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Evaluation of Crop Establishment Techniques and Weed Management Practices Under System of Rice Intensification

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Field experiments were conducted during *rabi* 2007 -08 and 2008-09, to evaluate crop establishment techniques and weed management practices under System of Rice Intensification. The experiments were laid out in split plot design with three replications. The main plot consisted of three age of seedlings *viz*., 14, 18 and 22 days old with two levels of planting methods *viz*., SRI planting and mechanical planting. Four weed management practices *viz*., hand weeding twice at 25 and 45 DAT, mechanical weeding thrice at 10, 25 and 45 DAT, pre emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT and unweeded check were assigned to sub plot. Transplanting of 14 days old seedlings with manual planting and pre emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT significantly reduced the weed density, weed DMP, nutrient removal and improved the growth parameters, yield attributes and yield of rice.

Key words: SRI, age of seedlings, mechanical weeding, butachlor

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Rice (*Oryza sativa* L.) is the major source of food for nearly half of the world's population. Cultivation of rice and its productivity is a challenge of coming decades due to potential changes in temperature, precipitation and sea level, as a result of global warming. Geometric growth of population and arithmetic increase in food grain production leave a vast gap in food supply. This gap is further widened due to urbanization and industrialization of fertile lands. In the global scenario, the present population of 6 billion is expected to reach 9 billion by 2050 (FAO, 2001). The global requirement of rice by 2025 AD would be 800 million tones, which is 26 per cent higher than the present level of production. In India, it is grown over an area of 44.6 million ha (m.ha) with a total production of 87 million tonnes (m.t) in 2003-2004 amounting to 41.8 per cent of total food grain production (Malik *et al*., 2006). The SRI has its own components *viz.,* transplanting of young seedlings usually 12 to 14 days seedlings transplanted single seedling per hill at wider spacing in a square geometry and use of mechanical weeder, need-based fertilizer application and optimum use of water for better growth especially soil aeration (Kumar and Shivay, 2004). Due to wider spacing of 25 x 25 cm, there are more weeds with SRI than conventional cultivation (Jiaguo Zheng *et al*., 2004). Weed control is the major problem in SRI and hence effective weed management practices need to be explored in early stages. Weeding operations using mechanical weeder permit greater root growth through better soil aeration and organic matter addition (Anon., 2002). But, early and frequent weeding is essential otherwise the weed growth will become a problem (Vijaya Kumar *et al*., 2005). Farmers of Tamil Nadu are reluctant to use mechanical device for weeding

in 30 days old crop in main field due to the fact that it may damage the root and shoot system. Moreover, the farmers' response to the mechanical rotary weeder was not satisfactory due to its single man labourious operations and so preference goes to group weeding. Control early emerging weeds can be made only through pre-emergence application of herbicides. Further there was no adverse effect of herbicides on young seedling in SRI practices and herbicide use would significantly reduce the labour cost as opposed to intensive manual or mechanical weed control encouraged for SRI (Uphoff, 2002). Keeping all the above aspects in view, the present investigation was planned to evaluate the crop establishment techniques and weed management practices under SRI with the objectives to optimize the suitable weed management practices under SRI technology and to work out economics.

Material and Methods

Field experiments were carried out at Agricultural College and Research Institute, Madurai during *rabi* 2007-08 and 2008 -09. The experimental soil was sandy clay loam with pH of 7.5, medium in organic carbon (0.52), low in available nitrogen (245.3 kg ha^{-1}), medium in phosphorus (19.5 kg ha^{-1}), and potassium (249.5 kg ha^{-1}). The experiments were laid out in split plot design with three replications. The main plot consisted of age of seedlings and planting methods. Three age of seedlings *viz*., 14, 18 and 22 days old seedlings were evaluated with two levels of planting methods *viz*., SRI planting (25 x 25 cm) and mechanical planting (23.8 x 17 cm). Four levels of weed management practices *viz*., hand weeding twice at 25 and 45 DAT, mechanical weeding thrice at 10, 25 and 45 DAT, pre emergence application

of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT and unweeded check were assigned to sub plot. Medium duration rice cultivar ADT 39 was grown during *rabi* (October – February) season of the years 2007-08 and 2008-9. The nursery was prepared by the modified dapog mat nursery method. The seedlings were transplanted by transplanter which was wheel driven and fitted with diesel engine and riding type which transplants seedlings from mat type nursery in eight rows in a single pass and manual planting as per the treatments followed. Hand operated mechanical weeder (rotary weeder) developed by Department of Agricultural Engineering, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu was used for mechanical weeding. Application of pre-emergence herbicide butachlor @ 1.25 kg ha^{-1} on third day after transplanting was made. Nitrogen was applied as urea based on LCC schedule. The LCC values were recorded as per the standard procedure (IRRI, 1996) at weekly intervals starting from 14 DAT to flowering. Whenever LCC values were found to be below the fixed critical level (No. 4), nitrogen @ 35 kg ha^{-1} was applied. The entire dose of phosphorus (50 kg ha^{-1}) as single super shosphate (16 per cent P_2O_5) was applied as basal and potassium (50 kg ha^{-1}) in the form of muriate of potash (60 per cent K_2O) was applied in four splits *viz*., 25 per cent each at active tillering, panicle initiation, booting and flowering stages after the weeding was over. Zinc sulphate @ 25 kg ha^{-1} was applied as basal to crop during both the seasons. Appropriate need based plant protection measures were taken up to control pest and diseases. The data on weed population was subjected to square root transformation $\sqrt{(x+0.5)}$ before analysis. As the trend of data was similar in both years, pooled data are presented.

Results and Discussion

Weed flora

The weed flora observed in the experimental fields during the course of study consisted of grasses, sedges and broad leaved weeds. The predominant weeds were grasses followed by broad leaved weeds and sedges. *Echinochloa colonum, Cyperus rotundus* and *Marsilea quadrifoliata* were the dominant weed species respectively, recorded under grass, sedge and broad-leaved.

Effect on weeds

The plots transplanted with 14 days old seedlings recorded lower total weed density and weed dry weight. This might be due to the better nourishment of young seedlings resulting in more vigorous seedlings with efficient root system and so were able to use efficiently the various growth attributing resources and resulted in more number of tillers, larger leaf area and taller plants thereby they suppressing the weeds. Reduced weed density resulted in reduced weed dry weight and thereby minimum removal of nutrients (Anitha, 2005). Grass, sedge, broadleaved weeds, total weed density and weed dry weight were minimum with SRI planting when compared to mechanical transplanting. This is due to the planting at one young seedling per hill with SRI method which was nourished well resulting in more vigorous growth with efficient root system. This was able to use efficiently the various growth attributing resources and resulted in more number of tillers, larger leaf area and taller plants thereby they suppressed the weeds. Reduced weed density resulted in reduced weed dry weight and thereby minimum removal of nutrients (Ancy Francis, 2007).

Pre emergence application of butachlor combined with two mechanical weeding at 25 and 45 DAT resulted in excellent control of grasses, sedges and broad-leaved weeds because of the complete removal of late emerging weeds by mechanical weeding at 25 and 45 DAT. This is in conformity with the findings of Suseela (2006). Butachlor as pre emergence was able to inhibit and prevent the germination and growth of weeds during initial period. There was no adverse effect of herbicides on young seedlings in SRI practices and use of herbicide significantly reduced the labour cost as opposed to intensive manual and mechanical weed control encouraged for SRI (Uphoff, 2002). This was followed by mechanical weeding thrice and hand weeding twice Though the mechanical weeding thrice and hand weeding twice effectively controlled the weeds, it was expensive, time consuming and tedious. Application of pre emergence herbicide + two mechanical weeding effectively controlled the weeds and resulted in significantly lower nutrient removal by weeds (Table.1). This result is in line with the findings of Rana *et al*. (2000). This treatment effectively reduced the weed growth upto the critical period of weed competition in rice. This weed free environment helped rice plants to absorb nutrients and exhibit vigorous growth in all the critical stages of nutrient requirement which supported the crop to produce more DMP and suppressed the weeds in the later stage of crop. These results are in agreement with the findings of Narayanaswamy *et al*. (2006). The extent of weed competition in transplanted rice was assessed through nutrient removal by weeds. Weeds showed higher nutrient uptake under unweeded check and the weed dry weight was inversely proportional to the crop dry weight. This result is in line with the findings of Balasubramanian and Veerabadran (1998). More quantum of nutrient uptake by weeds resulted in the reduction of availability of nutrients to the crop which adversely affected the growth and finally the yield of rice crop under unweeded check situation. Weed dry weight and NPK removal by weeds were positively correlated.

Effect on growth and yield of rice

The age of seedlings, planting methods and weed management practices improved the growth parameters and yield by eliminating weed competition. The 14 days old seedlings recorded taller plants (96.1), and higher leaf area (Table 2). It was due to the fact that young seedlings had higher vigor and more

Table 1. Effect of age of seedlings, planting methods and weed management practices on total weed density, total weed dryweight and nutrient removal by weeds

(Pooled data of two years)

Treatment	Total weed density (No m^{-2})		Total weed (Kg ha^{-1})		Nutrient dryweight removal by weeds (kg ha^{-1})		
	40 DAT	60 DAT	40 DAT	60 DAT	N	P_2O_5	K_2O
Age of seedlings							
A_1 – 14 DAS	4.98 (25.43)	4.33 (22.73)	41.17	35.72	4.07	1.06	4.34
A_2 – 18 DAS	5.07 (26.94)	4.54 (24.30)	43.26	41.41	4.37	1.13	4.66
A_3 – 22 DAS	5.20 (27.04)	4.70 (25.67)	46.93	47.00	4.84	1.25	5.15
SEd	0.04	0.03	0.05	0.06	0.07	0.02	0.08
CD (P=0.05)	0.09	0.07	0.11	0.12	0.16	0.04	0.17
Planting methods							
P_1 – Machine planting	5.17 (28.20)	4.60 (25.14)	44.96	44.04	4.70	1.22	5.00
P_2–SRI planting (manual)	4.99 (25.93)	4.44 (23.32)	42.61	38.71	4.15	1.08	4.42
SEd	0.04	0.03	0.04	0.05	0.06	0.02	0.06
CD (P=0.05)	0.09	0.07	0.08	0.10	0.13	0.03	0.14
Weed management practices							
W_1 – Hand Weeding (twice)	4.83 (22.37)	3.93 (14.06)	33.78	27.77	4.56	1.19	4.82
W_2 – Mechanical Weeding (thrice)	4.46 (21.20)	3.33 (12.85)	31.17	25.53	4.09	1.05	4.31
W_3 – Butachlor @ 1.25 kg ai ha^{-1}+ MW (twice)	4.25 (18.13)	3.06 (9.54)	28.80	23.34	3.67	0.94	3.86
W_4 – unweeded	6.78 (46.58)	7.75 (60.47)	81.40	88.87	5.39	1.43	5.87
check SEd	0.05	0.04	0.06	0.07	0.10	0.03	0.11
CD (P=0.05)	0.10	0.08	0.12	0.14	0.21	0.05	0.22
Interaction Effects	NS	NS	NS	NS	NS	NS	NS

Figure in pareanthesies are original values

root growth which stimulated cell divisions causing more stem elongation resulted in increased plant height (Prema, 2007). Fourteen days old seedlings recorded maximum LAI (5.9). This could be attributed to the higher tiller number which resulted in more leaf number leading to higher LAI value. Young seedlings recorded better root growth and facilitated increased cell division and cell enlargement due to increased photosynthetic rate subsequently increasing the LAI (Shrirame *et al*., 2000) ultimately resulted in higher economic yields. In the present investigation, 14 days old seedlings gave in higher grain and straw yield to the tune of 50 and 49 per cent increase over 22 days old seedlings. This might be attributed to increase in plant height, number of tillers m^{-2}, LAI, better rooting ability and finally the higher DMP. Transplanting of young seedlings provided sufficient nutrients for vegetative growth and also for reproductive phase due to better root growth. This might be due to efficient utilization of resources that ultimately lead to increased plant height and yield attributes thereby increased grain and straw yields (Kavitha *et al.,* 2010).

SRI method of planting had significant influence on growth parameters of rice. Plant height and LAI were increased. This was because of wider spacing which influenced the vegetative growth in a better way than closer spacing by increasing the nutrient absorption by plants and resulted in better growth of plants. There increased growth of plants under wider spacing, maintaining the good plant exposure to the sun and air (Jiaguo Zeng *et al.*, 2002). The present study also revealed that SRI method with wider spacing 25 x 25 cm recorded maximum plant height (91.6) and leaf area index (5.6) (Table 2). The closer spacing in transplanting decreased transmission of light in the canopy making the plant to grow taller for want of light (Anon., 1987). SRI produced more productive tillers $hill^{-1}$; higher panicle length (21.9), panicle weight, grains (123 $panicle^{-1}$) and thousand grain weights ultimately produced more straw (8971) which was due to increased value of yield attributing characters like panicle number, panicle length, total grains per panicle resulting from vigorous young seedlings which was due to more tillers m^{-2} under wider intra and inter row spacing and better assimilation of photosynthates due to better utilization of incident solar radiation might have increased the size of sink and effective translocation of assimilates which led to improved panicle length,

Table 2. Effect of age of seedlings, planting methods and weed management practices on growth, yield attributes and yield of rice

(Pooled data of two years)

Treatment	Growth attributes		Yield attributes and yield			
	Plant height at harvest (cm)	LAI at harvest	Panicle length (cm)	Total grains panicle^{-1}	Yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Age of seedlings						
A_1 – 14 DAS	96.1	5.9	23.4	129	8037	9592
A_2 – 18 DAS	87.0	5.2	22.0	118	6598	7931
A_3 – 22 DAS	78.0	4.8	19.0	100	5351	6459
SEd	1.8	0.1	0.4	2	168	170
CD (P=0.05)	3.9	0.2	0.9	5	374	379
Planting methods						
P_1 – Machine planting	82.4	5.0	21.0	108	5899	7017
P_2–SRI planting (manual)	91.6	5.6	21.9	123	7424	8971
SEd	1.4	0.1	0.3	2	138	139
CD (P=0.05)	3.2	0.2	0.8	4	306	310
Weed management practices						
W_1 – Hand Weeding (twice)	81.7	4.9	20.3	109	6394	7347
W_2 – Mechanical Weeding (thrice)	94.0	5.8	22.7	120	6949	8425
W_3 – Butachlor @ 1.25 kg ai ha^{-1}+ MW (twice)	103.5	6.3	23.7	134	8348	10059
W_4 – unweeded check	69.0	4.2	19.2	99	4956	6145
SEd	2.4	0.1	0.6	3	222	232
CD (P=0.05)	4.9	0.3	1.2	7	451	471
Interaction Effects	NS	NS	NS	NS	S*	S*

total grains panicle^{-1}. Similar finding was reported by Viraktamath (2006).

Increased plant height and higher LAI were recorded in the pre emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT at all crop growth stages was due to broad spectrum control of weeds cum reduced weed dry weight, which in turn increased the vigor and growth of rice by maximum root length with good crop establishment and lead to more nutrient uptake, exposure to sunlight and weed free condition at the early stages of crop growth. Weed free condition at critical stages of crop favors increased plant height and leaf development with higher LAI due to increased availability of nutrients with less competition. This was supported by Subramanian *et al*. (2006). The increased grain and straw yields in pre emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT clearly indicated the influence of weed free environment on grain production. Due to weed free condition provided in rice ecosystem the competition for light, space and nutrient were reduced and resulted in better availability and uptake of the required nutrients by the crop. This favourable environment resulted in higher production of plant DMP with increased plant height, LAI, number of tillers hill^{-1} and other yield attributes like number of productive tillers m^{-2}, number of filled grains panicle^{-1} and test grain weight. All these improved the performance of the crop under the favorable weed free condition leading to higher grain and straw yields. This is in conformity with the findings of Narayanaswamy *et al*. (2006).

The results of the present study explained the potential of agronomic practices *viz*., age of seedlings, planting methods and weed management practices in rice under SRI techniques of 14 days old seedlings with manual planting and pre emergence application of butachlor @ 1.25 kg *a.i.* ha^{-1} + two mechanical weeding at 25 and 45 DAT significantly reduced the weed density, weed dry weight, nutrient removal and improved the growth parameters, yield attributes and yield of rice.

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