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Performance of four row self propelled rice transplanter and weed management practices on productivity of lowland rice

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ABSTRACT

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore during dry season 2011-12 and 2012-13 in clayey loam soil to evaluate the different crop establishment methods and weed management practices in rice. The treatments consisted of three establishment methods in horizontal strips and six weed management practices in vertical strips. The results revealed that machine planting (30 cm x 20 cm) with conoweeding four times at 10 days interval starting from 10 days after transplanting (DAT) registered more tiller production contributing to higher grain yield and found to be economical by giving higher net return and this was followed by application of pretilachlor (0.75 kg a.i. ha^{-1} pre-emergence) + bispyribac sodium (20 g a.i. ha^{-1} early post-emergence) + conoweeding at 40 DAT.

Key words: *machine planting, hill survivality, tiller production, grain yield, straw yield*

Rice productivity in India is 3.37 t ha^{-1} while the world average is 4.25 t ha^{-1} (IRRI, 2011). Tamil Nadu alone contributes eight per cent of the national rice production from an area of 2.07 million hectares, with a production of 7.15 million tonnes (Ministry of Agriculture, Govt. of India, 2010). At the current population growth rate (1.5 per cent), the rice requirement of India by the year 2025 would be around 125 million tonnes (Kumar *et al*., 2009). To meet the food requirement of the growing population, rice production has to be enhanced with good management practices with shrinking availability of land and water resources condition. Rice production in India is adversely affected by such inhibiting factors as traditional modes of production, small-scale operations, irrigation difficulties, lack of appropriate tools and equipment for mechanized farming, all preventing the rapid growth of rice production. At transplanting time, there is an acute labor shortage, which results in increased labour wages and delay in the transplanting operation. Hand transplanting also results in a non-uniform and inadequate seedling populations. These problems necessitate the introduction of mechanized rice transplanting to achieve timelier establishment and better crop stands (Hemmat and Taki, 2003). In addition, weeds are the bounding factors of agricultural production, which compete crop plants, especially rice with their rapid growth. Besides, weeds compete with crop plants in catching light and food in growing season and causing yield reduction. Hence the present study was undertaken to study the performance of different transplanting methods with weed management practices.

MATERIALS AND METHODS

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore during dry season of 2011-12 and 2012-13, to examine the performance of four row mechanical transplanter and weed management practices on productivity of lowland rice. The soil of the experimental site was clay loam in texture, low in available nitrogen, medium in available phosphorus and high in available potassium during both the years. The experiment was replicated thrice in strip plot design with three crop establishment techniques *viz.*, Conventional planting, SRI marker planting and SRI machine planting were assigned to horizontal strips and six weed management practices *viz.*, Conoweeding 4 times at 10, 20, 30 and 40 DAT, Pre-emergence (PE) Pretilachlor 50%EC @ 0.75kg a.i. ha^{-1} + conoweeding

at 20 and 40 DAT, PE Pretilachlor 50%EC @ 0.75kg a.i. ha^{-1} + early post emergence (EPOE) Bispyribac sodium 10%SC @ 20g a.i. ha^{-1}, PE Pretilachlor 50%EC @ 0.75kg a.i. ha^{-1} + EPOE Bispyribac sodium 10%SC @ 20g a.i. ha^{-1} + conoweeding at 40 DAT, EPOE Laundax power @ 10 kg ha^{-1} + conoweeding at 30 and 40 DAT and un-weeded control were allotted to vertical strips. The variety CO(R) 49 was used as test variety in this experiments.

SRI with modification for machine planting and marker planting involved 12 days old two seedlings $hill^{-1}$ at 30 x 20 cm and 25 x 25 cm spacing, respectively in comparison to conventional transplanting (CT) of 21 days old 3-4 seedlings $hill^{-1}$ at 20 cm x 10 cm spacing. The seed requirement in SRI marker and machine planting was 8 kg ha^{-1} and for conventional planting is 40 kg ha^{-1}. Raised bed nursery for SRI planting (Baskar, 2009), tray type nursery for SRI mechanical transplanting (Bell *et al.,* 2003) and conventional nursery for conventional transplanting (CPG, 2005) were prepared. Number of seedlings was recorded a day before transplanting using quadrat (0.25 m^2) placed randomly at four places of the whole nursery and the mean expressed in percentage. Ten seedlings were taken at random from the nurseries at the time of transplanting for shoot length measurement. The length from the collar region to tip of the seedling leaf were measured and mean value expressed in cm. The seedlings taken for shoot length measurement were used for recording root length and mean value expressed in cm. Seedling vigour index (SVI) was calculated by adopting the formula suggested by Abdul-Baki and Anderson (1973).

SVI = Establishment percentage x (Root length+Shoot length)

One square-meter area was marked after transplanting and the numbers of hills transplanted were counted. After 7th day of transplanting, the numbers of hills survived were counted. Hill survivality was determined by the following formula (Garg *et al.,* 1997)

Hill survivality (%) = [1- (HS/ TNH)] x 100

Where,

HS = No. of hills survived 7 days after transplanting (DAT)

TNH = Total number of hills

In each net plot, four quadrates of 0.25 m^2 each were selected at random and total tillers were counted and expressed as number m^{-2}. Randomly selected 1000 grains were dried to 14 per cent moisture and weighed to obtain 1000 grain weight (g). Grain and straw were sun dried to 14 per cent moisture level and weight was recorded for each plot and computed on hectare basis. The data on various parameters were subjected to statistical scrutiny as suggested by Gomez and Gomez (2010).

RESULTS AND DISCUSSION

Tray nursery for machine planting recorded higher seedling establishment percentage than SRI and conventional nursery. The reason might be that the seedlings were raised with different type of nurseries and management practices were different which was reflected on the growth characters indicating superior result of shoot and root length is a direct index to measure the growth and vigour of plants (Table 1.) This corroborates with the findings of Veeramani (2010) modified mat nursery produced superior seedlings due to adequate nourishment of nutrition to the seedlings which induces vegetative growth influenced rooting and promote early root strike in the soil when compared with conventional method of nursery. Crop establishment methods have significant influence on plant population. Highest hill survivality rate was recorded

Table 1. Effect of nursery methods on seedling characters of rice

Treatments	Dry season 2011-12				Dry season 2012-13			
	Seedling establishment (%)	Shoot length (cm)	Root length (cm)	Seedling vigour index	Seedling establishment (%)	Shoot length (cm)	Root length (cm)	Seedling vigour index
Conventional planting	88.9	8.0	7.2	1351	89.5	7.8	7.0	1325
SRI marker planting	95.8	8.3	7.4	1504	95.3	8.1	7.4	1477
SRI machine planting	98.0	8.5	7.5	1568	98.2	8.4	7.5	1561

under machine planting which was significantly higher than SRI marker planting and conventional planting. Higher survival capacity of seedlings indicates that mechanically transplanted seedlings are placed at uniform depth and spacing which tends to establish faster and produce more number of tillers. It might be due to the fact that the mat seedlings, have higher seedling vigour index. The roots were inserted together with some soil within the root net, therefore the seedlings being mechanically detached in clusters from the mat which had more uniform placement in the puddle soil. It was in conformity with the findings of Singh and Vatsa (2006). Two seedlings hill^{-1} was maintained under machine planting to meet the agronomical requirement and also to minimize the missing hills, where it was already pre set before transplanting reduced the requirement of more seedlings per hill than SRI marker planting and conventional planting (Table 2). Number of seedlings hill^{-1} increased with increase in operating speed, age of seedlings and mat moisture content. This was in line with the findings of Behera *et al.,* 2007.

Tillering is the most important characteristic of rice cultivars. Among the establishment methods, SRI machine transplanting produced distinctly more number of tillers m^{-2}, however, it was comparable with SRI marker planting. This might be due to higher input efficiency under SRI method of cultivation, provided better aeration, more spacing and less competition, which enabled the plants to grow vigorously. The plants in SRI method had better partitioning of dry season matter, which lead to increase in the number of tillers m^{-2}. These results are in conformity with the findings of Hugar *et al.* (2009). Further, Baskar (2009) stated that enhanced availability of resources for the individual culms under wider spacing would have extended the duration of tiller production which resulted in profuse tillering.

Conoweeding four times at 10 days interval starting from 10 DAT produced more number of tillers m^{-2} which was followed by the application of pretilachlor (0.75 kg ha^{-1} pre-emergence) + bispyribac sodium (20 g ha^{-1} early post-emergence) + conoweeding at 40 DAT compared to other treatments. Uphoff (1999) also opined that frequent weeding with a rotating hoe would assist in aeration of the soil resulted in greater root development and would support greater tillering. In addition, according to Randriamiharisoa (2002), rotary weeding reduced the weeds besides increased the number of soil pores so that roots and microbes could more easily gain access to oxygen which facilitated more number of tillers.

Interaction effect was observed between crop establishment methods and weed management practices at all the crop growth stages during both the

Table 2. Effect of nursery methods on hill survivality (%) of different crop establishment methods in rice

Treatments	Dry season 2011-12				Dry season 2012-13				No of seedlings hill^{-1}			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
W_1	59.5	87.3	94.7	80.5	56.6	99.0	94.2	83.3	2.89	2.54	2.00	2.47
W_2	61.9	74.4	97.8	78.1	61.0	94.0	95.5	83.5	2.87	2.10	2.10	2.36
W_3	67.4	80.7	94.4	80.8	64.2	84.0	92.3	80.2	2.73	2.27	2.07	2.36
W_4	65.6	79.7	95.9	80.4	62.7	86.5	92.3	80.5	3.16	2.22	2.00	2.46
W_5	62.3	74.8	95.9	77.7	70.2	74.0	97.4	80.5	2.96	2.37	2.03	2.45
W_6	67.0	81.0	95.5	81.2	67.9	80.7	99.0	82.5	2.99	2.35	1.99	2.44
Mean	63.9	79.7	95.7		63.8	86.4	95.1		2.93	2.31	2.03	
	C	W	C at W	W at C	C	W	C at W	W at C	C	W	C at W	W at C
CD (P<0.05)	9.09	NS	NS	NS	10.80	NS	NS	NS	0.20	NS	NS	NS

C_1- Conventional planting, C_2- SRI marker planting, C_3- SRI machine planting
W_1- Cono weeding 4 times at 10, 20, 30, 40 DAT
W_2- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + 2 times conoweeding at 20 and 40 DAT
W_3- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + EPOE bispyribac sodium 10 % SC @ 20 g ai ha^{-1}
W_4- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + EPOE bispyribac sodium 10 % SC @ 20 g ai ha^{-1} + cono weeding at 40 DAT
W_5- EPOE Laundax power @ 4 kg ac^{-1} + 2 times cono weeding at 30 & 40 DAT
W_6- Unweeded control

years(Table 3). The SRI machine transplanting with conoweeding four times at 10 days interval starting from 10 DAT produced more number of tillers m^{-2} which was comparable with SRI marker planting than conventional planting which resulted in higher total dry season matter production due to larger and healthier root system, more tillers and photosynthetic activity which was facilitated by the rotary weeding under wider spacing and increased nutrient availability throughout the crop growth. This is in line with the findings of Uphoff (2002) who reported that under SRI higher number of tillers $hill^{-1}$ were produced which might be due to wider spacing, transplanting younger seedlings and better water management induced the transplanting shock at a more convenient point in the growth cycle when they could rebound faster and had a quick development of clonal tillers resulted in significantly highest number of tillers. Further, use of plastic trays for raising seedlings, and dry season cultivation of the nursery was beneficial to boost the vigorous root system for early and quick growing of tillers (Ang *et al.,* 2002)

Crop establishment methods and weed management practices had significant influence on grain yield (t ha^{-1}) during both the years of experimentation (Table 4). The SRI machine transplanting produced distinctly higher grain yield than conventional transplanting (CT). However, it was comparable with SRI marker planting. This might be due to less crop weed competition, larger root system and crop canopy and higher microbial population which facilitated the enhanced nutrient uptake, photosynthetic activity and remobilization of photosynthates to grain which resulted in higher yield attributes and yield. This is in accordance with the findings of Hugar *et al*. (2009) who stated that SRI gave higher grain yield due to large root volume, strong tillers with improved yield attributes. Chandrapala *et al*. (2010) also reported increased grain yield with SRI which was attributed to lesser competition, enhanced solar radiation interception, nutrients uptake and higher yield attributes.

Conoweeding four times at 10 days interval starting from 10 DAT attained its statistical supremacy by recording higher grain yield, which was on par with pretilachlor fb bispyribac sodium + conoweeding on 40 DAT than unweeded control. This finding is in accordance with the results of Thiyagarajan *et al.* (2002) who found that use of conoweeder resulted in increased yield of rice.

Crop establishment methods and weed management practices had significant interaction with

Table 3. Effect of crop establishment methods and weed management practices on tiller production in rice

Treatments	Number of tillers m^{-2}							
	Dry season 2011-12				Dry season 2012-13			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
W_1	241	303	312	285	256	284	298	279
W_2	170	257	264	230	174	244	243	220
W_3	197	278	268	248	193	276	246	239
W_4	223	295	299	272	240	305	289	278
W_5	192	263	267	241	219	259	249	242
W_6	151	208	231	197	135	178	205	173
Mean	196	267	274		203	258	255	
	C	W	C at W	W at C	C	W	C at W	W at C
CD (P<0.05)	9.0	10.0	10.0	11.0	8.0	11.0	13.0	12.0

C_1- Conventional planting, C_2- SRI marker planting, C_3- SRI machine planting
W_1- Cono weeding 4 times at 10, 20, 30, 40 DAT
W_2- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + 2 times conoweeding at 20 and 40 DAT
W_3- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + EPOE bispyribac sodium 10 % SC @ 20 g ai ha^{-1}
W_4- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + EPOE bispyribac sodium 10 % SC @ 20 g ai ha^{-1} + cono weeding at 40 DAT
W_5- EPOE Laundax power @ 4 kg ac^{-1} + 2 times cono weeding at 30 & 40 DAT
W_6- Unweeded control

Table 4. Effect of crop establishment methods and weed management practices on grain and straw yield (t ha^{-1}) in rice

Treatments	Grain yield (t ha^{-1})								Straw yield (t ha^{-1})							
	Dry season 2011-12				Dry season 2012-13				Dry season 2011-12				Dry season 2012-13			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
W_1	4.74	6.47	6.98	6.06	5.19	7.11	7.61	6.64	10.44	11.24	12.43	11.37	11.12	11.02	13.42	11.85
W_2	4.28	5.54	6.01	5.28	3.98	6.03	6.04	5.35	8.85	9.40	10.12	9.46	8.37	9.70	10.71	9.59
W_3	3.84	4.83	4.67	4.45	3.72	5.31	4.56	4.53	7.94	9.72	10.69	9.45	7.34	8.79	10.50	8.88
W_4	4.62	6.37	6.79	5.93	4.66	7.81	7.61	6.70	10.33	10.98	11.79	11.03	10.84	11.80	13.03	11.89
W_5	4.43	6.06	6.75	5.74	4.43	7.01	7.08	6.17	8.80	9.85	10.49	9.72	10.13	10.29	11.45	10.62
W_6	2.47	2.91	3.05	2.81	2.12	2.41	2.97	2.50	6.42	7.30	8.14	7.29	6.68	7.43	8.09	7.40
Mean	4.07	5.36	5.71		4.02	5.95	5.98		8.80	9.75	10.61		9.08	9.84	11.20	
	W	C	C at W	W at C	W	C	C at W	W at C	W	C	C at W	W at C	W	C	C at W	W at C
CD (P<0.05)	0.31	0.43	0.38	0.48	0.29	0.25	0.33	0.34	0.31	0.32	0.45	0.48	0.47	0.34	0.55	0.54

C_1- Conventional planting, C_2- SRI marker planting, C_3- SRI machine planting
W_1- Cono weeding 4 times at 10, 20, 30, 40 DAT; W_2- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + 2 times conoweeding at 20 and 40 DAT
W_3- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + EPOE bispyribac sodium 10 % SC @ 20 g ai ha^{-1}
W_4- PE pretilachlor 50 % EC @ 0.75 kg ai ha^{-1} + EPOE bispyribac sodium 10 % SC @ 20 g ai ha^{-1} + cono weeding at 40 DAT
W_5- EPOE Laundax power @ 4 kg ac^{-1} + 2 times cono weeding at 30 & 40 DAT; W_6- Unweeded control

each other at all the crop growth stages. The SRI machine transplanting with conoweeding four times at 10 days interval starting from 10 DAT registered higher grain yield than other combinations. This might be due to larger canopy with greater root development and activity, less intra plant competition, improved remobilization of assimilates to grain. These results are in accordance with the findings of Mohaptra *et al.* (2012) who reported that machine planting with mechanical weeding promoted profuse tillering which resulted in increases the yield attributes such as number of panicle m^{-2} and number grains panicle^{-1} and in turn increases the yield.Whilst, the least grain yield was recorded under conventional planting with unweeded check.

Significant difference due to the crop establishment methods and weed management practices were evident during both the years (Table 2). The SRI machine transplanting resulted in significantly higher straw yield. However, comparable straw yield was observed with SRI marker planting with that of SRI machine transplanting due to higher tillers and DMP. This result is in corroboration with the findings of Revathi (2009) who reported that higher straw yield in SRI due to higher tillers and DMP.

Conoweeding four times at 10 days interval starting from 10 DAT recorded higher straw yield over all other weed management practices during both the years. However, comparable straw yield was noticed with combined application of pretilachlor (0.75kg a.i. ha^{-1} pre-emergence) + bispyribac sodium (20g a.i. ha^{-1} early post-emergence) + conoweeding at 40 DAT during both the years. Invariably, lesser straw yield was registered with unweeded control over all other weed management practices during both the years. Ramamoorthy (2004) and Mohanty and Mohanty (2010) reported that four times conoweeding removes most of the weeds and incorporated in the soil which frequently loosening of the top soil to stimulate aerobic soil condition and provided weed free environment. This conducive environment enhanced the growth components which in turn increases the straw yield.

Crop establishment methods and weed management practices had significant interaction with each other at all the crop growth stages. SRI machine transplanting with conoweeding four times at 10 days

interval starting from 10 DAT registered higher grain yield than other combinations. This might be due to larger canopy with greater root development and activity, less intra plant competition, improved remobilization of assimilates to grain as reported by Mohapatra *et al.,* (2012). Whilst, the least grain yield was recorded under conventional planting with unweeded check.

The present findings indicated that SRI machine transplanting with conoweeding 4 times at 10 DAT of rice was found to be the most effective with higher seedling establishment percentage and hill survivality and producing more number of tillers which enhances the yield-attributing characters, grain and straw yields than all the other treatment combinations. Whereas, under labour shortage condition, machine planting with application of Pretilachlor (0.75kg a.i. ha^{-1} pre-emergence) + Bispyribac sodium (20g a.i. ha^{-1} early post-emergence) + conoweeding at 40 DAT was most effective to enhance the rice productivity under lowland conditions.

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