.4
Double	212.7	216.6	15.8	13.8	213.9	233.9
SEm±	1.7	2.2	0.1	0.1	1.7	2.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS

of 121.7, 41.3 and 143.2 kg/ha was recorded with of 20 cm x 20 cm spacing (Table 2). However, nutrient uptake was not influenced statistically by number of seedlings/ hill. It is in line with the findings of Ancy and Subbalakshmi (2006).

Soil nutrient status

Soil nutrient status in terms of available N, P and K was assessed at harvest stage which indicated, type of nursery and age of seedlings had significant effect on available N but not on available P and K status. Available N was significantly lower (206.8 kg/ha) in conventional nursery with 14-days-old seedlings which might be due to higher uptake of nutrients. Various spacings exerted significant influence on status of available nutrients of soil. Significantly lower available N (201.8 kg/ha), P (14.1 kg/ha) and K (211.8 kg/ha) was observed under 20 cm x 20 cm and highest at wider (30 cm x 30 cm) spacing (Table 3). Lower available nutrient status under closer spacing could be attributed to higher biomass production and uptake. Number of seedlings had no influence on available nutrient status of soil. Findings of Mohammad Safdar Baloch *et al.* (2006) also states that available nutrient status gets depleted as a consequence of biomass production under best combination of non monetary inputs.

Thus, it can be concluded that transplanting of 14-days-old single or double seedlings raised under conventional method with the spacing of 20 cm x 20 cm can be recommended for realizing efficient use of resources and productivity in Killikulam region of Tamil Nadu.

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