Indian Journal of Weed Science **51**(3): 232–235, 2019

Print ISSN 0253-8040 Online ISSN 0974-8164

Mechanized weed management to enhance productivity and profitability in system of rice intensification

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Article information

DOI: 10.5958/0974-8164.2019.00049.2

Type of article: Research article

Received : 7 May 2019
Revised : 25 July 2019
Accepted : 2 August 2019

Key words

Bispyribac-Na

Conoweeder

Economics

SRI

Yield

ABSTRACT

An experiment was conducted during 3 consecutive rainy seasons of 2015 to 2017 at ICAR-Research Complex for Eastern Region, Patna to evaluate the mechanized weed management practices for enhancing the productivity in system of rice intensification (SRI) against farmers' practice. The seven weed management treatments, *viz.* conoweeder thrice at 15, 25 and 35 DAT, conoweeder twice at 15 and 30 DAT, post-emergence (PoE) application of bispyribac-Na 25 g/ha (20 DAT) + conoweeder at 35 DAT, conoweeder 15 DAT + bispyribac-Na 25 g/ha (20 DAT), conoweeder on 15 DAT + bispyribac-Na 25 g/ha (20 DAT) + conoweeder 35 DAT, unweeded check and farmers' practice were evaluated under randomized block design with three replications. *Fimbristylis miliacea* was the top ranking weed with the highest degree of weed infestation. Significantly the highest grain yield (5.97 t/ha) was obtained from 3 times conoweeder at 15, 25 and 35 DAT, which was at par with conoweeder twice on 15 and 30 DAT (5.40 t/ha). Integration of herbicide with mechanical weeder did not improve the weed control efficiency and grain yield over conoweeder twice on 15 and 30 DAT. The highest weed control efficiency of 93.3 and 91.7% at 60 DAT were obtained with application of conoweeder thrice at 15, 25 and 35 DAT and conoweeder twice at 15 and 30 DAT, respectively. The crop raised by SRI method produced significantly higher grain and straw yields than that of farmers' practice except unweeded check under SRI, which was heavily infested with weeds (weed density 153.27/m^2 and weed biomass 129.93 g/m^2). However, in SRI, 2 times conoweeder at 15 and 30 DAT, was found to be effective and economical leading to cost saving for the farmers.

INTRODUCTION

The system of rice intensification (SRI) is a methodology aimed at increasing the yield of rice through effective integration of crop, soil, water and nutrient management (Uphoff 2003). It is a low water and labour intensive method that uses younger seedlings singly spaced and typically hand weeded with special tools under wide planting geometry. Water productivity increased by 61.8% in check basin irrigated SRI as compared to water productivity of 0.34 kg/m^3 in farmers' method of rice establishment (Kumar *et al.* 2015). Under SRI, weeds grow more vigorously, and need to be kept under control at an early stage. A rotary hoe or conoweeder is used starting at 15 days after transplanting (DAT), repeated ideally every 10 days until the canopy is closed. Use of mechanical weeders breaks up the surface soil as it turns weeds into mulch, stimulates root growth by root pruning and conserving their nutrients as they decompose in the soil. The use of the weeder contributes to homogeneous field conditions, creating a uniform crop stand and leading to increased yields. This practice, especially if done several times, can add 1 to 3 t/ha to yield without other soil amendments, by inducing better soil health and more nutrient cycling and solubilization through microbial activity (Singh 2018). On the other hand, chemical methods lead to environmental pollution and in many weed species developed resistance against herbicides. In view of the increasing labour scarcity and negative impact of indiscriminate herbicides use, weed management strategy needs to be reoriented towards mechanical means for satisfactory monetary benefits. The present study was undertaken to study the effect of different weed management options in SRI and their effects on yield attributes, grain yield and economics.

MATERIALS AND METHODS

Field experiments were conducted during 3 consecutive rainy seasons of 2015 to 2017 at ICAR-Research Complex for Eastern Region, Patna (25º 37'

N, 85° 13' E and 53 m above mean sea level). The soil was silty clay loam (55.6% sand, 15.5% silt and 28.9% clay) in texture, neutral in reaction (pH 6.6 in 1: 2.5 soil: water), having 250 kg/ha available N, 10.5 kg/ha Olsen's P and 250 kg/ha extractable K. The top 15 cm soil had bulk density of 1.5 g/cm^3, field capacity 35% and permanent wilting point of 15.5% on oven-dry basis. Seed of rice variety '*Arize 6444*' was treated with *Trichoderma viride at* 5 g/kg seed. 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 to facilitate transplanting of younger seedlings) and farmers' method (in well puddled nursery bed in densely spread out germinated seeds). Twelve days old seedlings were transplanted singly for SRI in well puddled, clean and moist plots measuring 6 x 4 m at 25 x 25 cm hill spacing on 16 July, 6 August and 14 August, receiving total rainfall of 296.9, 554.7 and 199.7 mm during crop period of 2015, 2016 and 2017, respectively.

In all the SRI planted plots irrigation was applied so as to maintain saturation all throughout. Whereas, in farmers' practice, 21 days old seedlings were transplanted on the same dates as in the case of SRI during all the three years maintaining 20 x 15 cm hill spacing in well puddled 6 x 4 m plots with 2-3 seedlings/hill. In farmers' practice, crop was managed with inorganic fertilization, flooded irrigation and one hand weeding at 25-30 DAT. The seven weed management treatments, *viz.* conoweeder thrice at 15, 25 and 35 DAT, conoweeder twice at 15 and 30 DAT, post-emergence (PoE) application of bispyribac-Na 25 g/ha (20 DAT) + conoweeder at 35 DAT, conoweeder 15 DAT + bispyribac-Na 25g/ha (20 DAT), conoweeder on 15 DAT + bispyribac-Na 25 g/ha (20 DAT) + conoweeder 35 DAT, unweeded check and farmers' practice were evaluated under randomized block design with three replications.

In SRI plots, half of the recommended dose of N (50 kg/ha) through vermicompost and full dose of P_2O_5 and K_2O 60 and 40 kg/ha, respectively were given through single super phosphate and muriate of potash before transplanting at final land preparation and remaining N (50 kg/ha) was top-dressed in 2 equal splits (half at active tillering and the rest half at panicle initiation stage).

The crop was harvested on 10 November, 1 December and 7 December during 2015, 2016 and 2017, respectively and the farmers method planted plots were harvested about 10 -12 days before SRI. Observations on weed counts (no./m^2) and weed dry weight (g/m^2) were taken by sampling randomly at 4 places with the help of 0.25 m^2 quadrates at 40 and 60 DAT and the data were transformed using $\sqrt{x+0.5}$ before statistical analysis. Weed control efficiency $[WCE = \{(WC - Wt)/WC\} * 100]$ was also calculated. Panicle numbers were recorded on the day of crop harvest based on randomly selected 10 panicles/hills of each plot, 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. The statistical analysis was done with the standard statistical method (Sheoran *et al.* 1998).

RESULTS AND DISCUSSION

Effect on weeds

Nine different weed species were found to infest the experimental crop. The most important weed species in the experimental plots throughout the growing period were *Fimbristylis miliacea, Echinochloa crus-galli, Eleusine indica, Leptochloa chinensis* and *Cynodon dactylon*. At 40 DAT, *Fimbristylis miliacea* was the top ranking weed with the highest degree of weed infestation (**Table 1**) followed by *Echinochloa crus-galli* and *Eleusine indica*. Further at 60 DAT, four new weed species emerged and *Fimbristylis miliacea* followed by *Echinochloa crus-galli* maintained their superiority in terms of degree of infestation over other weeds (**Table 1**).

Table 1. Degree of weed infestation in experimental field at different stages (pooled mean of 3 years)

Weed species	Degree of weed infestation (%)	
	40 DAT	60 DAT
Echinochloa crus-galli	16.21	20.96
Cyperus rotundus	0	5.13
Cyperus iria	0	10.74
Cyperus difformis	0	12.21
Cynodon dactylon	2.74	3.32
Fimbristylis miliacea	63.65	35.91
Ludwigia parviflora	0	1.31
Leptochloa chinensis	4.13	4.30
Eleusine indica	13.27	6.12

The highest weed density (153.3/m^2) and weed biomass (129.93 g/m^2) were found in the unweeded treatment at 60 DAT, which was significantly higher than in other treatments (**Table 2**). Similar results were also reported by Mandal *et al.* (2013) and Mitra *et al.* (2005). Farmers' practice resulted inthe second highest weed density and weed biomass at 40 and 60 DAT, which were significantly higher than other treatments. Mechanical weeding by conoweeder at 15, 25 and 35 DAT followed by conoweeder at 15 and 30 DAT were most effective than the other treatments in controlling the weeds up to 60 DAT (**Table 2**). SRI with conoweeding four times at 10 days interval resulted in significantly lower weed biomass (Uprety 2010). Row weeding machine can be run in SRI fields up to 30 DAT because profuse lateral vegetative growth of rice is vulnerable to the damage by the row weeding (Haden 2007). Moreover, weeders fail to remove all the weeds growing in intra-row spaces, which compete with rice plants; even some of the weeds are able to re-grow from their roots, particularly, rhizomatous, weeds, sedges, *etc*. (IRRI 2014).

Effect on rice

Weed management treatments had the significant effect on production of number of panicle/ m^2 and grains/panicle. The highest number of panicle and number of grains/panicle were obtained in conoweeder at 15, 25 and 35 DAT followed by conoweeder at 15 and 30 DAT (**Table 3**). It might be due to the least crop-weed competition that ensured sufficient nutrients and other growth resources, which enhanced higher grains/panicle production. Roy (2012) also reported that three times mechanical weeding in both direction was capable to produce higher yields. 1000-grain weight was also influenced by weed control treatments, but the variation was not significant. It might be due to that grain size is a genetically controlled character and influenced little by management practices. Grain yield was also significantly affected by weed control treatments (**Table 3**). The significantly highest grain yield (5.97 t/ha) was obtained from 3 times conoweeder at 15, 25 and 35 DAT among all treatments except with conoweeder twice on 15 and 30 DAT (5.40 t/ha). Integration of herbicide in weed management treatments, *viz*. conoweeder 15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT) + conoweeder 35 DAT, Conoweeder15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT) and PoE application of bispyribac-Na 25 g/ha (20 DAT) + conoweeder use 35 DAT failed to improve weed control efficiency over conoweeder twice on 15 and 30 DAT. The highest weed control efficiency of 93.3 and 91.7% up to 60 DAT (**Table 2**) were obtained in treatments of conoweeder thrice at 15, 25 and 35 DAT and conoweeder twice at 15 and 30 DAT, respectively. The results corroborate the findings of Mohapatra *et al.* (2012). The use of conoweeder caused 10-17% increase in grain yield during wet season (Mandal *et al.* 2013). Higher numbers of conoweeding effectively buries and incorporates the weeds into soil and minimizes the weed competition. Further it improves the soil aeration, root development, nutrient absorption and more number of tillers, which favoured the crop growth, yield attributes and resulted in higher grain

Table 2. Effect of weed management treatments on weed density, dry weight and weed control efficiency (pooled mean of three years)

Treatment	Weed density (no./m^2)		Weed dry biomass (g/m^2)		Weed control efficiency (%)	
	40 DAT	60 DAT	40 DAT	60 DAT	40 DAT	60 DAT
Conoweeder thrice on 15, 25, and 35 DAT	6.06(36.8)	5.21(27.0)	2.59(6.3)	3.04 (8.8)	67.36	93.3
Conoweeder twice on 15 and 30 DAT	7.34 (53.6)	6.29(39.3)	2.81(7.5)	3.36 (10.8)	61.14	91.7
Bispyribac-Na as PoE 25 g/ha (20 DAT) + conoweeder use 35 DAT	6.77 (45.3)	5.84(33.6)	2.95(8.3)	4.13(16.5)	56.99	87.3
Conoweeder 15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT)	6.84(46.8)	5.88(34.3)	3.33(10.7)	4.19(17.0)	44.56	86.9
Conoweeder on 15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT) + conoweeder on 35 DAT	6.67(44.2)	5.71(32.4)	2.93(8.2)	4.24(17.5)	57.51	86.6
Unweeded check	14.13(200.4)	12.36(153.3)	8.54(73.4)	11.42(129.9)	0	0
Farmers' practice	9.73(94.5)	8.29(69.3)	3.7(13.3)	5.05 (25.0)	31.09	80.8
LSD (p=0.05)	1.25	1.59	0.79	0.94	-	-

Values in parentheses are original means

Table 3. Effect of weed management treatments on yield attributes, grain yield of rainy season planted SRI (pooled mean of three years)

Treatment	Panicle no./m^2	No. of grains/ panicle	1000-grain weight (g)	Straw yield (t/ha)	Rice grain yield (t/ha)			
					2015	2016	2017	Mean
Conoweeder thrice on 15, 25, and 35 DAT	253	96	22.33	6.56	6.35	6.15	5.41	5.97
Conoweeder twice on 15 and 30 DAT	225	93	21.00	5.96	6.20	6.00	4.00	5.40
Bispyribac-Na as PoE 25 g/ha (20 DAT) + conoweeder use 35 DAT	194	89	21.00	5.6 1	5.80	5.35	3.76	4.97
Conoweeder 15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT)	195	90	21.66	5.76	5.95	5.45	3.60	5.00
Conoweeder on 15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT) + conoweeder on 35 DAT	196	90	22.33	5.78	6.15	5.80	3.14	5.02
Unweeded check	135	71	19.33	3.50	3.20	3.00	2.20	2.80
Farmers' practice	161	80	20.00	4.37	3.65	3.25	3.18	3.36
LSD (p=0.05)	27	10	NS	1.24	0.77	0.82	1.14	0.91

Table 4. Effect of weed management treatments on economics of rainy season planted SRI (pooled mean of three years)

Treatment	Economics			
	Gross return (x10^3 `/ha)	Cost of cultivation (x10^3 `/ha)	Net return (x 10^3 `/ha)	Benefit : cost ratio
Conoweeder thrice on 15, 25, and 35 DAT	92.53	70.62	21.91	1.31
Conoweeder twice on 15 and 30 DAT	91.14	66.62	24.52	1.37
Bispyribac-Na as PoE 25 g/ha (20 DAT) + conoweeder use 35 DAT	84.04	64.62	19.42	1.30
Conoweeder 15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT)	84.70	64.00	20.70	1.32
Conoweeder on 15 DAT + bispyribac-Na as PoE 25 g/ha (20 DAT) + conoweeder on 35 DAT	85.03	64.00	21.03	1.32
Unweeded check	47.77	46.00	1.77	1.04
Farmers' practice	57.54	56.50	1.04	1.02

Sale price of paddy is ` 15500/t and Straw: ` 1250/t

yield (**Table 3**). The SRI yield reduction due to weed competition could be up to 69.15% (Babar and Velayutham 2012). The crop raised by SRI method produced significantly higher grain and straw yield than plots planted under farmers' practice except unweeded check under SRI, which was heavily infested with weeds (**Table 2**). Regarding economics, the higher yielding treatments recorded higher net returns and benefit: cost ratio (**Table 4**). Conoweeder further reduced man-days required for weeding from 30 to 10 (Mrunalini and Ganesh 2008), thus helped saving labour and time. In lowland *(tarai)* belt of Uttarakhand, a decrease in cost of cultivation by ` 1,000/ha mainly due to less cost involved in transplanting of rice seedlings and 5% increase in grain yield increased net returns by over ` 3,000/ha under wider spacing (25 x 25 cm) compared to closer spacing of 20 x 20 cm (Dass and Chandra 2012).

It may be concluded that weed management through conoweeder twice at 15 and 30 DAT has been found most effective and economical in SRI method of rice establishment.

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