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Crop establishment and weed management techniques to control in wet-rice weeds under lateritic soils of West Bengal

A. Hossain*

Sriniketan Centre, Palli Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal 731 236

**Email: ahossaindwsrc@yahoo.in*

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ABSTRACT

A field experiment was conducted in sandy loam soil at Visva-Bharati University, Sriniketan, West Bengal in three consecutive rainy season of 2008, 2009 and 2010 to study the effect of crop establishment techniques and weed management on weed dynamics and yield of rice. Conventional transplanting method was found to be the most effective in controlling all categories of weeds throughout the growth period because of stagnation of water in the plots. Among weed management practices, pyrazosulfuron-ethyl (25 g/ha at 3 DAS/ DAT) + mechanical weeding (cono-weeder) was the most effective in controlling the mixed weed flora. Similar trend was also observed in dry matter of weeds. The highest grain yield (3.75 t/ha) was obtained under system of rice intensification (SRI) with pyrazosulfuron-ethyl (25 g/ha at 3 DAS/DAT) + mechanical weeding while drum seeded with no weed control practices recorded the lowest grain yield (2.00 t/ha). SRI system with pyrazosulfuron-ethyl + mechanical weeding also gave the highest net return (` 19890/ha).

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food crop for more than half of the world's population, including regions of high population density and rapid growth. It provides about 21 per cent of the total calorie intake of the world population. Transplanting is the most dominant and traditional method of establishment in irrigated low land rice. The area under transplanted rice in world is decreasing due to scarcity of water and labour. So, there is need to search for alternate crop establishment methods to increase the productivity of rice (Farooq *et al.* 2011). Pandey and Valesco (2005) stated that transplanted rice can be practiced in areas where low wages for labour and adequate water is available whereas direct-seeded rice can be practiced in areas with high wages and low water availability. Direct seeding reduces labour requirement, shortens the crop duration by 7-10 days and can produce as much grain yield as that of transplanted crop. It needs only 34% of the total labour requirement and saves 29% of the total cost of the transplanted crop (Ho and Romali 2000). Direct-seeding constitutes both wet- and dry-seeding and it does away with the need for seedlings, nursery preparation, uprooting of seedlings and transplanting. Irrespective of the method of rice establishment, weeds are a major impediment to rice production through their ability to compete for resources and their impact on product quality. Weed competition would be less severe under transplanting than those under direct-seeding (Singh *et al.* 2005 Savary *et al.* 2005, Rao and Nagamani 2007). Uncontrolled weeds reduced the grain yield by 75.8, 70.6 and 62.6% under dry-seeded rice (DSR), wet-seeded rice (WSR) and transplanted rice (TPR), respectively (Singh *et al.* 2005). Direct-seeding of rice allows early establishment of the succeeding crop and higher profit in areas with assured water supply by utilizing short duration modern varieties and cost efficient herbicides (Balasubramanian and Hill 2002). However, this has been accompanied by increase in weed problems and a shift in dominant grassy weeds. The innovative system of rice cultivation such as System of Rice Intensification (SRI) is being evolved to increase the productivity of irrigated rice. Under this perspective, the investigation was carried out with a view to find out the suitable crop establishment techniques along with weed management practices in rice.

MATERIALS AND METHODS

A field experiment was conducted at Visva-Bharati University, Sriniketan, West Bengal in three consecutive rainy seasons of 2008, 2009 and 2010 to study the effect of weed management and crop establishment techniques on weed dynamics and

grain yield of rice. The soil of the experimental field was sandy loam in texture, porous, slightly acidic (pH 6.2), low in organic carbon and phosphorus and medium to high in available potash. The average rainfall varied from 1200 – 1400 mm of which maximum quantity is received in the month of June to October. The experiment was laid out in a split plot design with three replications involving four rice establishment techniques, *viz*. SRI, conventional transplanting, drum seeding and broadcasting in main plots and four weed management practices *viz*. pyrazosulfuron-ethyl at 25 g/ha in 3 DAS/DAT + mechanical weeding, cono- weeder at 30 DAS/DAT, two hand weeding at 30 and 45 DAS/DAT and unweeded control in sub-plots. Two types of nurseries were raised for conventional transplanting and SRI system. In conventional transplanting system, the seedlings of 25-30 days of age and in SRI system, seedlings of 12-15 days of age were transplanted. In drum seeding and direct-broad casting, pre-germinated seeds were used. For conventional transplanting, 2-3 seedlings were planted in normal spacing of 20 x 15 cm where as in case of SRI, single seedling was planted with a spacing of 25 in the soil that was muddy but not flooded. In conventionally establishment plots recommended NPK (60:30:30 kg/ha) and in SRI system, drum seeded and broadcasted system 75% of the recommended dose of fertilizer were applied. Data on weed density were recorded at 60 DAT/DAS. Yield and yield attributes were recorded as well as economics was calculated accordingly.

RESULTS AND DISCUSSION

Weed flora

The experimental rice field was infested with 23 weed species composing 5 grasses, 13 broad-leaved and 5 sedges. The weed species were *Digitaria sanguinalis, Echinochloa colona, Panicum repens, Paspalum scrobiculatum, Cynodon dactylon, Ludwigia parviflora, Hydrolea zeylanica, Lindernia ciliata, Alternanthera sessilis, Ammania baccifera, Phyllanthus simplex, Eclipta alba, Commelina nudiflora, Commelina diffusa, Spilanthes acmella, Oldenlandia corymbosa, Veronica anagallis, Gomphrena celosioides, Fimbristylis dichotoma, F. miliacea, Cyperus iria, C. haspan* and *C. difformis.* The pre-dominant weed species were *Echinochloa colona* (35% among grasses), *Fimbristylis miliacea*(50% among sedges), *Ludwigia parviflora* (30%) and *Lindernia ciliata* (25%) among the broad-leaved weeds.

Effect on weeds

Among the weed management practices pyrazosulfuron (25 g/ha at 3 DAS/DAT) + mechanical weeding significantly reduced the density and dry weight of all categories of weeds significantly as compared to weedy check. Cono weeder and twice hand weeding were more effective in controlling grassy weeds than broad-leaved and sedges (**Table 1 and 2**). Among the crop establishment techniques, conventional method of transplanting was found to be most effective in reducing the number and dry matter of weeds (11% weed density and 28% dry weight as compared to drum-seeding) and closely followed by SRI technique (8 and 9%, respectively).

Effect on yield attributes and yield

Among the establishment techniques, SRI, transplanting and broadcasting produced more effective tillers than that of drum seedling (**Table 3**). Among the weed management practices, significant results were found in number of effective tillers and grains/panicle, but there were no significant differences in test weight. Pyrazosulfuron ethyl +

Table 1. Effect of crop establishment techniques and weed control treatments on weed population in rice at 60 DAS / DAT

Treatment	No. of weeds / m^2 at 60 DAS / DAT											
	Grass			Broad-leaved			Sedge			Total		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Rice establishment techniques												
SRI	8	7	8	54	49	46	51	49	46	113	105	100
Transplanting	5	6	6	53	51	47	48	47	45	106	104	98
Broadcasting	6	7	6	52	52	51	53	52	49	111	111	106
Drum seeding	8	9	10	57	57	51	51	52	51	116	118	112
LSD (p=0.05)	2.2	1.7	NS	2.4	5.6	2.5	3.0	NS	NS	4.8	6.5	7.3
Weed management practice												
Pyrazosulfuron 25 g/ha at 3 DAS/DAT)	2	2	2	21	21	20	24	24	22	47	47	44
Cono weeder (30 DAS/DAT)	6	6	6	58	27	52	44	45	44	108	108	102
2 HW (30 and 45 DAS/DAT	2	2	2	34	34	34	34	33	33	70	69	69
Weedy	20	19	20	104	97	89	101	98	92	225	214	201
LSD (p=0.05)	2.0	1.2	1.7	3.2	4.1	4.7	3.4	3.0	7.9	5.5	5.8	14.2

Table 2. Effect of crop establishment techniques and weed control treatments on dry matter of weeds in rice

Treatment	Dry matter (g/m²) of weeds at 60 DAS / DAT											
	Grass			Broad-leaved			Sedge			Total		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Rice establishment techniques												
SRI	4.2	4.1	4.3	20.7	20.3	22.5	23.5	23.1	43.4	48.5	47.6	48.0
Transplanting	3.4	3.5	3.8	20.2	18.9	19.6	13.9	14.9	15.0	38.4	37.3	38.5
Broadcasting	3.7	4.4	4.6	26.5	26.8	27.5	20.1	20.0	20.1	49.5	51.2	52.1
Drum seeding	4.9	4.7	4.9	25.4	25.5	25.5	28.1	20.6	21.1	58.4	50.7	51.5
LSD (p=0.05)	0.98	0.31	NS	1.41	1.73	2.49	0.94	1.35	4.79	3.22	1.93	5.28
Weed management practice												
Pyrazosulfuron(25g/ha at 3DAs/DAT)	0.5	0.8	0.9	9.1	8.3	8.4	5.8	5.7	5.3	15.5	14.7	14.6
Conoweeder(30 DAS/DAT)	2.5	2.5	2.7	19.1	19.0	19.9	16.4	16.0	15.6	38.9	37.5	38.2
2 HW(30 and 45 DAS/DAT	0.5	0.7	0.8	12.7	12.6	13.1	9.3	11.1	10.2	22.6	23.3	24.0
Weedy	12.7	12.7	13.3	51.8	51.5	53.6	54.0	48.0	48.6	117.7	111.2	113.3
LSD (p=0.05)	0.85	0.38	1.67	1.52	1.66	4.68	1.28	2.08	4.21	2.89	3.01	6.78

Table 3. Effect of crop establishment techniques and weed control treatments on yield attributes of rice

Treatment	No. of effective tillers/m²			No. of grains/ panicle			Test weight (g)		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Rice establishment techniques									
SRI	353	348	270	73	74	63	23.6	23.3	21.7
Transplanting	329	328	264	71	71	60	23.4	23.4	21.7
Broadcasting	239	310	263	71	71	58	23.5	23.4	21.7
Drum seeding	253	272	249	71	71	57	23.4	23.3	21.7
LSD (p=0.05)	6.6	6.7	7.0	NS	2.0	NS	NS	NS	NS
Weed management practice									
Pyrazosulfuron (25 g/ha at 3 DAS/DAT)	345	356	298	77	76	65	23.6	23.5	22.0
Cono weeder (30 DAS/DAT)	289	336	285	72	73	59	23.4	23.3	21.7
2 HW (30 and 45 DAS/DAT	312	316	289	76	75	62	23.6	23.4	21.8
Weedy	230	242	174	62	64	51	23.3	23.2	21.3
LSD (p=0.05)	5.2	5.4	16.0	2.4	1.1	6.0	NS	0.11	0.17

mechanical weeding produced more number of effective tillers and number of grains/ panicle. SRI, transplanting and broadcasting produced more effective tillers (25.5, 19 and 5%, respectively) than that of drum seedling rice, Among the establishment techniques.

SRI system recorded the highest grain yield of 3.30 t/ ha (**Table 4**) whereas it was the lowest in drum seeded rice (2903 kg /ha) among the rice establishment techniques. Among the weed management practices, pre-emergence application of pyrazosulfuron (25 g/ha at 3 DAS/DAT) + mechanical weeding (cono weeder) produced the highest grain yield (3.59 t /ha) and it was closely followed by HW twice (3.48 t /ha). The interaction effect was also significant. The highest grain yield (3.75 t/ha) was obtained in SRI system with pyrazosulfuron + mechanical weeding (cono weeder) followed by transplanting with pyrazosulfuron + mechanical weeding (3.71 t/ha). Higher grain yield was the resultant effect of higher yield attributes which is influenced by the reduced weed competition. The SRI system coupled with pyrazosulfuron-ethyl + mechanical weeding reduced the total weed population and dry weight to a great extent which ultimately resulted in higher grain yield.

Table 4. Effect of crop establishment techniques and weed control treatments on grain yield (kg/ha) of rice (pooled)

Weed management	Grain yield (t/ha)				
Rice establishment technique	Pyrazo-sulfuron + mechanical	Cono weeder	HW	Weedy	Mean
SRI	3.75	3.47	3.61	2.38	3.30
Transplanting	3.71	3.52	3.64	2.24	3.28
Broadcasting	3.58	3.24	3.43	2.03	3.07
Drum seeding	3.34	3.03	3.24	2.00	2.90
Mean	3.59	3.32	3.48	2.16	
	M	W	MW		
LSD (p=0.05)	0.020	0.028	0.056		

Economics: Among the rice establishment techniques, SRI system produced the highest net return (` 15813/ha) whereas it was the lowest in drum seeded rice (` 12,935/ha). Among the weed control treatments pyrazosulfuron-ethyl (25 g/ha at 3

Table 5. Economics of rice cultivation under different crop establishment methods and weed management (pooled)

Rice establishment technique	Weed management	Pyrazosulfuron + mechanical	Cono weeder	HW	Weedy	Mean net returns (`/ha)
SRI	Cost of cultivation (`/ha)	17600	17100	19000	15100	15813
	Gross returns (`/ha)	37490	34600	36120	23780	
	Net returns (`/ha)	19890	17560	17120	8680	
Transplanting	Cost of cultivation (`/ha)	17400	17200	18900	14900	15680
	Gross returns (`/ha)	37100	35220	36370	22430	
	Net returns (`/ha)	19700	18020	17470	7530	
Broad-casting	Cost of cultivation (`/ha)	16300	15600	17400	14500	14778
	Gross returns (`/ha)	35840	32440	34340	20290	
	Net returns (`/ha)	19540	16840	16940	5790	
Drum-seeding	Cost of cultivation (`/ha)	16500	16000	17100	14800	12935
	Gross returns (`/ha)	33360	30320	32410	20050	
	Net returns (`/ha)	16860	14320	15310	5250	
Mean net return (`/ha)		18978	16685	16710	6813	

Sale price of rice – ` 10/kg

DAS/DAT) + mechanical weeding (cono weeder) fetched the highest net return (` 18,998/ha). The highest net return ` 19,890/ha was recorded in SRI system coupled with pyrazosulfuron-ethyl + mechanical weeding whereas it was the lowest (` 5,250/ha) in drum seeding rice with no weed control treatment (**Table 5**).

The SRI system coupled with pyrazosulfuron-ethyl + mechanical weeding reduced the total weed population and dry weight to a great extent which ultimately resulted in higher grain yield and net return. Hence, SRI system integrated with pyrazosulfuron + mechanical weeding (cono weeder) may be recommended to the farmers for achieving higher yield and returns.

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