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Crop establishment and weed managment effects on rice productivity and weed dynamics

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ABSTRACT

A field experiment was conducted in strip-plot design with three crop establishment techniques and six weed management practices to study the effect of crop establishment and weed management on weeds and yield of lowland rice at Coimbatore during *Rabi* 2011-12 and 2012-13. The field was dominated by *Echinochloa colona, Cyperus difformis, Eclipta alba*, *Marselia quadrifoliata* and *Ammania baccifera*. The results revealed that machine planting (30 x 20 cm) and subsequent cono-weeding at 10, 20, 30 and 40 days after transplanting (DAT) registered lower density and biomass of sedges, grasses, broad-leaved and total weeds resulting in higher grain yield than other treatments. Weed control efficiency (93.2 and 90.8% in 2011-12, and 2012-13, respectively) was higher with this treatment compared with the other treatments. Next best treatment was the machine planting with pretilachlor (0.75 kg/ha at 3 DAT) + bispyribac-sodium (20 g/ha at 15 DAT) + cono-weeding at 40 DAT.

Key words: Crop establishment, Herbicides, Machine planting, Weed management

Transplanting of rice seedlings in the traditional way is laborious, time consuming and causes drudgery. The non-availability of labourers for transplanting at appropriate time leads to late planting, which results in poor yields (Singh *et al.* 2013). To get maximum returns, the cost of cultivation has also to be reduced through the minimization of the dependence on labour for transplanting. Mechanization in transplanting through use of rice transplanter reduces the cost of cultivation and large area can be transplanted within very short period (Hemmat and Taki 2003).

Weed competition is one of the prime yield–limiting biotic constraints in rice. Weeds are the most competitive in their early growth stages than at later stages and hence, the growth is affected and finally grain yield decreases (Jacob and Syriac 2005). For keeping weed population below threshold level, there is a need to evolve an effective integrated strategy involving chemical and mechanical methods. Hence, agronomical manipulations such as establishment techniques with weed management may offer an effective option for better control of weeds in rice. The present study was undertaken with an objective to study the effect of crop establishment and weed management practices on weed characteristics and yield of lowland rice

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MATERIALS AND METHODS

Field experiments were conducted at Coimbatore during *Rabi* of 2011- 12 and 2012-13. The experiment was replicated thrice in strip-plot design with three crop establishment techniques, *viz.* conventional planting (C_1), SRI marker planting (C_2) and SRI machine planting (C_3) assigned to horizontal strips and six weed management practices, *viz.* cono-weeding 4 times at 10, 20, 30 and 40 days after transplanting (W_1), pretilachlor at 0.75 kg/ha 3 DAT + cono-weeding at 20 and 40 DAT (W_2), pretilachlor at 0.75 kg/ha 3 DAT + bispyribac-sodium at 20 g/ha 15 DAT (W_3), pretilachlor at 0.75 kg/ha 3 DAT + bispyribac-sodium at 20 g/ha 15 DAT + cono-weeding at 40 DAT (W_4), bensulfuron-methyl + pretilachlor (60 g + 600 g/ha) 15 DAT + cono-weeding at 30 and 40 DAT (W_5) and un-weeded control (W_6) were allotted to vertical strips. The soil of the experimental site was clay-loam in texture, low in available N (224 and 23l kg/ha of 2011- 12 and 2012-13, respectively), medium in available P (19.0, 17.8 kg/ha of 2011- 12 and 2012-13, respectively) and high in available K (446, 549 kg/ha of 2011- 12 and 2012-13, respectively). Rice *"CO (R) 49"* was used as test variety for this experiment.

The seed requirement in SRI marker and machine planting was 8 kg/ha while for conventional planting, 40 kg/ha. Transplanting of rice seedlings with row planting (seedlings planted in lines with

definite planting geometry) to ensure optimum plant population was adopted. In row planting, the population becomes more assured and intercultural operations are much easier as compared to random planting (CPG 2005). The sprouted seeds with a seed rate 40 kg/ha were sown in the wet nursery area of 20 cents (about 810 $m^{2)}$. Then 21 days old seedlings were pulled out and transplanted at the rate of two to three seedlings/hill with a spacing of 20 x 10 cm.

System of Rice Intensification (SRI), a "less water" method of production is ideal for poor farmers with relatively more family labour than land and capital. The sprouted seeds were sown on the mat nursery which was prepared by using the polythene or gunny bags on the shallow raised bed to prevent roots growing deep into the soil. Nursery area of 2.5 cents (about 100 m^2)/ha of main field was used for raising seedlings. Then 12 days old seedlings were pulled out and planted single seedling with the spacing of 25 cm × 25 cm following Baskar (2009) method.

Mechanical transplanting requires a special method of raising seedlings called mat type seedlings. About 125 plastic trays with a length and breadth of 55 x 21 cm were selected to raise seedlings for planting one ha. Soil was sieved and mixed with equal quantity of farm yard manure and spread in the plastic trays to a depth of 2 cm. Sprouted seeds were spread uniformly on the tray and pressed gently. They were covered with paddy straw and watered through rose cans for four days. After 4^{th} day, the straw was removed and water was applied by flooding so as to keep the mat soil wet throughout its growth period. To enhance the growth of seedlings, 2% foliar spray of nitrofoska (19:19:19 N: P: K) was given once at 8-12 days after sowing. When the seedlings were about 2-3 leaf stage, water was drained from the nursery and seedling mat was cut to required size using a knife and rolled and fed to the mechanical transplanter. Transplanting was done through self-propelled walking behind hitech mechanical transplanter with the spacing of 30 cm × 20 cm by running length wise of the field on the puddled and leveled field at 2 cm water depth to avoid floating of seedlings (Bell *et al.* 2003).

Herbicides were dissolved in 500 litres water and sprayed with knapsack sprayer using deflector nozzle. Pretilachlor was applied at 3 DAT and bispyribac-sodium and bensulfuron-methyl + pretilachlor were applied at 15 DAT. Weed count was recorded at 40 DAT using quadrat and expressed in number/m^2.The collected weeds were first dried in the sun and then kept in an electrical oven for 72 hours maintaining a constant temperature of 80 ˚C. After drying, weight of each species was taken and expressed as biomass kg/ha. The data on weed density and biomass were subjected to square root ($\sqrt{(X+2)}$) transformation before statistical analysis to normalize their distribution. Weed Control efficiency (WCE) was calculated by using standard formula.

RESULTS AND DISCUSSION

Weed density and biomass

The dominant weed flora in experimental field was *Echinochloa colona, Cyperus difformis, Eclipta alba, Marselia quadrifoliata* and *Ammania baccifera* as also reported by (Mandal *et al.* 2013). Rice establishment methods exerted significant influence on the grass density (no./m^2) recorded at 40 DAT during both the years. Grass weed density under machine planting was significantly lower being at par with SRI marker planting than conventional transplanting (Table 1). Among the weed control methods, density of grasses was significantly lower in cono-weeding at 10,20,30 and 40 DAT and pretilachlor 0.75 kg/ha *fb* bispyribac- sodium 20 g/ha + cono weeding 40 DAT. It was clearly evident that combination of two chemicals gave higher weed control efficacy than sole application. Mahajan *et al.* (2009) also reported that sequential application of pretilachlor and bispyribac-sodium was more efficient in controlling the weeds in direct-seeded rice.

Rice establishment methods and weed management practices had significant interaction on grass weed density at 40 DAT. SRI machine transplanting with cono-weeding resulted in significantly lower density of grasses, this was followed by pretilachlor *fb* bispyribac-sodium. Better efficacy of herbicides in conjunction of cono-weeding under machine planting might be due to emergence of weeds in short span in which most of the weeds were affected by herbicides (Maity and Mukherjee 2008)**.** The poor efficacy of herbicides under conventional planting was due to extended period of weed emergence in several flushes coupled with smaller period of herbicide persistence. The same trend was observed under sedges and broad leaved weed density (Table 1 and 2).

Rice establishment methods exerted significant influence on the total weed count (no./m^2) at 40 DAT. Total weed density recorded in machine planting and SRI marker planting compared to conventional transplanting (Table 1). Subbalakshmi and Pandian (2002) have also reported similar results.

Table 1. Effect of rice establishment and weed management on grass and sedge weeds density in rice

Treatment	Grasses (no./m^2)								Sedges (no./m^2)							
	2011-12				2012-13				2011-12				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	2.43	1.73	1.41	1.86	3.97	2.22	1.75	2.65	2.41	1.79	1.41	1.87	1.97	1.58	1.41	1.65
	(3.9)	(1.0)	(0.0)	(1.6)	(13.8)	(2.9)	(1.1)	(5.9)	(3.8)	(1.2)	(0.0)	(1.7)	(1.9)	(0.5)	(0.0)	(0.8)
W_2	4.11	3.78	3.21	3.70	5.60	4.65	4.63	4.96	4.49	3.78	3.65	3.97	4.69	3.36	2.28	3.44
	(14.9)	(12.3)	(8.3)	(11.8)	(29.4)	(19.6)	(19.4)	(22.8)	(14.7)	(12.3)	(11.3)	(12.8)	(20.0)	(9.3)	(3.2)	(10.8)
W_3	2.64	1.82	1.82	2.09	4.64	2.77	2.31	3.24	3.30	2.30	2.08	2.56	2.51	2.02	1.97	2.17
	(5.0)	(1.3)	(1.3)	(2.5)	(19.5)	(5.7)	(3.3)	(9.5)	(7.0)	(3.3)	(2.3)	(4.2)	(4.3)	(2.1)	(1.9)	(2.7)
W_4	2.63	1.82	1.41	1.96	4.06	2.55	2.12	2.91	2.83	2.21	1.98	2.34	2.35	2.02	1.41	1.93
	(4.9)	(1.3)	(0.0)	(2.1)	(14.5)	(4.5)	(2.5)	(7.2)	(4.6)	(2.9)	(1.9)	(3.1)	(3.5)	(2.1)	(0.0)	(1.9)
W_5	2.88	2.45	2.29	2.54	5.12	3.10	2.84	3.69	2.25	1.41	1.41	1.69	1.99	1.82	1.89	1.90
	(6.3)	(4.0)	(3.2)	(4.5)	(24.3)	(7.6)	(6.1)	(12.6)	(2.2)	(0.0)	(0.0)	(0.7)	(2.0)	(1.3)	(1.6)	(1.6)
W_6	11.34	9.67	7.87	9.63	8.10	7.67	6.37	7.38	9.33	7.35	6.96	7.88	7.67	6.84	6.02	6.84
	(126.6)	(91.6)	(59.9)	(92.7)	(63.6)	(56.8)	(38.6)	(53.0)	(69.9)	(52.0)	(46.4)	(56.1)	(56.9)	(44.7)	(34.2)	(45.3)
Mean	4.34	3.55	3.00		5.25	3.83	3.34		4.10	3.14	2.92		3.53	2.94	2.50	
	(26.9)	(18.6)	(12.1)		(27.5)	(16.2)	(11.8)		(17.0)	(11.9)	(10.3)		(14.8)	(10.0)	(6.8)	
	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
LSD (P=0.05)	0.96	0.81	0.79	0.94	0.21	1.11	0.46	1.04	0.62	0.50	0.45	0.55	0.63	0.68	0.52	0.72

Figures in parentheses are original values, which were subjected to square root ($\sqrt{(X+2)}$) transformation

C_1- Conventional planting, C_2- SRI marker planting, C_3- SRI machine planting W_1- Cono-weeding at 10, 20, 30, 40 DAT, W_2- pretilachlor at 0.75 kg /ha 3 DAT + cono-weeding at 20 and 40 DAT, W_3- pretilachlor 0.75 kg/ha 3 DAT + bispyribac-sodium 20 g/ha 15 DAT, W_4- pretilachlor 0.75 kg/ha 3 DAT + bispyribac-sodium 20 g/ha 15 DAT + cono-weeding 40 DAT, W_5- bensulfuron-methyl + pretilachlor (60 g + 600 g/ha) 15 DAT + cono-weeding at 30 and 40 DAT , W_6- unweeded control

Table 2. Effect of rice establishment and weed management on density of broad-leaved weeds and total weeds in rice

Treatment	Broad-leaved weeds (no./m^2)								Total weeds (no./m^2)							
	2011-12				2012-13				2011-12				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	3.33	2.18	1.41	2.31	3.47	2.21	1.41	2.37	4.34	2.64	1.41	2.80	5.26	2.88	1.75	3.30
	(9.1)	(2.8)	(0.0)	(4.0)	(10.1)	(2.9)	(0.0)	(4.3)	(16.8)	(5.0)	(0.0)	(7.3)	(25.7)	(6.3)	(1.1)	(11.0)
W_2	10.23	8.06	6.76	8.35	12.11	9.47	8.48	10.02	11.85	9.46	8.08	9.80	14.37	10.89	9.72	11.66
	(84.5)	(63.0)	(43.7)	(63.7)	(119.2)	(87.6)	(69.9)	(92.2)	(114.1)	(87.6)	(63.3)	(88.3)	(168.6)	(116.6)	(92.5)	(125.9)
W_3	4.31	3.07	2.41	3.26	4.93	3.46	2.76	3.72	5.75	3.75	3.08	4.19	7.28	4.45	3.58	5.10
	(13.3)	(7.4)	(3.8)	(8.2)	(18.1)	(10.0)	(5.6)	(11.2)	(25.3)	(12.0)	(7.5)	(14.9)	(41.8)	(17.8)	(10.8)	(23.5)
W_4	4.11	3.01	1.41	2.85	4.20	3.00	1.41	2.87	5.33	3.64	1.98	3.65	6.28	3.95	2.12	4.12
	(12.0)	(7.1)	(0.0)	(6.4)	(12.6)	(7.0)	(0.0)	(6.5)	(21.5)	(11.3)	(1.9)	(11.6)	(30.6)	(13.6)	(2.5)	(15.6)
W_5	6.22	5.08	3.41	4.90	8.15	7.18	5.61	6.98	7.00	5.46	3.85	5.44	9.91	7.77	6.25	7.98
	(29.9)	(23.8)	(9.6)	(21.1)	(53.0)	(49.5)	(29.4)	(44.0)	(38.4)	(27.8)	(12.9)	(26.4)	(79.2)	(58.4)	(37.1)	(58.2)
W_6	13.95	10.91	10.67	11.84	16.45	13.23	12.49	14.06	20.79	16.20	14.84	17.28	20.41	16.63	15.13	17.39
	(158)	(117)	(111)	(129)	(221)	(173)	(154)	(183)	(355)	(260)	(218)	(278)	(342)	(274)	(227)	(281)
Mean	7.03	5.39	4.35		8.22	6.42	5.36		9.18	6.86	5.54		10.59	7.76	6.42	
	(51.3)	(36.8)	(28.2)		(72.4)	(55.0)	(43.2)		(95.2)	(67.4)	(50.6)		(114)	(81.2)	(61.8)	
	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
LSD (P=0.05)	0.98	0.89	0.69	0.95	1.21	1.06	0.87	1.15	1.45	1.13	1.04	1.26	1.43	1.27	1.06	1.38

Among weed control treatments, cono-weeding resulted in lower weed density and biomass than other treatments. This might be due to the incorporation of weeds by frequent cono-weeding and smothering effect of the larger rice canopy. (Anitha and Chellappan 2011). Among the herbicidal application, pretilachlor 0.75 kg/ha *fb* bispyribac-sodium 20 g/ha + cono-weeding at 40 DAT resulted in significantly lower weed density. This may be attributed to more bioefficacy of pretilachlor *fb* bispyribac-sodium, which effectively controlled both the narrow and broad-leaved weeds. Herbicides alone were least effective in minimizing the density of weeds. This might be due to better control of weeds by pre-emergence herbicides in early stages and control of later emerging weeds, particularly sedges and broad-leaved weeds by sequential application of bispyribac-sodium at later stages (Chinnusamy *et al*. 2006).

Rice establishment methods and weed management practices had significant interaction on total weed density at 40 DAT. SRI machine planting with cono-weeding four times at 10 days interval resulted in significantly lower weed density, This was followed by pretilachlor *fb* bispyribac-sodium. Conventional transplanting resulted in maximum total weed density. This was corroborated with the findings of Cherati *et al.* (2011).

Table 3. Effect of rice establishment and weed management on total weed biomass and rice grain yield

Treatment	Total weed biomass (kg/ha)								Grain yield (t/ha)							
	2011-12				2012-13				2011-12				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	8.56 (71.2)	5.93 (33.2)	3.73 (11.9)	6.07 (38.8)	7.83 (59.3)	8.13 (64.1)	5.44 (27.6)	7.13 (50.3)	4.74	6.47	6.98	6.06	5.19	7.11	7.61	6.64
W_2	14.80 (217.4)	10.50 (107.7)	8.050 (62.8)	11.11 (129.3)	11.69 (111.0)	9.56 (89.5)	8.24 (65.9)	9.83 (88.8)	4.28	5.54	6.01	5.28	3.98	6.03	6.04	5.35
W_3	10.90 (117.8)	9.78 (93.7)	6.66 (42.3)	9.13 (84.6)	8.18 (53.3)	7.89 (60.3)	6.29 (37.6)	7.45 (50.4)	3.84	4.83	4.67	4.45	3.72	5.31	4.56	4.53
W_4	9.25 (83.5)	6.90 (45.6)	4.55 (18.7)	6.90 (49.3)	8.85 (62.7)	8.47 (69.8)	6.17 (36.1)	7.83 (56.2)	4.62	6.37	6.79	5.93	4.66	7.81	7.61	6.70
W_5	9.51 (88.5)	7.05 (47.7)	5.13 (24.3)	7.23 (53.5)	9.11 (66.7)	8.61 (72.2)	6.36 (38.5)	8.03 (59.1)	4.43	6.06	6.75	5.74	4.43	7.01	7.08	6.17
W_6	17.50 (304.1)	15.20 (228.1)	13.30 (174.6)	15.30 (235.6)	23.00 (435.9)	18.70 (348.9)	17.40 (300.6)	19.70 (361.8)	2.47	2.91	3.05	2.81	2.12	2.41	2.97	2.50
Mean	11.80 (147.1)	9.22 (92.7)	6.90 (55.8)		11.45 (131.5)	9.92 (112.4)	8.32 (84.4)		4.07	5.36	5.71		4.02	5.95	5.98	
	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
LSD (P=0.05)	1.22	2.44	0.95	2.37	1.27	1.67	0.91	1.68	0.31	0.43	0.38	0.48	0.29	0.25	0.33	0.34

Weed biomass

Rice establishment methods exerted significant influence on the total weed biomass (kg/ha) at 40 DAT. Total weed biomass in SRI machine transplanting was at par with SRI marker planting (Table 3). This might be due to suppression of initial emerging and emerged weeds on one hand and better crop growth on the other. The results are in agreement with the findings of Mohapatra *et al.* (2012).

Among the vertical strips, considerable reduction in total weed biomass was recorded with cono-weeding four times at 10 days interval and pretilachlor *fb* bispyribac-sodium. This might be attributed to the lesser number of total weeds (Table 1). This is in line with the findings of Anitha and Chellappan (2011).

Rice establishment and weed management had significant interaction on all the stages of crop. SRI machine transplanting with cono-weeding four times at 10 days interval resulted in significantly lower weed biomass or pretilachlor *fb* bispyribac-sodium, This was in conformity with the findings of Uprety (2010), who revealed that machine planting with frequent conoweeding encourages frequent loosening of soil to stimulate aerobic conditions and reduces the density of weeds, which causes reduction in dry matter and also incorporation of weed as a manure to crop.

Weed control efficiency

The maximum weed control efficiency (WCE) was recorded under machine transplanting of rice in conjunction with cono-weeding four times at 10 days interval followed by machine transplanting with pretilachlor *fb* bispyribac-sodium + cono-weeding 40 DAT (Table 4). Remesan *et al.* (2007) had also reported that the weed control efficiency was higher in mechanical weeding.

Yield

Grain yield of rice was influenced by establishment methods. SRI machine transplanting resulted in significantly higher grain yield compared to SRI marker planting and CT (Table 3). Transplanting by paddy transplanter caused minimum transplanting shocks to seedling and uniform depth of planting resulted in earlier establishment of crop and maximum number of productive tillers resulting in increase in rice yield as reported by Singh and Rao (2010).

Table 4. Effect of rice establishment and weed management on weed control efficiency in rice

Treatment	Weed control efficiency (%)	
	2011-12	2012-13
C_1W_1	86.8	86.4
C_1W_2	28.5	74.5
C_1W_3	81.3	87.8
C_1W_4	82.1	85.6
C_1W_5	76.5	84.7
C_1W_6	-	-
C_2W_1	87.7	84.5
C_2W_2	52.8	74.4
C_2W_3	82.2	82.7
C_2W_4	83.1	82.9
C_2W_5	77.3	82.2
C_2W_6	-	-
C_3W_1	93.2	90.8
C_3W_2	69.8	78.1
C_3W_3	87.8	87.5
C_3W_4	89.3	88.0
C_3W_5	86.1	87.2
C_3W_6	-	-

Data statistically not analysed

Among the weed management practices, higher grain yield was recorded in cono-weeding four times at 10 days interval which was at par with pretilachlor *fb* bispyribac-sodium + cono-weeding at 40 DAT. Ramamoorthy (2004) and Mohanty and Mohanty (2010) reported that four times cono-weeding removes most of the weeds by incorporating in the soil, frequently loosens the top soil to stimulate aerobic soil condition and provides weed-free environment. This conducive environment enhanced the growth and yield components of rice which in turn resulted in higher rice grain yield.

Crop establishment methods and weed management practices had significant interaction effect. Treatment combination of SRI machine transplanting with cono-weeding four times at 10,20,30, and 40 DAT (C_3W_1) and (C_3W_4) were at par. These results are in accordance with the findings of Mohaptra *et al.* (2012), who reported that machine planting with mechanical weeding encourages profuse tillering which increases the number of panicle/m^2 and number of grains per panicle and in turn the yield.

It can be concluded from the study that under labour scarcity condition, machine transplanting of rice with pretilachlor 0.75 kg/ha *fb* bispyribac-sodium 20 g/ha + cono-weeding at 40 DAT may be the better option for rice cultivation.

REFERENCES

Anitha S and Chellappan M. 2011. Comparison of the system of rice intensification (SRI), recommended practices, and farmers' methods of rice (*Oryza sativa* L.) production in the humid tropics of Kerala, India. *Journal of Tropical Agriculture* **49**(1-2): 64-71.

Baskar P. 2009. *Standardization of nursery techniques and crop geometry for rice under system of rice intensification (SRI)*. M.Sc. (Ag.) Thesis**.** Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Bell M, Balasubramanian V and Rickman J. 2003. International Rice Research Institute (IRRI). ***In***: http:// www.knowledgebank.irri.org.

Cherati FE, Bahrami H and Asakereh A. 2011. Evaluation of traditional, mechanical and chemical weed control methods in rice fields. *Australian Journal of Crop Science* **5**(8):1007-1013.

Chinnusamy C, Prabhakaran NK and Shanmughansundaram R. 2006. Sequential herbicidal weed management in transplanted rice (*Oryza sativa* L.), pp. 317–318, In: *Extended Summaries, Golden Jubilee National Symposium on Conservation Agriculture and Environment*, held during 26–28 October 2006 at India Society of Agronomy, BHU Varanasi.

CPG. 2005. *Crop Production Guide*. Directorate of Agriculture, Chennai and Tamil Nadu Agricultural University, Coimbatore.

Hemmat A and Taki O. 2003. Comparison of compaction and puddling as pre-planting soil preparation for mechanized rice transplanting in very gravelly *Calcisols* in central Iran. *Soil and Tillage Research* **70**: 65–72.

Jacob D and Syriac EK. 2005. Performance of transplanted scented rice (*Oryza sativa* L.) under different spacing and weed management regimes in southern Kerala. *Journal of Tropical Agriculture* **43**(1/2): 71-73.

Mahajan G, Chauhan BS, Johnson DE. 2009. Weed management in aerobic rice in northwestern Indo-gangetic plains. *Journal of Crop Improv*ement **23**: 366-382.

Maity SK and Mukherjee PK. 2008. Integrated weed management in dry direct-seeded rice (*Oryza sativa*). *Indian Journal of Agron*omy **53**(2): 116–120.

Mandal MK, Duary B and De GC. 2013. Effect of crop establishment and weed management practices on weed growth and productivity of Basmati rice. *Indian Journal of Weed Science* **45(3)**: 166–170

Mohanty DK and Mohanty MK. 2010. Assesment of yield using conoweeder in SRI method of paddy cultivation. *Agricultural Engineering Today* **34**(1): 21-24.

Mohapatra PC, Din M, Parida BC, Patel SP and Mishra P. 2012. Effect of mechanical planting and weeding on yield, water-use efficiency and cost of production under modified system of rice intensification. *Indian Journal of Agricultural Sciences* **82**(3): 280–283.

Ramamoorthy K. 2004. *Effect of square planting and mechanical weeding on the growth and yield of rice.* M.Sc. (Ag.) Thesis**.** Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Remesan R, Roopesh, MS, Remya N and Preman PS. 2007.Wet Land paddy weeding- A comprehensive comparative study from south India. Agricultural Engineering International: *The CIGR e-journal. Manuscript PM 07 011. Vol. IX*.

Singh RK, Singh AK, Singh VB and Kannaujia SK. 2013. Yield performance of rainfed rice under planting methods and weed control measures, *Indian Journal of Weed Science* **45(3)**: 163–165.

Singh RS and Rao KVR. 2010. Impact of self propelled transplanter in rice. *Journal of Environment, Agriculture and Food Chemistry* **9**(1):150-153.

Subbalakshmi S and Pandian BJ. 2002. Effect of water management practices and crop establishment techniques on weed growth and productivity of rice. *Indian Journal of Weed Science* **34(2)**: 124-48

Uprety R. 2010. Meshing mechanization with SRI methods for rice cultivation in Nepal. In: 2*8 th International Rice Research Conference*, 8- 12 November.