Indian Journal of Weed Science **45**(3): 166–170, 2013

Effect of crop establishment and weed management practices on weed growth and productivity of Basmati rice

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Received: 13 July 2013; Revised: 3 September 2013

ABSTRACT

A field experiment was conducted at village Binuria of the district Birbhum, West Bengal, India during rainy seasons (*Kharif*) of 2008 and 2009 to study the effect of crop establishment methods and weed management practices on weed growth and productivity of aromatic rice *cv.* '*Basmati 370*'. Three crop establishment methods *viz.* drum seeding (DS), system of rice intensification (SRI) and conventional transplanting (CTR) were assigned in main plots and six weed management practices, *viz.* weed-free check (WFC), unweeded check (WC), pyrazosulfuron-ethyl (PSE) at 20 g/ha, cono weeder (CW) twice at 15 and 30 DAS/DAT, combination of pyrazosulfuron-ethyl (PSE) at 20 g/ha and cono weeder twice (PSE + CW) and metsulfuron -methyl 10% + chlorimuron- ethyl 10% (Almix) at 4 g/ha in sub-plots, replicated thrice. *Cynodon dactylon, Echinochloa colona* and *Oryza rufipogon* under grasses, *Hydrolea zeylanica, Ludwigia parviflora, Sphenoclea zeylanica, Monochoria vaginalis, Sagittaria sagitifolia* and *Marsilea quadrifolia* among broad-leaved and *Cyperus iria, C. difformis* and *Fimbristylis miliacea* among the sedges were predominant weeds. *Hydrolea zeylanica* was the most pre-dominant species in SRI as well as conventional transplanting method while *Fimbristylis miliacea* in drum seeding. SRI recorded significantly lower number of total weeds at 60 DAT, the highest number of panicles (231/m^2), filled grains (98/panicle) and grain filling efficiency (84.79%) producing the highest grain yield (3.23 t/ha), 19.68 and 25.8% higher than that of CTR and DS methods respectively. Pyrazosulfuron-ethyl in combination with cono-weeder recorded the lowest weed population and dry weight at 40 DAS/DAT, higher grain yield (2982 kg/ha), 20.58% more over weedy check and was equivalent to sole application of pyrazosulfuron-ethyl and metsulfuron-methyl + chlorimuron-ethyl.

Key words: Cono weeder, Drum seeding, Metsulfuron-methyl + chlorimuron-ethyl, Pyrazosulfuron-ethyl, SRI, Weed management

India is bestowed with a rich diversity of aromatic rice. *Basmati Rice*, a variety of long grain with a fine texture, is the world's best rice for cooking and the leading aromatic fine quality rice in the world trade. In India, Basmati rice is characterized by extra long, superfine slender grains having a length to breadth ratio of more than 3.5, sweet taste, soft texture, delicate curvature and an extra elongation with least breadth-wise swelling on cooking (Yoshihashi 2005). This highly aromatic rice is India's gift to the whole world. Among several grown and marketed Basmati varieties, only six in India are recognized as traditional varieties of which '*Basmati 370*'or '*Punjab Basmati'* is most popular one which conform various standards of genetic purity as prescribed under the provisions of the Seed Act 1966. The crop of '*Basmati 370'* is about 165 cm tall, highly photosensitive and grows under high fertility conditions. It grows best on average fertility soils. '*Basmati 370'* rice variety is a *Kharif* crop and gives an approximate yield of 1.2 t of paddy per acre. Improper planting technique is one of the important factors limiting rice yield. The conventional method of planting rice in India is through transplanting after raising nursery, which is not only more laborious and time consuming but also expensive and inconvenient. Conventional method of transplanting can be replaced by direct seeding thereby reducing labour needs by more than 20% in terms of working hours required. In such situation, direct seeding is helpful because of less labour and time requirement, low cost of cultivation due to skipping of nursery raising and transplanting, maintaining recommended plant population and early crop maturity by 7-12 days (Gill 2008). Productivity of direct seeded rice is comparable with conventional transplanting method (Yadav and Singh 2006, Gangwar *et al*. 2008). The system of rice intensification (SRI) – a technique for rice culture is being practiced/evaluated in almost 22 countries. The proponents

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of SRI have claimed substantial increases in rice yields, sometimes as high as 3-4 times, with the consequent increase in the productivity of land, labour, water and capital (Uphoff 2002). System of rice intensification increases rice yield over the conventional method of cultivation by 32% and net returns by 67%, while decreases labour input by 8% in West Bengal, India (Sinha and Talati 2007). Weed menace is more in wet direct-seeded rice than in transplanted rice and the loss may be to the extent of 50-60% and even a complete crop failure. Manual weeding in rice becomes difficult because of possible damage to rice plants, problems in differentiating grassy weeds, scarcity of labours and more time and cost involvement. Chemical weed management using herbicide alone or in combination may result in effective and economic control of weeds.

Cultivation of *'Basmati 370'* is mainly confined to the foot hills of the Himalayas along with some distant pockets in few states of our country (Siddiq 2002). *'Basmati 370'* is new introduction in this region particularly lateritic belt of West Bengal. At present only a small fraction of land is occupied by this cultivar in this region, so there is lack of information about establishment method, weed management and productivity of this variety. With this background, the present study was undertaken to study the effect of crop establishment methods and weed management practices on weed growth and productivity of '*Basmati 370*' in the lateritic belt of West Bengal.

MATERIALS AND METHODS

Field experiments were conducted during *Kharif* seasons of 2008 and 2009 at the farmer's field at village Binuria (GPS point: $23^0$39.951' N, $87^0$37.971' E and 51 m above MSL), adjacent to Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal, India located in the lateritic belt of West Bengal. The experimental site represents low rainfall area of the state, with average annual rainfall of 1480 mm. The mean monthly temperature varied between 36.98 °C in April (the hottest month) and 11.7 °C in January (the coldest month) and mean relative humidity between 57.8% in March and 86.6% in August. The experimental soil (lateritic soil) was clay loam (38.6% sand, 22.8% silt and 38.6% clay) in texture, slightly acidic in reaction (6.1 pH in 1:2.5 soil: water) having 328 kg/ ha available N (by $KMNO_4$ method), 22.5 kg/ha Olsen's P and 228.7 kg/ha of 1 N neutral ammonium-acetate-extractable K (by emission spectro-photometry).

The experiment comprising three rice establishment methods *viz*. drum seeding (DS), system of rice intensification (SRI) and conventional transplanting (CTR) in main plots and six weed management practices comprising two controls (weed free and unweeded check), two herbicides *viz.* pyrazosulfuron-ethyl (PSE) at 20 g/ha on 6 days after sowing or transplanting (DAS/DAT) and metsulfuron-methyl 10% + Chlorimuron-ethyl 10% (Almix) at 4 g/ha on 20 DAS/DAT, mechanical weeding with cono weeder (CW) at 15 and 30 DAS/DAT and one chemical and mechanical combination (PSE + CW) in sub plots of 12 m^2 plots was conducted under split- plot design with three replications.

In case of drum seeding, a modified drum seeder (IRRI model) was used. It was an eight row seeder spaced at 20 cm row spacing and required 9 kg of pressure to operate the machine. The drum was mounted on two wheels which were placed at both ends. Pre-germinated seeds (soaking for 24 hours in water and treated with mancozeb at 2 g/litre of water for five minutes followed by incubation for 36-48 hours in jute bag under moist condition) of paddy cultiver *'Basmati- 370'* were filled in the drums after drying in shade for 2 hours and the drum seeder was manually dragged on the field after draining the water to saturation on July, 04 in 2008 and 2009. On the same day seeds were sown in nursery bed for SRI (in raised bed, germinated seeds were spread and covered with well rotten dry FYM and ash to facilitate transplanting of younger seedlings) and CTR (in well puddled nursery bed in densely spread out of germinated seeds). Eleven day old seedlings were transplanted singly for SRI in well puddled, clean, moist plots measuring 4 × 3 m at 25 × 25 cm hill spacing on July, 15th in both the years and for conventional transplanting, 21 day old seedlings were transplanted on 25th July 2008 and 2009 respectively maintaining 25 × 20 cm hill spacing in well puddled 4 × 3 m plots with 2-3 seedlings/hill.

The recommended dose of fertilizer (RDF) for Basmati rice in the experiment was at 80: 40: 40 kg N, P_2O_5 and K_2O/ha, respectively in the form of urea, single super phosphate (SSP) and muriate of potash (MOP). Half of the fertilizer N and K, full dose of P, along with 5 t/ha farm yard manure (FYM) were applied as basal (at the time of puddling). Remaining half of N and K was applied in two equal splits once at tillering and rest at panicle initiation stage.

The crop was harvested at the end of October to first week of November and DS plots were harvested 3-4 days before SRI and later one harvested 2-3 days prior to CTR. Plant protection measures were adopted as per need. Observations on weed counts (number/m^2) and weed dry weight (g/m^2) were taken by sampling randomly at 5 places

with the help of 0.25 m^2 quadrates at 40 and 60 days and the data were transformed using $\sqrt{x + 0.5}$ before statistical analysis. Weed control efficiency [WCE= {(WC-Wt)/WC} x 100] was also calculated [average weed dry weight per unit area in weedy check (WC) and average weed dry weight per unit area in treatment plot (Wt)]. Plant height, panicle numbers, were recorded at the day of crop harvest based on randomly selected 10 plants/hills of each plot and length of panicle, filled grains/ panicle were recorded at 2-3 days after crop harvest based on randomly selected ten panicles. Test weight of grains was computed by taking 1000 bold seeds from each plot after proper sun-drying. Weed Index [WI= $\{(Y_{WF}-Y_T)/ Y_{WF}\} \times 100$] was calculated from the grain yield data of weed management treatments [average grain yield of rice in weed free plot (Y_{WF}) and average grain yield of rice in weed management treatments (Y_T)].

RESULTS AND DISCUSSION

Weeds and weed growth

The experimental field was infested with three categories of weeds under nine families. The total number of species was 12, out of which, *Echinochloa colonum* (L.) Link, *E. crus-galli* (L.) Beauv. and weedy rice - *Oryza rufipogon* Griff. among grasses, *Hydrolea zeylanica* (L.) Vahl., *Ludwigia parviflora* Roxb., *Marsilea quadrifolia* L., *Sphenoclea zeylanica* Gaertn., *Monochoria vaginalis* (Burm.f.) C. Presl. and *Sagittaria sagitifolia* L. among broad-leaved and *Cyperus iria* L., *C. difformis* L. and *Fimbristylis miliacea* (L.) Vahl. among sedges were present as major weeds in rice field. *Hydrolea zeylanica* was the most predominant species in SRI and Conventional Transplanting plots whereas, *Fimbristylis miliacea* in drum seeding plots during both the years. Rice establishment methods had significant effect on the reduction of weed

Table 1. Effect of crop establishment and weed management practices on weed population, dry weight and weed control efficiency (mean of two years)

Treatment	Weed population (no./m^2)								Total weed dry weight (g/m^2)		Weed control efficiency (%)	
	40 DAS/DAT				60 DAS/DAT							
	Grass	Broad-leaved	Sedge	Total	Grass	Broad-leaved	Sedge	Total	40 DAS/ DAT	60 DAS/ DAT	40 DAS/ DAT	60 DAS/ DAT
Crop establishment												
DS	2.04 b (6.5)	2.61 c* (15.2)	1.69 b (4.7)	3.45 c (26.3)	1.67 b (3.7)	2.53 b (11.6)	2.57 c (8.1)	3.84 c (23.4)	3.64 c (29.7)	4.73 c (36.4)	-	-
SRI	1.83 a (5.0)	2.04 a (8.4)	1.31 a (2.1)	2.73 a (15.5)	1.37 a (2.0)	1.95 a (5.9)	1.62 a (3.2)	2.65 a (11.1)	2.22 a (6.0)	3.23 a (17.3)	-	-
CTR	2.07 b (6.2)	2.30 b (11.4)	1.43 a (3.1)	3.16 b (20.7)	1.60 b (3.4)	2.45 b (10.0)	2.09 b (5.1)	3.42 b (18.4)	2.58 b (8.4)	4.21 b (28.8)	-	-
LSD (P=0.05)	0.13	0.12	0.12	0.23	0.20	0.36	0.17	0.29	0.10	0.37	-	-
Weed management												
PSE at 20 g	0.98 b (0.5)	0.71 a (0.0)	0.71 a (0.00)	0.98 b (0.5)	0.98 b (0.5)	0.90 a (0.4)	1.79 c (3.0)	2.01 c (3.8)	1.01 b (0.6)	2.45 c (6.0)	99.5	93.9
CW	3.56 c (12.4)	3.47 b (11.9)	2.05 b (3.9)	5.29 c (28.2)	2.26 c (5.0)	4.30 c (18.3)	3.12 d (10.0)	5.71 d (33.2)	5.62 c (31.8)	7.12 d (51.8)	70.46	47.8
PSE + CW	0.95 b (0.4)	0.71 a (0.0)	0.71 a (0.0)	0.95 b (0.4)	0.98 b (0.5)	1.03 b (0.6)	1.36 b (1.5)	1.72 b (2.6)	0.98 b (0.5)	2.08 b (4.0)	99.53	95.9
MSM + CMU at 4 g	0.99 b (0.6)	0.71 a (0.0)	0.71 a (0.0)	0.99 b (0.6)	0.83 a (0.2)	1.03 b (0.7)	1.47 b (1.8)	1.73 b (2.6)	1.02 b (0.7)	2.09 b (4.1)	99.36	95.8
Weed-free check	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	0.71 a (0.0)	100	100
Unweeded check	4.69 d (21.5)	7.60 c (58.1)	3.98 c (15.7)	9.74 d (95.3)	3.51 d (12.0)	5.88 d (35.0)	4.11 e (16.6)	7.94 e (63.5)	10.36 d (107.7)	9.90 e (99.1)	0	0
LSD (P=0.05)	0.20	0.09	0.08	0.21	0.18	0.23	0.13	0.22	0.23	0.28	-	-

Values given in parentheses are original means; *Means followed by common letters do not differ significantly at P = 0.05 level; DS- Drum Seeding; SRI- System of rice intensification; CTR- Conventional transplanting; PSE - Pyrazosulfuron-ethyl at 20 g/ha at 6 DAS/DAT; PSE + CW - Combination of PSE + cono-weeder (twice application at 15 and 30 DAS/ DAT); MSM + CMU - Metsulfuron-methyl 10% + chlorimuron-ethyl 10% at 4 g/ha at 20 DAS/DAT.

population. SRI plots had the lowest number of weeds in respect of morphological groups as well as total weeds at 40 and 60 DAS/DAT whereas drum seeding plots had the highest number of weeds. Effective reduction of broad-leaved, grasses and sedges was recorded with PSE + cono-weeder, PSE and Almix alone and these were statically at par with weed free check. However, regeneration of sedges occurred in all weed management treatments (Table 1). None of the treatments could effectively control weedy rice (*Oryza rufipogon*). All the treatments were significantly superior to weedy check. Pal *et al*. (2012) also found similar results.

Among the crop establishment methods, SRI had the lowest dry weight of total weed and drum seeding plots had the highest dry weight of weeds both at 40 and 60 DAS/DAT. The treatment PSE + cono weeder significantly reduced the total weed dry weight followed by PSE and Almix alone (Table 1). Absolute WCE was only in weed free check, above 95% in PSE + cono weeder, PSE and Almix and below 75% in Cono weeder. Besides that Almix had the certain level of phytotoxicity in DS and SRI treated plots at the early stage of crop growth.

Effect on rice

Weed management treatments had the significant effect on crop height at harvest. PSE + cono weeder and weedy check plots recorded the tallest and shortest plants respectively; whereas, rice establishment techniques had no significant effect on crop height at harvest. Rice establishment techniques had significant effect on production of tillers/m^2. SRI and DS recorded the highest and the lowest number of tillers respectively. Among the weed management treatments PSE + cono weeder recorded the higher number of tillers/m^2 over others except weed-free check followed by cono weeder alone simply due to effective weed suppression and better root aeration in this integrated approach. However, Almix recorded the highest efficiency regarding panicle production; followed by PSE, PSE + cono weeder and weedy check.

Number of filled grains per panicle was significantly influenced both on the rice establishment methods and weed management practices. The number of filled grains and grain filling efficiency were highest under SRI and were significantly superior over DS and CTR which were however at par with each other. Among the weed management practices PSE + cono weeder recorded higher number of filled grains (98/panicle) which was statistically at par with weed free check followed by sole application of PSE and Almix (Table 2). Weed free check registered significantly higher grain filling efficiency (89.1%) over other treatments followed by PSE + cono weeder (84.7%), sole application of PSE (82.7%) and Almix (82.1%). Test weight (1000 seeds weight) was significantly influenced both by rice establishment system and weed management

Table 2. Effect of crop establishment and weed management practices on plant height, yield components, harvest index and weed index (mean of two years)

Treatment	Plant height at harvest (cm)	Effective tillers /m^2	Filled grains/ panicle	Grain filling efficiency (%)	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Weed index (%)
Crop establishment									
DS	147.0	203.4 b	85.3 b	79.7 b	21.87 b	2.57 b	9.13 b	21.9 b	-
SRI	149.7	230.8 a	97.8 a	84.9 a	22.82 a	3.23 a	9.52 b	25.3 a	-
CTR	148.6	228.1 a	88.1 b	80.0 b	22.07 b	2.70 b	10.44 a	20.6 b	-
LSD (P=0.05)	NS	17.7	3.63	3.6	0.27	4.43	0.50	2.7	-
Weed management practice									
PSE at 20g	146.1 c	221.1 bc	91.3 bc	82.7 b	22.26 b	2.90 bc	9.69 c	23.0	5.01
Conoweeder (CW)	151.8 ab	230.3 abc	89.0 c	78.9 c	21.92 c	2.76 d	9.80 bc	21.9	9.35
PSE+CW	152.4 a	241.9 ab	97.1 ab	84.7 b	22.48 b	2.98 ab	10.12 ab	22.7	2.35
MSM+CMU at 4g	146.8 bc	210.9 c	87.8 c	82.1 bc	22.37 b	2.84 cd	0.96 c	22.8	6.86
Weed free check	144.7 c*	248.7 a	101.9 a	89.1 a	22.79 a	3.05 a	1.03 a	22.9	0.00
Unweeded check	148.8 abc	171.7 d	75.3 d	71.6 d	21.70 c	2.47 e	8.64 d	22.2	19.00
LSD (P=0.05)	5.14	22.7	6.65	3.7	0.26	0.13	0.38	NS	-

*Means followed by common letters do not differ significantly at P = 0.05 level; DS- Drum Seeding; SRI- System of rice intensification; CTR- Conventional transplanting; PSE - Pyrazosulfuron-ethyl at 20 g/ha at 6 DAS/DAT; PSE + CW - Combination of PSE + cono-weeder (twice application at 15 and 30 DAS/ DAT); MSM + CMU - Metsulfuron-methyl 10 % + chlorimuron-ethyl 10 % at 4 g/ha at 20 DAS/DAT.

treatments. SRI produced more bold seeds than that of CTR and DS. On the other hand weed-free check recorded significantly the highest test weight, followed by PSE + Cono weeder, Almix and PSE; which were at par; whereas, weedy-check recorded the lightest grains.

SRI recorded significantly the highest grain yield (3235 kg/ha) which was 19.7 and 25.8% higher over CTR and DS, respectively. Though the lowest (2572 kg/ ha) grain yield was recorded under DS but it was at par with CTR (2703 kg/ha). About 19% yield loss was occurred due to weed competition in Basmati rice. Weed-free check recorded the highest grain yield and was at par with PSE + cono weeder (2.98 t/ha), followed by sole application of PSE, Almix, cono weeder and the significantly lowest gain yield was in weedy-check. Crop establishment methods and weed management treatments had no significant interaction effect. The results corroborate the findings of Kumar *et al*. (2012). Conventional transplanting recorded the highest straw yield and DS the lowest and the later was statistically at par with SRI. The opposite result was observed with respect to HI. PSE + cono weeder recorded significantly higher straw yield followed by Cono weeder, PSE and Almix. Weed management treatments had no significant effect on HI. PSE + cono weeder recorded lower weed index (WI) value (2.35%) followed by sole application of PSE, almix and cono weeder.

It can be concluded that application of PSE at 20 g/ha at 6 DAS/DAT and twice application of cono weeder at 15 and 30 DAS/DAT was the most effective weed management practice and among the rice establishment systems SRI was the most appropriate system in Basmati rice in the *Kharif* season. Thus, SRI system along with pyrazosulfuron-ethyl at 20 g/ha at 6 DAT + cono weeder may be recommended for Basmati rice cultivation in the lateritic belt of West Bengal.

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