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Weed management in wet (drum)-seeded rice under Southern dry zone of Karnataka

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ABSTRACT

A field experiment was conducted during *Kharif* (rainy season) 2014 and 2015 at Zonal Agricultural Research Station, V.C. Farm, Mandya, to identify suitable weed management practices for wet (drum)-seeded rice under Southern dry zone of Karnataka. Among the various treatments, pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR10 kg/ha *fb* post-emergence application of bispyribac sodium 25 g/ha at 20 days after sowing (DAS) being on par with weed free check, recorded significantly higher net monetary returns and B: C ratio. Uncontrolled weed growth caused 48.23-50.0% reduction in grain yield of wet (drum)-seeded rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important global food grain crops. In India, rice is contributing 45% to the total food grain production and is grown in an area of 44.1 million ha with a production of 106.64 million tonnes and productivity of 2.42 t/ha (Bhatt *et al*. 2017). Among several reasons for low rice productivity, the losses due to weeds are one of the most important. Herbicides are used to control weeds in crop as pre- or post-emergence application which reduce the population of weeds significantly resulting in higher yield and profit (Mishra *et al.* 2016).

In recent years, rice (*Oryza sativa* L.) production systems are undergoing several changes and one of such changes is shifting from transplanted rice to direct-seeded rice due to increased cos and non availability of labour during peak periods of agricultural operations. Sowing of sprouted rice seeds in wet puddled soils (wet-seeded rice) offers an alternative and labour-saving technique for stand establishment to the traditional transplanting. Wet-seeded rice is gaining momentum in India and it have the advantages of quick and easier planting, reduces labour requirement and increased water use efficiency. However, direct-seeded rice (DSR) is associated with several constraints like heavy weed infestation, water management immediately after sowing and lack of perfect leveling *etc*. Among them, heavy infestation of heterogenous weed flora becomes the biggest biological constraint as rice and weed seeds germinate simultaneously. The yield loss due to unchecked weed growth was reported up to 30-48% in DSR (Naseeruddin and Subramanyam 2013). The success of DSR is mainly depends on better weed management practices. Several studies indicated that, alone application of either pre-/post-emergence herbicides were not effective in seasonal long control of weeds (Dibyendu *et al.* 2019). Under such situation, sequential application of pre- and post emergence herbicide is a better option. Hence, the present investigation was carried out to identify suitable weed management practices for wet (drum)-seeded rice under Southern dry zone of Karnataka.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* (rainy season) 2014 and 2015 to identify suitable weed management practice for wet (drum)-seeded rice under Southern dry zone of Karnataka. The field study was conducted at Zonal Agricultural Research Station, V. C. Farm, Mandya (12^0 34.3' N latitude, 76^0 49.8' E longitude and at an elevation of 697 m above mean sea level), of University of Agricultural

Sciences, Bengaluru. The soil of experimental site was red sandy loams with bulk density and particle density of 1.15 and 2.65 g/cc, respectively. The soil pH was 6.5 (neutral in reaction). It was low in available nitrogen and phosphorus and high in potassium. Eight treatments, *viz.* pyrazosulfuron-ethyl 25 g/ha as pre-emergence application (PE) + passing of one conoweeder at 40 DAS, bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha (PE) + passing of one conoweeder at 40 DAS, pyrazosulfuron-ethyl 25 g/ha (PE) + bispyribac-sodium 25 g/ha (30 DAS) as post-emergence application (PoE), bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha (PE) + bispyribac-sodium 25 g/ha (30 DAS) as PoE, bispyribac-sodium 25 g/ha as early post-emergence application (early post – 15 DAS). These weed control treatments were compared with hand weeding thrice at 20, 40 and 60 DAS, weedy and weed free check. These eight treatments were laid out in complete randomized block design with three replications.

Sowing of pre-germinated seeds of medium duration rice variety '*MTU-1001*' was done through 8 row drum seeders with a row to row spacing of 20 cm on well puddled and leveled field in June 2014 and 2015 with a seed rate of 62.5 kg/ha. The crop was fertilized with 100:50:50 kg N: P: K/ha and 50% nitrogen, entire dose of phosphorous and potassium was applied as basal in addition to zinc sulphate 25 kg/ ha. The remaining 50% of the nitrogen was top dressed at two equal splits at tillering and panicle initiation stage. The gross plot size was 5.0 x 3.0 m. Pre-emergence herbicides were mixed with sand 100 kg/ha and applied uniformly in the field on 5 DAS. A thin film of water was maintained at the time of pre-emergence herbicide application. The post-emergence herbicides were sprayed at 3-4 leaf stage of weeds at 30 DAS by using knap-sack sprayer fitted with deflector nozzle mixed with water 750 liter/ha. Mechanical weeding with two row cono-weeder was carried out at 40 DAS as per the treatments. Hand weeding was carried out as per the treatment schedule. All other agronomic and plant protection measures were adopted as per the recommended packages of University of Agriculture Science (UAS), Bangalore. Bensulfuron-methyl 0.6% + pretilachlor 6% GR is combination of two herbicides and is in granular form and found safe to rice.

The efficacy of herbicides was tested by taking the observation on category wise weeds *viz.* grasses, sedges and broad-leaved weeds, weed density and biomass at 30 and 60 days after treatment of the crop by using a quadrate (0.5 x 0.5 m) randomly in each plot and their subsequent effect on growth and yield of wet (drum)-seeded rice. The weeds were uprooted from one m^2 area selected at random and were oven dried to a constant weight at 65°C and dry weight of weeds in each treatment was recorded and expressed as g per square meter. Data on growth parameters like plant height (cm) and number of tillers at harvest and yield parameters like grain weight per panicle (g), 100-seed weight (g), per cent choppiness and yield (kg/plot) of wet (drum)-seeded rice was recorded at harvest. The per cent choppiness was worked out by using the following formula.

$$\text{Per cent Choppiness} = \frac{\text{Number of unfilled grains per panicle}}{\text{Total number of grains per panicle}} \text{ X } 100$$

The data collected from the experiment at different growth stages were subjected to statistical analysis as described by Panse and Sukhatme (1967). The normality of distribution was not seen in case of observation on weeds hence, the values were subjected to square root transformation ($\sqrt{x+0.5}$) prior to statistical analysis to normalize their distribution. Statistical analysis was carried out based on mean values obtained. The level of significance used in 'F' and 't' test was P= 0.05. Critical difference values were calculated wherever 'F' test was significant as per the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Weed flora

The extent of growth and yield loss caused by weeds depends on weed species and their density in a crop community. Major weed flora observed in the experimental field in association with the wet (drum)-seeded rice, *viz. Eclipta alba* (false daisy) (16.2%), *Echinochloa colonum* L. (barnyard grass) (10.6%), *Echinochloa crus-galli* L. (barnyard grass) (3.5%), *Digitaria sanguinalis* L. (large crab grass) (3.2%), *Cynodon dactylon* (bermuda grass) (2.8%) and *Panicum repens* L. (quack grass) (1.2%) among grasses; *Ludwigia parviflora* (water primerose) (19.5%), *Ammannia baccifera* (blistering ammannia) (14.2%), *Commelina Benghalensis* L. (benghal dayflower) (8.0%), *Cyanotis cristata* (L.) (creseted dew grass) (3.2%), *Oxalis corniculata* L. (wood sorrel) (2.8%), *Marsilea quadrifolia* (water clover) (2.4%) among broad-leaved weeds (BLW); and *Cyperus rotundus* L. (purple nut sedge) (8.2%) and *Cyperus iria* L. (rice flat sedge) (4.2%) among sedges.

Weed density and biomass

All the weed control treatments significantly reduced the density and biomass of grasses, BLW, sedges and total weeds as compared to unweeded check **(Table 1, 2, 3** and **4)**. Among different category of weeds, density and biomass of broad-leaved weeds was higher in weedy check followed by grasses and sedges at 30 and 60 DAS in weedy check. Among the weed control treatments, hand weeding thrice at 20, 40 and 60 DAS recorded significantly lower weed density and biomass in both the years as compared to other treatments. However, it was at par with bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha PE *fb* bispyribac-sodium 25 g/ha PoE, pyrazosulfuron-ethyl 25 g/ha *fb* bispyribac-sodium 25 g/ha PoE and bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha PE + one conoweeder at 40 DAS also reduced the weed density and biomass as compared to application of pyrazosulfuron-ethyl 25 g/ha + conoweeder (40 DAS) and bispyribac-sodium 25 g/ha alone. However, all these treatments significantly lowered the weed density as compared to weedy check. Effective control of weeds with combination of

Table 1. Weed density (no./m^2) as influenced by weed management treatments in wet (drum)-seeded rice at 30 DAS

Treatment	Grasses		BLW		Sedges		Total	
	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl 25 g/ha (PE) + passing of one conoweeder at 40 DAS	2.46 (5.57)	2.53 (5.94)	3.85 (14.5)	3.95 (15.4)	1.72 (2.47)	1.83 (2.93)	4.79 (22.5)	4.96 (24.2)
Bensulfuron-methyl + pretilachlor 10 kg/ha (PE) + passing of one conoweeder at 40 DAS	2.23 (4.47)	2.31 (4.90)	3.26 (10.1)	3.34 (10.7)	1.69 (2.36)	1.78 (2.69)	4.00 (15.5)	4.33 (18.3)
Pyrazosulfuron-ethyl 25 g/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	2.76 (7.10)	2.81 (7.41)	3.87 (14.5)	3.91 (14.8)	1.72 (2.45)	1.94 (3.28)	4.17 (16.9)	5.09 (25.5)
Bensulfuron methyl + pretilachlor 10 kg/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	2.19 (4.33)	2.30 (4.89)	3.26 (10.1)	3.32 (10.6)	1.65 (2.26)	1.99 (3.61)	3.57 (12.3)	4.42 (19.1)
Bispyribac-sodium 25 g/ha (early post) (15 DAS)	4.82 (22.8)	4.88 (23.4)	5.81 (33.3)	5.94 (34.8)	2.72 (6.91)	2.83 (7.55)	7.65 (58.0)	8.14 (65.8)
Hand weeding thrice at 20, 40 and 60 DAS	2.00 (3.52)	2.18 (4.26)	3.07 (8.9)	3.21 (9.9)	1.28 (1.14)	1.30 (1.18)	3.51 (11.9)	3.97 (15.3)
Weed free check (6 hand weeding)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.00)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
Weedy check	6.04 (36.0)	6.29 (39.1)	8.12 (65.9)	8.31 (69.2)	3.11 (9.24)	3.57 (12.4)	10.19 (103.5)	10.99 (120.7)
LSD (p=0.05)	0.35	0.48	0.60	0.83	0.28	0.48	0.44	0.64

Square root $\sqrt{x+0.5}$ transformed values. Values in the parentheses are original values

Table 2. Weed density (no./m^2) as influenced by weed management treatments in wet (drum)-seeded rice at 60 DAS during 2014 and 2015

Treatment	Grasses		BLW		Sedges		Total	
	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl 25 g/ha (PE) + passing of one conoweeder at 40 DAS	3.97 (15.54)	4.05 (16.18)	3.98 (15.34)	4.00 (15.55)	1.68 (2.31)	1.78 (2.71)	5.79 (33.2)	5.90 (34.4)
Bensulfuron-methyl + pretilachlor 10 kg/ha (PE) + passing of one conoweeder at 40 DAS	3.08 (9.02)	3.19 (9.73)	3.73 (13.49)	3.80 (14.10)	1.51 (1.80)	1.55 (1.95)	4.98 (24.3)	5.12 (25.8)
Pyrazosulfuron-ethyl 25 g/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	3.94 (15.06)	4.00 (15.58)	3.83 (14.20)	3.88 (14.59)	1.64 (2.19)	1.70 (2.38)	5.65 (31.5)	5.74 (32.6)
Bensulfuron methyl + pretilachlor 10 kg/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	2.95 (8.23)	2.98 (8.46)	3.72 (13.38)	3.80 (13.93)	1.50 (1.75)	1.55 (1.92)	4.88 (23.4)	4.98 (24.3)
Bispyribac-sodium 25 g/ha (early post) (15 DAS)	5.26 (27.16)	5.34 (28.17)	6.07 (36.39)	6.11 (36.87)	2.45 (5.58)	2.55 (6.16)	8.34 (69.1)	8.47 (71.2)
Hand weeding thrice at 20, 40 and 60 DAS	2.88 (7.81)	2.93 (8.13)	3.48 (11.65)	3.54 (12.05)	1.40 (1.45)	2.29 (6.40)	4.62 (20.9)	5.15 (26.6)
Weed free check (6 hand weeding)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy check	6.72 (44.79)	6.80 (45.97)	8.66 (74.41)	8.71 (75.39)	2.93 (8.10)	2.99 (8.50)	11.30 (127.3)	11.41 (129.9)
LSD (p=0.05)	0.58	0.76	0.34	0.47	0.25	1.04	0.45	0.74

Square root $\sqrt{x+0.5}$ transformed values. Values in the parentheses are original values

bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha *fb* bispyribac sodium 25 g/ha PoE was noticed at 30 and 60 DAS as evident from the reduced weed density and biomass. These findings were in conformity to Sangeetha (2006) and Dhanapal *et al.* (2018a). The crop yield is directly proportional to weed control efficiency. The weed control efficiency was maximum in hand weeding thrice at 20, 40 and 60 DAS (87.1% and 85.1% at 30 DAS and 83.5% and 82.1% at 60 DAS in 2014 and 2015, respectively) and bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha PE *fb* post-emergence application of bispyribac-sodium 25 g/ha PoE was best treatment among the herbicides in terms of higher WCE (87.1% and 86.0% at 30 DAS and 79.4% and 77.9% at 60 DAS in 2014 and 2015, respectively). These results were in agreement with (Pratik and Manoj 2017).

Growth, yield and yield attributes

All the herbicide treatments produced significantly higher grain yield compared to weedy check. Unweeded check registered 48.23% during 2014 and 50.0% during 2015 reduction in grain yield as compared to weed free check owing to sever competition offered by uncontrolled weeds for nutrients, soil moisture, space and light. Among the

Table 3. Weed biomass (g/m^2) as influenced by weed management treatments in wet (drum)-seeded rice at 30 DAS

Treatment	Grasses		BLW		Sedges		Total		Treatment	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl 25 g/ha (PE) + passing of one conoweeder at 40 DAS	1.44 (1.63)	1.53 (1.97)	1.24 (1.04)	1.26 (1.08)	1.35 (1.33)	1.39 (1.44)	2.12 (4.00)	2.22 (4.49)	78.8	77.1
Bensulfuron-methyl + pretilachlor 10 kg/ha (PE) + passing of one conoweeder at 40 DAS	1.38 (1.42)	1.49 (1.83)	1.22 (0.98)	1.31 (1.24)	1.51 (1.81)	1.60 (2.12)	2.17 (4.22)	2.38 (5.19)	77.5	73.4
Pyrazosulfuron-ethyl 25 g/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	1.45 (1.62)	1.51 (1.84)	1.20 (0.95)	1.30 (1.23)	0.97 (0.45)	1.00 (0.49)	1.87 (3.01)	2.01 (3.56)	83.9	81.6
Bensulfuron methyl + pretilachlor 10 kg/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	1.31 (1.22)	1.36 (1.37)	1.06 (0.63)	1.09 (0.71)	1.03 (0.57)	1.07 (0.65)	1.71 (2.41)	1.79 (2.73)	87.1	86.0
Bispyribac-sodium 25 g/ha (early post) (15 DAS)	2.36 (5.10)	2.43 (5.43)	1.85 (2.95)	1.93 (3.29)	1.56 (2.11)	1.64 (2.43)	3.25 (10.15)	3.40 (11.15)	46.0	42.9
Hand weeding thrice at 20, 40 and 60 DAS	1.41 (1.48)	1.50 (1.77)	0.92 (0.35)	0.97 (0.46)	1.04 (0.59)	1.08 (0.66)	1.71 (2.41)	1.84 (2.90)	87.1	85.1
Weed free check (6 hand weeding)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100.0	100.0
Weedy check	2.88 (7.81)	2.90 (7.95)	2.71 (6.85)	2.79 (7.35)	2.15 (4.14)	2.20 (4.36)	4.39 (18.79)	4.49 (19.66)	0.0	0.0
LSD (p=0.05)	0.29	0.46	0.18	0.33	0.37	0.47	0.27	0.37	-	-

Square root $\sqrt{x+0.5}$ transformed values. Values in the parentheses are original values

Table 4. Weed biomass (g/m^2) as influenced by weed management treatments in wet (drum)-seeded rice at 60 DAS

Treatment	Grasses		BLW		Sedges		Total		Treatment	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl 25 g/ha (PE) + passing of one conoweeder at 40 DAS	1.72 (2.46)	1.83 (2.91)	1.94 (3.27)	2.05 (3.72)	1.71 (2.44)	1.75 (2.59)	2.94 (8.17)	3.10 (9.23)	74.9	72.5
Bensulfuron-methyl + pretilachlor kg/ha (PE) + passing of one conoweeder at 40 DAS	1.67 (2.32)	1.75 (2.62)	1.88 (3.06)	1.94 (3.29)	1.75 (2.58)	1.83 (2.87)	2.91 (7.96)	3.04 (8.79)	75.3	73.6
Pyrazosulfuron-ethyl 25 g/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	1.79 (2.75)	1.87 (3.09)	1.86 (2.95)	1.93 (3.24)	1.40 (1.46)	1.46 (1.64)	2.77 (7.16)	2.91 (7.97)	77.9	76.4
Bensulfuron methyl + pretilachlor 10 kg/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	1.71 (2.44)	1.78 (2.72)	1.77 (2.67)	1.84 (2.96)	1.43 (1.54)	1.47 (1.67)	2.67 (6.65)	2.78 (7.35)	79.4	77.9
Bispyribac-sodium 25 g/ha (early post) (15 DAS)	2.47 (5.64)	2.54 (6.02)	3.03 (8.89)	3.08 (9.26)	2.28 (4.72)	2.35 (5.07)	4.44 (19.25)	4.56 (20.35)	41.1	40.6
Hand weeding thrice at 20, 40 and 60 DAS	1.55 (1.91)	1.62 (2.17)	1.37 (1.38)	1.41 (1.50)	1.60 (2.06)	1.71 (2.47)	2.42 (5.36)	2.57 (6.14)	83.5	82.1
Weed free check (6 hand weeding)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100.0	100.0
Weedy check	3.37 (10.85)	3.51 (11.92)	3.66 (12.93)	3.71 (13.39)	3.08 (9.00)	3.18 (9.71)	5.76 (32.78)	5.94 (35.02)	0.0	0.0
LSD (p=0.05)	0.26	0.51	0.43	0.56	0.20	0.37	0.37	0.65	-	-

Square root $\sqrt{x+0.5}$ transformed values. Values in the parentheses are original values

weed control treatments, significantly higher grain yield (5.62 and 5.50 t/ha in 2014 and 2015, respectively) was obtained with season long weed free check as compared to weedy check (**Table 6**). However, it was on par with pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha PE *fb* post-emergence application of bispyribac-sodium 25 g /ha PoE (5.24 and 4.90 t/ha in 2014 and 2015, respectively) and hand weeding thrice at 20, 40 and 60 DAS (5.39 and 4.98 t/ha in 2014 and 2015, respectively). The superior performance of these treatments was mainly attributed to enhanced yield parameters, *viz.* number of tillers/plants, grain weight/panicle and 100 seed weight **(Table 5).** The increase in rice grain yield over weedy check due to different treatments was attributed to the reduced density and biomass of weeds at all stages of crop growth, which resulted in increased dry matter of rice and number of panicles/ m^2. These results were in accordance with Sangeetha (2006), Dhanapal *et al*. (2018a) and Singh and Pairka (2014).

Economics

Among different weed management practice, the higher net returns (₹ 47,800 in 2014 and 43,935/ ha in 2015) and B:C (2.55 and 2.48 in 2014 and 2015, respectively) was recorded with bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha PE *fb* bispyribac-sodium 25 g/ha PoE. While, the lowest net returns (₹ 18,635 and 16,295 /ha in 2014 and 2015, respectively) and B:C (1.75 and 1.65 in 2014 and 2015, respectively) was observed in un weeded check **(Table 6)**. The increased monetary benefits in

Table 5. Growth and yield parameters of wet (drum)-seeded rice as influenced by weed management treatments

Treatment	Plant height at harvest (cm)		No. of tillers at harvest		Grain weight/ panicle (g)		100-seed weight (g)		Percent choppiness	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl 25 g/ha (PE) + passing of one conoweeder at 40 DAS	48.37	47.91	14.82	13.62	1.75	1.66	1.22	1.15	25.43	26.76
Bensulfuron-methyl + pretilachlor 10 kg/ha (PE) + passing of one conoweeder at 40 DAS	51.21	50.24	14.98	13.88	2.78	2.67	1.57	1.52	17.85	18.78
Pyrazosulfuron-ethyl 25 g/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	51.97	51.28	15.18	13.87	2.78	2.67	1.58	1.50	17.71	19.24
Bensulfuron-methyl + pretilachlor 10 kg/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	52.59	51.56	15.32	14.04	2.85	2.70	1.77	1.61	14.99	16.31
Bispyribac-sodium 25 g/ha (early post) (15 DAS)	40.90	40.50	13.12	12.33	1.67	1.52	1.16	1.14	28.23	30.38
Hand weeding thrice at 20, 40 and 60 DAS	54.29	53.51	15.82	15.21	2.64	2.54	1.82	1.74	12.21	12.77
Weed free check (6 hand weeding)	56.60	55.77	17.11	15.99	2.66	2.54	1.84	1.72	10.82	11.88
Weedy check	37.77	37.09	10.38	9.57	1.51	1.44	1.12	1.10	56.66	58.82
LSD (p=0.05)	5.65	5.74	1.95	1.84	0.17	0.38	0.19	0.30	4.49	7.00

Table 6. Yield and economics of wet (drum)-seeded rice as influenced by weed management treatments.

Treatment	Grain yield (t/ha)		Weed Index (%)		Net returns (Rs./ha)		B:C ratio	
	2014	2015	2014	2015	2014	2015	2014	2015
Pyrazosulfuron-ethyl 25 g/ha (PE) + passing of one conoweeder at 40 DAS	5.13	4.86	8.53	11.54	47195	43140	2.58	2.45
Bensulfuron-methyl + pretilachlor 10 kg/ha (PE) + passing of one conoweeder at 40 DAS	5.16	5.05	8.22	8.38	40430	38735	2.09	2.05
Pyrazosulfuron-ethyl (PE) + bispyribac-sodium 25+25 g/ha (PoE) (30 DAS)	5.20	4.87	7.42	11.50	48330	43235	2.63	2.45
Bensulfuron methyl + pretilachlor 10 kg/ha (PE) + bispyribac-sodium 25 g/ha (PoE) (30 DAS)	5.24	4.90	6.61	10.55	47800	43935	2.55	2.48
Bispyribac-sodium 25 g/ha (early post) (15 DAS)	3.04	2.92	45.95	46.93	18640	16930	1.69	1.63
Hand weeding thrice at 20, 40 and 60 DAS	5.39	4.98	3.99	9.53	51255	43900	2.73	2.42
Weed free check (6 hand weeding)	5.62	5.51	0.00	0.00	41300	39605	1.96	1.92
Weedy check	2.91	2.75	48.16	49.91	18635	16295	1.75	1.65
LSD (p=0.05)	0.40	0.71	6.96	12.78	-	-	-	-

this treatment were mainly attributed to higher grain yield and reduced labour cost. This result was obtained due to effective weed management at critical stages by integration of effective pre- and post-emergence herbicides along with manual weeding, which resulted in higher grain with reduced cost of cultivation. Similar findings have also been reported by Prameela *et al*. 2014 and Dhanapal *et al.* 2018b. Similar results of higher net returns and B:C ratio in direct seeded rice due to sequential application of herbicides were also reported by Pinjari *et al.* (2016) and Sumana Ghosh *et al.* (2016).

On the basis of two years observations, it was concluded that pre-emergence application of bensulfuron-methyl 0.6% + pretilachlor 6% GR 10 kg/ha *fb* post-emergence application of bispyribac-sodium 25 g/ha found most effective and economical in controlling the weeds in wet (drum)-seeded rice in Cauvery command area of Karnataka, India.

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