



Integrated weed management with brown manuring and herbicides in dry-seeded rice

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Article information

DOI: 10.5958/0974-8164.2020.00053.2

Type of article: Research note

Received : 29 March 2020

Revised : 17 July 2020

Accepted : 22 July 2020

Key words

Brown manuring

Herbicides

Sequential application

Weed dynamics

ABSTRACT

The study was carried out in rainy season in 2015 at Ludhiana, India. Present study evaluated the effect of timing of brown manuring with *Sesbania aculeata* alone and its integration with herbicides on weed incidence and rice grain yield. *Sesbania* seed was broadcasted at time of rice sowing and brown manured using 2,4-D at 580 g/ha at 4- and 5-weeks age. BM plots had significantly lower weed density and biomass than without BM (sole rice). BM at 4 weeks was more effective in suppressing weeds than BM at 5 weeks age. Among weed control methods, sequential application of pendimethalin and bispyribac gave best weed control and highest rice grain yield. Combination treatments of BM (4 weeks) with pendimethalin and, sole rice with pendimethalin and bispyribac gave similar rice grain yield. It was concluded that BM has weed control potential equivalent to one post-emergence herbicide, however, for getting the highest rice productivity it must be used in combination with pre- and post-emergence herbicides.

Dry-seeded rice (DSR) is a mechanized system of rice establishment. It has less human labour and water requirement as compared to conventional system of rice establishment (transplanting rice seedlings in puddled soils). In North-West Indo-Gangetic Plains (IGP), water table has been declining at an alarming rate of 0.1–1.0 m per year which has mainly been attributed to puddled transplanted rice (PTR) (Bhat *et al.* 2016). Less availability of farm labour owing to increasing urbanization, and higher labour costs make rice transplanting a costly affair, and in many cases rice transplanting is delayed.

Any change in establishment method changes weed composition. DSR is more prone to infestation with diverse weed flora than PTR in which ponded water provide complete check over aerobic weeds and fair control of typical rice weeds (Bhullar *et al.* 2016). Higher yield penalty in DSR is attributed to initial flush of weeds which is controlled by continuous flooding in PTR (Rao *et al.* 2007, Chauhan 2012, Singh *et al.* 2014, Singh *et al.* 2016). Under these situations, a single weed control approach is not sufficient to keep the weeds under check and avoid economic losses. Therefore, adoption of integrated weed management (IWM) practices is essential for weed management in DSR. Singh *et al.* (2018) recorded better control of weeds

and higher DSR yield under integrated use of stale seed bed and post-sowing herbicides than either of two methods used alone. Anitha *et al.* (2012) observed that concurrent growing of *Sesbania* and its incorporation at 30 DAS resulted decline in total weed count due to concurrent growing of *Sesbania* was 72%, while that in weed dry matter production was 57% compared to rice grown alone. Present study investigated effect of timing of brown manuring (with *Sesbania aculeata*) and herbicides on weeds incidence, growth and yield of DSR

The field experiment was conducted in rainy season in 2015 at Research Farm, Department of Agronomy, Punjab Agricultural University (PAU), Ludhiana (30°54' North latitude, 75°48' East longitude, 247 m). The meteorological data have showed that average maximum weekly temperature ranged between 28.7°C to 44.5°C. The total amount of rainfall received during the crop season was 441.70 mm, whereas; mean relative humidity varied between 27 to 85%. The total sunshine hours varied between 1.7 to 11.7 hours during the crop season. Experimental soil type was sandy loam with 0.39% organic C with pH 8.0, low in available N (243 kg N/ha) and available P (8.8 kg/ha), and high in available K (337 kg/ha). The experiment was laid out in a factorial randomized complete block design with four

replications. Twelve treatments included three brown manuring (BM)-(without BM rice sole, BM at 4 weeks; BM at 5 weeks after sowing) and four weed control (pendimethalin 750 g/ha as pre-emergence (PE), bispyribac-sodium 25 g/ha as post-emergence (PoE), pendimethalin 750 g/ha as PE followed by bispyribac-sodium 25 g/ha as PoE, unsprayed check) treatments. Pendimethalin was sprayed in the evening on the day of sowing while bispyribac-sodium was sprayed when weeds were at 3-4 leaf stage. The herbicides were sprayed with a knapsack sprayer fitted with flat fan nozzle using 500 and 375 litres of water/ha for pre- and post-emergence herbicide, respectively. In rice sole, weeds were not removed. The gross plot size was $9 \times 2.3 \text{ m} = 20.7 \text{ m}^2$.

The field was ploughed once with disc harrow and cultivated twice with tractor drawn cultivator followed by planking. The field was then levelled with laser land leveller and layout was done. Rice seed was then air dried under shade to facilitate sowing and seeded directly in moist soil 20 kg/ha in rows spaced at 20 cm in 2-3 cm depth using an inclined-plate seed drill on 15th June, 2015. *Sesbania* seed at 25 kg/ha was broadcast just before sowing of rice and brown manured with 2,4-D amine at 580 g/ha at 4 and 5 weeks after sowing. Nitrogen at 150 kg/ha was applied through urea, in three equal splits, at 2, 5 and 9 weeks after sowing. The whole dose of 30 kg/ha P (in the form of single super phosphate) and 30 kg/ha K (in the form of muriate of potash) were applied at the time of field preparation as basal dose. Zn at 62.5 kg/ha was applied two weeks after sowing. The crop was sprayed with 1% Fe solution (250 L/ha) at 2, 4 and 6 weeks after sowing, to prevent iron deficiency. Experimental plot was irrigated twice weekly during first two weeks to keep seed zone moist under hot dry conditions during that period. Thereafter, irrigations were applied at 7-10 days interval depending upon rainfall and last irrigation was given 12 days before crop harvest. For control of termites, chlorpyrifos 20 EC was applied at 50 g/ha by mixing with 150 kg dry sand in moist field. Leaf folder was controlled with spray of chlorpyrifos 20 EC at 50 g/ha in 250 litres of water/ha at 75 days age and propiconazole 25 EC at 62.5 g/ha was used at 90 days age to control sheath blight. The crop was harvested manually on 21st October 2015. Data on number of grains per panicle and grain weight per panicle was recorded from ten representative plants per plot. Grain and straw yield were recorded from the net plot area ($7 \times 1.9 \text{ m} = 13.3 \text{ m}^2$) in the centre of each plot. The harvested crop was threshed manually. The grain yield was recorded in kilograms/plot and expressed as t/ha at 14% grain moisture content.

Data on major weed density and dry biomass were recorded at 60 days after sowing (DAS), quadrat ($40 \times 40 \text{ cm}$ size) was placed at two representative places in each plot. Weeds were recorded species wise and weed biomass for grass, sedge and broad-leaf weeds. Weed samples were oven dried at 70°C for constant dry biomass. All data were analyzed by factorial RBD using the SAS Proc GLM (SAS 9.3). The comparisons were made at 5% level of significance by using duncan's multiple range test (DMRT). Data were analyzed using analysis of variance (ANOVA) to evaluate the differences among treatments while the means were separated using the least significant difference (LSD) test at the 5% level of significance. Weed density and biomass data were subjected to square root transformation; however, it did not improve the homogeneity of variance. Therefore, original values were used in ANOVA.

Effect on weeds

Predominant weed species in experimental field consisted of *Echinochloa colona* L., *Dactyloctenium aegyptium* (L.) Wild, *Eleusine indica* L. among grassy weeds and *Cyperus rotundus* L., *Cyperus iria* L. among sedges. Grass weeds and *C. rotundus* appeared during initial crop growth stages and *C. iria* emerged late after *C. rotundus*. Few broad-leaved weed species, viz., *Phyllanthus niruri*, *Alternanthera* sp. and *Digera arvensis* were recorded but with very low densities (<5%). At 60 day, rice + BM at 4/5 weeks had lower densities of *E. colona*, *D. aegyptium*, *C. rotundus*, *C. iria* and total weed density than sole rice; BM at 4 weeks had similar grass weed density but lower density of sedges (*C. rotundus* and *C. iria*) and total weed density than BM at 5 weeks (**Table 1**). Among weed control, pendimethalin and bispyribac combination had lower density of all weed species than when herbicides used alone and unsprayed check, in both years. Bispyribac plots had lower density of *E. colona*, *C. rotundus*, *C. iria* and total weed density than pendimethalin and unsprayed check. Pendimethalin plots had lower density of all grass weeds and total weed density but had similar density of sedges compared to unsprayed check; compared to bispyribac, it had lower density of aerobic grass weeds *D. aegyptium* and *D. sanguinalis*. Pendimethalin and bispyribac sequence was more effective in reducing weed density than used alone, and reduced density of grass weeds to zero under rice + BM (4 and 5 WAS).

Effect on crop

Among BM treatments, rice + BM at 4/5 weeks had similar panicle density, grain weight/ panicle

(Table 2). Both these BM treatments had higher values of all these yield parameters than sole rice. Among weed control, unsprayed control had lower panicle density, and weight/panicle than pendimethalin and bispyribac applied alone or in sequence. Among herbicides, panicle density, grain weight/panicle were the highest under sequential application of pendimethalin and bispyribac and these values were higher than when herbicides used alone and unsprayed check.

Rice panicle had the highest grain weight under combination of rice + BM at 4 weeks, pendimethalin and bispyribac (Table 2). Grain weight under this treatment combination was similar to combination of both herbicides under sole rice or rice + BM at 5 weeks, pendimethalin or bispyribac alone under rice + BM at 4 or 5 weeks.

In case of rice grain yield, among BM treatments, rice + BM at 4/5 weeks gave higher grain yield than sole rice while rice + BM at 4 weeks gave higher yield than rice + BM at 5 weeks (Table 2). Among weed control, all herbicidal treatments gave higher grain yield than unsprayed control. Sequential application of pendimethalin and bispyribac gave higher grain yield than when these herbicides used alone while pendimethalin alone gave higher grain yield than bispyribac used alone. Integration of rice + BM at 4 weeks with sequential application of pendimethalin and bispyribac gave the highest grain yield which was higher than all other treatment combinations. Integration of rice + BM at 4 weeks with pendimethalin gave rice grain yield similar to when sole rice and rice + BM at 5 weeks were raised with sequential application of pendimethalin and bispyribac.

Brown manuring with *Sesbania* significantly reduced weed density and biomass without any adverse effect on DSR grain yield. The lower weed density in BM plots, as compared to sole rice, would probably be attributed to decreased availability of sunlight to germinating weed seeds which inhibited weed seed germination (Chauhan 2012).

In unsprayed control, higher grain yield under brown manuring as compared to sole rice was attributed to the differences in weed density and biomass. In BM treatments, *Sesbania* crop suppressed the weed emergence and growth as compared to without BM, and the rice crop had better growth environment which increased grain yield and attributes. Among BM treatment also, higher grain under BM at 4 weeks than at 5 weeks was attributed to better control of sedge weeds, as explained earlier. These results indicated that 4 week stage seems to be better than 5 weeks for getting best benefits in term of weed management. In BM treatments, the grain yield was lower under bispyribac alone compared to pendimethalin alone treatment. This indicates the importance of early season weed control in DSR. Pendimethalin gave effective control of grass weeds during initial crop growth stages and BM provided effective control of sedges and broad-leaf weeds. In case of bispyribac alone, higher weed growth particularly of grassy weeds provided competition to crop during initial stages which was reflected in lower grain yield. These results indicated the importance of integration of pre- than post-emergence herbicide along with BM. However, under both BM treatments, the integration of both pre- and post-emergence herbicides enhanced grain yield as compared to pre- or post-herbicides alone. These

Table 1. Effect of brown manuring and herbicide treatments on density of different weed species in direct-seeded rice (60 days after sowing) in 2015

Treatment	Weed density (no./m ²) ^{a,b}					Weed biomass (g/m ²) ^{a,b}			
	<i>Echinochloa colona</i>	<i>Dactyloctenium aegyptium</i>	<i>Cyperus rotundus</i>	<i>Cyperus iria</i>	Total weed density	Grass	Broad-leaf weeds	Sedges	Total weeds
<i>Brown manuring (BM)</i>									
Rice sole	10a	13a	185a	15a	248a	53a	13a	241c	312a
Rice + BM (4WAS)	3b	4b	83c	7c	105c	18b	2b	72a	91c
Rice + BM (5WAS)	3b	4b	117b	9b	142b	18b	1b	149b	168b
<i>Herbicide</i>									
Unsprayed controls	12a	12a	186a	15a	252a	61a	15a	253a	330a
Pendimethalin 750 g/ha	6b	4b	151a	13a	191b	20c	5b	174b	199bc
Bispyribac 25 g/ha	4c	11a	101b	8b	139c	56ab	1c	98c	155bc
Pendimethalin 750 g/ha fb bispyribac 25 g/ha	0d	1c	69c	6c	76d	2d	0c	58c	59d
Interaction	S	S	S	S	S	S	NS	S	S

^aMeans presented within each column with no common letter (s) are significantly different according to Fisher's Protected least significant difference (LSD) test where P<0.05.

^bData were square root transformed before analysis; however, back-transformed actual mean values are presented based on the interpretation from the transformed data.

Table 2. Interaction effect of brown manuring and herbicides on yield attributes and rice grain yield

Treatment	Grain weight/ panicle (g)				Panicle density (no. /m ²)				Grain yield (t/ha)			
	Rice sole	Rice + BM (4WAS)	Rice+ BM (5WAS)	Mean	Rice sole	Rice + BM (4WAS)	Rice+ BM (5WAS)	Mean	Rice sole	Rice + BM (4WAS)	Rice+ BM (5WAS)	Mean
Unsprayed control	0.98d	2.34b	3.17ab	2.17c	94h	148e	199fg	147d	1.37hi	3.36f	3.37g	26.84d
Pendimethalin 750 g/ha	3.16b	3.52ab	3.32ab	3.34ab	186ef	274bc	229cde	230b	3.71ef	5.20bc	4.56d	44.94b
Bispyribac 25 g/ha	2.10c	3.31ab	3.30ab	2.91b	120gh	228cde	217de	188c	2.68gh	4.06e	4.01e	35.86c
Pendimethalin 750 g/ha fb bispyribac 25 g/ha	3.62ab	3.79a	3.44ab	3.62a	290b	355a	252bcd	299a	5.47b	5.97a	4.78cd	54.02a
Mean	2.47b	3.31a	3.24a		172b	251a	224a		33.09c	46.39a	41.77b	

^aMeans presented within each column with no common letter(s) are significantly different according to Fisher's Protected least significant difference (LSD) test where P<0.05; WAS - Week after sowing

results indicated the need for post-emergence herbicide also, along with pre-emergence for achieving the best DSR yield. The critical periods in case of DSR are longer (Singh *et al.* 2014) which supports our results in that combination of BM and pre- and post-emergence herbicides were able to maintain effective control of broad spectrum of weeds over longer period and hence gave the highest grain yield. Pendimethalin and bispyribac complement each other; pendimethalin is effective against annual aerobic grass weeds and bispyribac against typical grass, broadleaf and sedge weeds of rice but does not control *D. aegyptium* (Chauhan 2011, Gopal *et al.* 2010). In our case also, pendimethalin recorded effective control of grass weeds especially aerobic grasses and follow up application of bispyribac effectively controlled typical grass weeds of rice, broadleaf and sedges. Hence, the sequential application of pendimethalin as pre- and bispyribac as post-emergence provides broad spectrum control of weeds, which was true in this case also, hence the rice grain yield under combination treatment was higher as compared to when these herbicides used alone, both under sole rice and BM treatments.

Conclusions

In dry- seeded rice, brown manuring (BM) with *Sesbania aculeata* reduced weed density and biomass than sole rice; BM at 4 weeks provided higher level of weed suppression than BM at 5 weeks. Among herbicides, pendimethalin 750 g/ha as pre- and bispyribac-sodium 25 g/ha as post-emergence gave the highest rice grain yield and reduced weed density and biomass as compared to pendimethalin and bispyribac applied alone.

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