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Effect of younger seedlings / direct wet seeding over conventional transplanting in lowland hybrid rice

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Abstract : Two field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, India in the wet (September 2001 to January 2002) and dry seasons (February to June 2002) aimed at understanding the effect of different crop management practices on rice yield. Four crop management practices were investigated with two levels: crop establishment (transplanting of 23 d old seedlings vs. 14 d old seedlings in wet season and direct sowing in dry season), Irrigation (conventional flooded irrigation vs. water saving irrigation), weeding methods (manual vs. mechanical weeding) and nutrient management (recommended amount of fertilizers without vs. with green manure). There was no grain yield advantage for planting 14 days old seedlings compared to 23 days old conventional seedlings, though produced higher tillers and spikelets, but because of increased sterility and reduced grain weight in wet season. In dry season, direct wet seeding to 20x20cm spacing was better than transplanting due to higher number of filled grains per unit area, in spite of higher sterility and reduced grain weight. Modified method of planting either younger seedlings/direct sowing is an alternate to the conventional method of planting irrespective of the season or variety. Its superiority lies only when it combines with appropriate irrigation and weed management practices. The water saving irrigation is suitable for the wet season but not for the dry season since it affects the spikelet formation.

Keywords: Rice, younger seedlings, direct sowing, mechanical weeding

Introduction

Rice, the staple food of Asians, occupies an area of 44.9 million hectares in India. Tamil Nadu alone contributes nearly 8 per cent of the national rice production from an area of 2.1 million hectares, with a production of 6.58 million tonnes. India is the second highest populated country in the world and the population is still growing at exponential rate. To sustain the present food self sufficiency and to meet future food requirements, India has to realize an annual growth in rice productivity at least 3 per cent (Thiyagarajan and Selvaraju, 2001). Considering the future food requirements, new methods of rice cultivation have to be identified to increase the crop productivity.

In India, rice is grown under different ecosystems characterized by dominant agro-ecological situations. Transplanted/wet seeded lowland, transplanted / direct seeded, semi dry irrigated lowland (rainfed tanks) and rainfed upland (unbunded) cultural systems are widely practiced. The problems and prospects of its production in different ecosystems vary greatly.

This paper describes the results of two field experiments aimed at understanding the effect of different crop management practices on rice yield. The practices have been derived from the concept of the System of Rice Intensification (SRI) developed at Madagascar (Uphoff, 1999). In these two field experiments,

Table 1. Crop management practices adopted in conventional and modified planting

Management factor		Alternatives
Crop establishment (P)	P_1	Conventional planting (24 day old seedlings; single seedling per hill)
	P_2	Modified SRI planting. In the wet season, 14 days old single seedling per hill. In the dry season, direct wet seeding, 2-3 seeds manually sown but later thinned to single seedling per hill.
Irrigation (I)	I_1	Conventional irrigation (irrigating to 5 cm depth one day after disappearance of surface water).
	I_2	Water saving irrigation after crop establishment (irrigating to 2 cm depth after surface crack development). In the wet season, water saving irrigation up to flowering and followed by conventional irrigation during grain filling. In dry season, water saving irrigation till maturity.
Weed management (W)	W_1	Conventional weeding. In the wet season, weeds removed by manual weeding (three times). In the dry season, pre-emergence application with herbicide Butachlor followed by manual weeding (Two times).
	W_2	Weeds mechanically incorporated with a rotary weeder, crisscross used five times during the growing season.
Nutrient management (N)	N_1	Recommended amount of N (150 kg ha^{-1}), P_2O_5 (60 kg ha^{-1}), K_2O (90 kg ha^{-1}) and Zn in splits applied.
	N_2	The same as N_1 plus green manure (fresh weight 6.25 t ha^{-1})

four crop management factors were investigated, each with two alternatives (Table 1). Nevertheless, the results of the first factor alone (Crop establishment; conventional planting vs. modified planting) is described in detail in terms of number of days required for different crop growth stages, tiller density, spikelet sterility and grain yield are presented.

Materials and Methods

Two field experiments were conducted in the wetlands of Tamil Nadu Agricultural University (11°N 77°E). The first experiment was in the wet season (September 2001-January 2002 with rice hybrid CORH2 (125 days duration) and the second experiment in the dry season (February - June, 2002) with rice hybrid ADTRH1 (115 days duration)).

The experimental site had clay-loam soil with the pH of 8.3, its electrical conductivity was 0.54 dS m^{-1}, organic carbon content was 8.2 g kg^{-1}, available N ($KMnO_4$-N) was 232 kg ha^{-1}, Olsen-P was 32 kg ha^{-1}, and available K (NH_4OAc-K) was 740 kg ha^{-1}.

Plant density was 25 m^{-2} with the spacing 20 x 20 cm (square planting) for all treatments. Normal plant density is 50 m^{-2} (20 x 10 cm) for medium duration (125-135 d) and 66m^{-2} for short duration (105-115 d) rice in Tamil Nadu. The treatment combinations were replicated four times in a strip plot design. Irrigation water was measured using a parshall flume from transplanting. Rainfall during the growing season was also quantified.

The crop growth characters were recorded at different growth stages of the crop. Tiller density was recorded by counting the mean number of tillers in 20 hills per plot. For total biomass production of the crop, the sample plants along with roots were collected and oven dried for 48 hours at 70°C and recorded as kg ha^{-1}. The yield attributing characters such as total spikelet number m^{-2}, total filled grain number m^{-2}, sterility percentage and single grain weight were recorded. Grain yields were at 14 % moisture. Plant samples were collected as suggested by Thiyagarajan *et al.* (1995) and the crop data were analyzed using GENSTAT (Payne *et al.*, 2002) in Plant Research International, The Netherlands. In both experiments the same management factors were investigated each with two alternatives.

Results and Discussion

Methods of stand establishment did not vary in total field duration (Table 2). Rice hybrid CORH2 cultivated in wet season had a total duration of 131 days, whereas the other hybrid ADTRH1 cultivated during dry season had a total duration of 113 days. Variety and seasonal variations were the major causes for the variation in field duration. Actual field duration for the hybrid CORH2 (planting to maturity) was shortest (108 days) in conventional planting (P_1) compared to 117 days for younger seedlings (P_2) (Table.2). These variations were accounted between transplanting and active tillering. Differences were accounted for 9 extended days, during establishment, to younger seedlings (36 days). After active tillering till maturity there was no differences in crop growth stages.

There were contradicting statements for enhanced or reduced or equal total duration (seed to seed) for direct seeding and transplanting. Direct seeding with a spacing of 20x20cm and later thinning the extra plants to single as that of transplanted rice was better than transplanting with respect to grain yield. There was no planting shock as experienced in transplanting besides, the tillering started at the earliest and produced higher than the transplanted, were all the reasons for the higher yield in direct seeded. The productive tillers m^{-2} were significantly less in transplanted treatment as compared to those in direct seeded ones (Sharma, 1996; Zhu-Guan and Zhu, 1996; Ye-Ding Chi and Ye, 1997). According to Rillon and Justo (1998), direct seeding is an attractive alternative to transplanting, mainly due to ease of crop establishment and to the elimination of labor cost from pulling, hauling and transplanting of seedlings in the field.

Actual field duration of ADTRH1 in conventional planting was only 91 days, whereas; direct seeding took 113 days to complete the life cycle. The variation of 22 days were mainly accounted to the period between active tillering to panicle initiation in young seedlings (Table.2), wherein, direct sowing had taken longer period to produce more

Table 2. Duration of different growth stages (in days) in wet and dry season (2001-2002)

Crop growth stages	Wet season (CORH2)		Dry season (ADTRH1)	
	Conventional (P_1)	SRI (P_2)	Conventional (P_1)	SRI (P_2)
Transplanting to Active tillering	27	36	19	19
Active tillering to Panicle initiation	20	20	18	36
Panicle Initiation to Flowering	25	25	24	26
Flowering to Harvesting	36	36	30	32
Total field duration	108	117	91	113

Table 3. Total tillers and productive tillers (m^{-2}) at various growth stages as influenced by planting methods

Treatments	Active tillering	Panicle initiation	Flowering	Grain filling	Harvest	
					Total tillers	Prod. tillers
a) Wet season (CORH2)						
Conventional planting	325	469	494	438	284	243
Modified SRI planting	291	569	578	500	373	287
CD(5%)	NS	38.7	26.9	19.2	41.4	29
b) Dry season (ADTRH1)						
Conventional planting	129	416	475	389	393	328
Modified SRI planting	350	573	632	476	480	400
CD(5%)	86.9	64.4	50.6	56.6	62.6	34

NS: Not Significant; CD (5%): Critical Difference at 5%probability level.

tillers and biomass, which ultimately reflected in the yield parameters.

In between panicle initiation and flowering, there were four extended days for direct seeded crop which ultimately reflected on the grain yield difference, wherein direct seeding was better than transplanting. The duration between panicle initiation to flowering was longer in winter, 61 days, compared to 54 -58 days in dry season (ADRTH1) (Table 2). The average grain yield variation between winter sown CORH2 (6406 kg ha^{-1}) and summer sown ADTRH1 (6331 kg ha^{-1}) might be attributed to the extended field duration during reproductive period (panicle

Table 4. Yield and yield parameters as influenced by the conventional and modified planting in rice hybrid CORH2 and ADTRH1

Particulars	Wet season (CORH2)			Dry season (ADTRH1)		
	Conv. (P_1)	SRI (P_2)	CD (5%)	Conv (P_1)	SRI (P_2)	CD (5%)
Total number of spikelets m^{-2}	54175	65778	6472	50237	65759	7664
Filled grain number m^{-2}	36489	38534	NS	30216	33218	NS
Single grain weight (mg $grain^{-1}$)	23.22	22.88	0.305	20.88	20.55	0.146
Water used ($1000m^3$ ha^{-1})	11.95	13.58	-	10.37	13.09	-
Harvest index	0.403	0.382	NS	0.476	0.452	NS
Total dry weight at harvest (t ha^{-1})	15.74	17.46	NS	12.63	14.45	1.73
Grain yield (t ha^{-1})	6.27	6.54	NS	6.05	6.61	0.31

NS: Not Significant; CD (5%): Critical Difference at 5%probability level.

initiation to maturity). Normally grain yield advantage of 300 kg day^{-1} can be expected under typical situation (Penning de Vries *et al.*, 1989).

In wet season with the rice hybrid CORH2, the total biomass did not significantly vary for conventional (P_1) (15740 kg ha^{-1}) and young seedlings (P_2) (17458 kg ha^{-1}). But the total tillers and the productive tillers were higher for younger seedlings (Table 3). The conversion of tillers to productive tillers was higher with conventional seedlings (86%) compared to the younger seedlings (77%), consequently there was no variation in the grain yield. In the dry season with the rice hybrid ADTRH1, the total biomass significantly varied for conventional (P_1) (12625 kg ha^{-1}) and direct seeded SRI method (P_2) (14446 kg ha^{-1}) and it corresponded to the significant yield difference. The total tillers for all the growth stages and the productive tiller at harvest were significantly higher for the modified planting which directly correlated to the yield advantage over the conventional planting (Fig1).

Total number of spikelets per unit area was higher for younger seedlings (P_2) in wet season and direct seeded SRI (P_2) in dry season compared to conventional method of transplanting (Table 4), but the percentage of sterility was higher in the younger and direct sown SRI methods, which ultimately could not maintain the spikelets advantage to end up with final rice grain yield. Conventional planting was found advantageous for the individual grain weight (Table 4), compared to younger seedlings. Higher grain weight and filled grain percentage recorded under conventional seedlings compared to other methods might be attributed to relatively less competition to resources to fill the spikelets into filled grains. Whereas, in SRI method the tiller production was higher, but not all the tillers converted as productive, might be the spacing should be more than 20 x 20cm tested here.

Water requirement for establishment of younger seedlings (wet season) and direct wet seeding (dry season) was higher compared to conventional method of transplanting simply because of extended field duration for these two methods of crop establishment (Table 2 and 4).

There was no difference in grain yield for the conventional and younger seedlings in wet season, whereas in dry season direct sown SRI was superior to the conventional seedling (Table 4). Harvest Index estimated did not vary for the methods of stand establishments in both the seasons. The HI measured in the wet season was rather low (0.393) compared to (0.467) in dry season. Though the biomass was higher in the wet season, there was no grain yield advantage compared to dry season.

From the study it is concluded that planting younger seedlings (modified planting) behaved alike the conventional planting. Younger seedlings attributed to more tiller production, higher number of spikelets per unit area but it did not reflect on final grain yield because of the high sterility percentage and reduced grain weight. In case of direct sowing (modified SRI planting), it was superior to conventional planting in terms of tiller density, higher number of filled grains per unit area and increased grain yield in spite of higher sterility and reduced grain weight.

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