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Weed management in irrigated dry-seeded rice

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ABSTRACT

A field experiment was conducted during *Kharif* 2015 and *Summer* 2016, at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka, India, to study the effect of different herbicides for control of weeds in irrigated dry-seeded rice. The dominant weeds in fields were *Echinochloa* sp. *Panicum repens, Cynodon dactylon, Bracharia mutica, Digitarias anguinalis* and *Leptochloa chinensis* among grasses, *Eclipta alba,Commelina communis* and *Ludwigia parviflora* as among broad-leaf weeds and *Cyperus* sp. as sedge. Among herbicidal treatments, post-emergece application of BAS 9548 H (penoxsulam 10 g/l + bentazone 360 g/l SC) 3000 ml/ha recorded significantly higher rice grain yield followed by the application of BAS 9548 (penoxsulam 10 g/l + bentazone 360 g/l SC) 2500 ml/ha and twice hand weeding at 15 and 30 days after sowing (DAS). The maximum B:C ratio was observed in plots treated with BAS 9548 H (penoxsulam 10 g/l + bentazone 360 g/l SC) and twice hand weeded check.

Key words: Weeds biomass, Weed control efficiency, Direct-seeded rice, BAS 9548 H, Weed managment

Rice (*Oryza sativa* L.) is the staple food for more than 60% of the world population, providing energy for about 40% of the world population where every third person on earth consumes rice every day in one form or other (Datta and Khushi 2002). Among several reasons for low rice productivity, the losses due to weeds are one of the most important. Weeds are most severe and widespread biological constrains to crop production in India and weeds alone cause 33% of losses out of total losses due to pests (Verma *et al.* 2015). Irrespective of the method of rice establishment, weeds are a major impediment to rice production due to their ability to compete for resources. In general, weeds problem in transplanted paddy is lower than that of direct-seeded rice (Rao *et al.* 2007). But in situations where continuous standing water cannot be maintained particularly during the first 45 days, weed infestation in transplanted rice also may be as high as direct-seeded rice. According to Singh *et al.* (2004), weeds can reduce the grain yield of dry-seeded rice (DSR) by 75.8%, wet-seeded rice (WSR) by 70.6% and transplanted rice (TPR) by 62.6%. Weeds by virtue of their high adaptability and faster growth dominate the crop habitat and reduce the yield potential. Therefore, the present investigation was undertaken to study the effect of early post-emergent herbicide for control of major weeds in irrigated dry-seeded rice.

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MATERIALS AND METHODS

A field study was taken during *Kharif*-2015 and *Summer*-2016 on effect of different herbicides against weeds in irrigated dry-seeded rice at Agricultural Research Station, Dhadesugur, Raichur, Karnataka. The soil of the experimental site was medium deep black and neutral in pH (8.04), EC (0.47 ds/m), medium in organic carbon content (0.41%), low in nitrogen (189 kg/ha), medium in phosphorus (58.5 kg/ha) and potassium (287.5 kg/ha). There were eight treatments, *viz*. BAS 9548 H (penoxsulam 10 g/l + bentazone 360 g/l SC) 840 g/ha (2270 ml/ha), BAS 9548 H (penoxsulam 10 g/l + bentazone 360 g/l SC) 925 g/ha (2500 ml/ha), BAS 9548 H (penoxsulam 10 g/l + bentazone 360 g/l SC) 1110 g/ha (3000 ml/ha), bentazone 480 g/l SL 960 g/ha (2000 ml/ha), penoxsulam 21.7% SC 18 g/ha (83.3 ml/ha), cyhalofop-butyl 10% EC 150 g/ha (1500 ml/ha), hand weeding and weedy check and replicated thrice. Herbicides were sprayed using a Knapsack sprayer fitted with a flat-fan nozzle at a spray volume of 500 l/ha.

Rice was sown by tractor drawn seed drill at spacing of 20 x 10 cm in both the years. Recommended dose of fertilizer (150:75:75 kg NPK/ha) was applied uniformly in three equal splits. Irrigation comprised of alternate drying and wetting followed by intermittent irrigation at seven days interval up to 15 days before harvest. Other agronomic and plant protection measures were adopted as recommended during the crop growth. The efficacy of different treatments on weeds was evaluated at crop maturity. Quadrates (0.25 m^2) were placed in each plot at random to determine the weed density. Weed seedlings within these quadrates were counted and the efficacy of weed control treatments was evaluated by comparing the density with the untreated control. Weeds were cut at ground level, washed with tap water, oven dried at 70 ^{0}C for 48 hours and then weighed for biomass. The weed control efficiency was calculated using the formula given by Tawaha *et al.* (2002).

After harvest and threshing of crop, grain yield was recorded in net plot wise and converted to grain yield per hectare. The cost of inputs that were prevailing at the time of their use was considered for working out the economics of various treatments. Net return was calculated by deducting the cost of cultivation from gross returns and gross returns was calculated by using the total income obtained from grain and straw yield of rice and the benefit: cost ratio was worked out.

To see the impact of this herbicide on succeeding crop, the blackgram crops was sown after harvesting of the paddy crop from the herbicide treated plots and the data recorded on germination of seed and impact on crop growth and development *viz.* leaf injury on tips and leaf surface, wilting, vein clearing, necrosis, epinasty, hyponasty, stunted growth *etc.* after 7, 15 and 21 days after germination (DAG). The data of each year was analysed separately. MSTAT was used for statistical analysis of data and means were separated using critical difference (LSD) at p=0.05. The data on weeds were transformed by square root transformation before being subjected to ANOVA (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on weed density

Grassy weeds: The grassy weeds, which were predominant in trials field were *Echinochloa* sp. *Panicum repens, Cynodon dactylon, Bracharia mutica, Digitarias anguinalis* and *Leptochloa chinensis* (**Table 1)**. Post-emergence application of BAS 9548 H 3000 ml/ha recorded significantly lower grassy weeds followed by the application of BAS 9548 H 2500 ml/ha and twice hand weeded check as compared to application of bentazone 480 g/l SL 960 g/ha (2000 ml/ha), penoxsulam 21.7% SC 18 g/ha (83.3 ml/ha), cyhalofop-butyl 10% EC 150 g/ha (1500 ml/ha) and weedy check in *Kharif* 2015 and summer 2016 when observed at 60 DAS. Singh *et al.* (2007) reported that post-emergence application of penoxsulam recorded significantly lower grassy weed population in rice. Similarly, Yadav *et al.* (2007) have also reported penoxsulam as an effective post-emergence herbicide against mixed weed flora in rice.

Broad-leaf weeds: The predominant broad-leaf weeds in the trials field were *Eclipta alba, Commelina communis* and *Ludwigia parviflora*. Post-emergence application of BAS 9548 H 2500 ml/ ha was at par with the application of BAS 9548 H 3000 ml/ha and twice hand weeded check found to be significantly superior treatment with recorded lowest population of broad-leaf weeds over rest of the treatments (**Table 1)**. Further, weedy check recorded significantly higher weed population of broad-leaf weeds. These results were in conformity with the findings of Yadhav *et al.* (2008).

Sedges: Post-emergence application of BAS 9548 H 2500 ml/ha, 3000 ml/ha and twice hand weeded check were found equally effective in controlling sedges in direct-seeded rice. Post emergence application of bentazone 480 g/l SL 960 g/ha (2000 ml/ha), penoxsulam 21.7% SC 18 g/ha (83.3 ml/ha), cyhalofop-butyl 10% EC 150 g/ha (1500 ml/ha) were at par with each other in controlling sedges in direct-seeded rice. Weedy check recorded significantly higher sedges density compared to other weed controlling treatments. These results were in conformity with the findings of Jabusch *et al.* (2005) and Jason *et al.* (2007).

Effect on weeds biomass

Post-emergence application of BAS 9548 H 2500 ml/ha, 3000 ml/ha and twice hand weeded check found to be significantly superior to the rest of the treatments in controlling the weeds and recorded least weeds biomass. Post-emergence application of bentazone 480 g/l SL 960 g/ha (2000 ml/ha), penoxsulam 21.7% SC 18 g/ha (83.3 ml/ha), cyhalofop-butyl 10% EC 150 g/ha (1500 ml/ha) were at par with each other in recording lower weeds biomass by controlling weeds in direct-seeded rice. Further, weedy check recorded significantly higher dry weight of weeds compared to other weed controlling treatments. These results were in conformity with the findings of Mishra *et al.* (2007) and Nandal *et al.* (1999).

Effect on weed control efficiency (WCE)

Post-emergence application of BAS 9548 H 3000 ml/ha recorded significantly higher weed control efficiency (92.4 and 92.2% in *Kharif* 2015 and summer 2016, respectively) and which was at par with the post-emergent application of 2500 ml/ha and twice hand weeded check (**Table 1)**. However, post-emergence application of bentazone 480 g/l SL 960 g/ha (2000 ml/ha), penoxsulam 21.7% SC 18 g/ ha (83.3 ml/ha), cyhalofop-butyl 10% EC 150 g/ha (1500 ml/ha) were at par with each other in recording weed control efficiency. These results were in conformity with the findings of Jabusch *et al.* (2005) and Jason *et al.* (2007).

Effect on yield and economics

During both the seasons studies, twice hand weeding at 15 and 30 days after sowing recorded significantly higher rice grain yield (6.05 and 5.80 t/ha in *Kharif* 2015 and summer 2016, respectively) and which was at par with post-emergent application of BAS 9548 H 2500 ml/ha (5.37 and 5.17 t/ha in *Kharif* 2015 and summer 2016, respectively) and application of BAS 9548 2500 ml/ha (5.62 and 5.42 t/ha in *Kharif* 2015 and summer 2016, respectively). Post-emergence application of bentazone 480 g/l SL 960 g/ ha (2000 ml/ha), penoxsulam 21.7% SC 18 g/ha (83.3 ml/ha), cyhalofop-butyl 10% EC 150 g/ha (1500 ml/ha) were at par with each other in recording grain and straw yield. Maximum B:C ratio was also observed in plots treated with BAS 9548 H along with twice hand weeded check (**Table 2**). Efficacy of penoxsulam in controlling weeds and increasing rice grain yield was also reported by Yadhav *et al.* (2008).

Table 1. Effect of weed control treatments on weed density (no./m^2), total weed biomass and weed control efficiency in direct-seeded rice at 60 days after sowing (1st season- *Kharif* 2015 and 2nd season- summer 2016)

Treatment	Grasses					Broad-leaf weeds				Sedges	Total weed dry weight (g/m^2)	Weed control efficiency (%)
	Echinochloa sp.	*Panicum repens*	*Cynodon doctylon*	*Leptochloa chinensis*	*Brachiaria mutica*	*Digitaria sanguinalis*	*Eclipta alba*	*Ludwigia parviflora*	*Commelina communis*	*Cyperus* sp.		
1st season- Kharif 2015												
BAS 9548 H 840 g/ha (2270 ml/ha)	1.40 (0.96)	1.40 (0.96)	1.49 (1.21)	1.47 (1.15)	1.49 (1.21)	1.49 (1.21)	1.47 (1.16)	1.49 (1.21)	1.46 (1.12)	1.46 (1.13)	4.03 (15.3)	89.8
BAS 9548 H 925 g/ha (2500 ml/ha)	1.36 (0.86)	1.36 (0.86)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.40 (0.95)	1.40 (0.95)	3.80 (13.5)	91.0
BAS 9548 H 1110 g/ha (3000 ml/ha)	1.35 (0.82)	1.31 (0.71)	1.40 (0.95)	1.31 (0.71)	1.31 (0.71)	1.39 (0.92)	1.39 (0.92)	1.36 (0.85)	1.36 (0.86)	1.36 (0.86)	3. 50 (11.3)	92.4
Bentazone 480 g/l SL 960 g/ha (2000 ml/ha)	1.65 (1.72)	1.60 (1.56)	1.66 (1.74)	1.66 (1.74)	1.66 (1.74)	1.66 (1.74)	1.93 (2.74)	1.90 (2.61)	1.91 (2.65)	1.67 (1.78)	6.40 (40.0)	73.3
Penoxsulam 21.7% SC 18 g/ha (83.3 ml/ha)	1.53 (1.35)	1.51 (1.28)	1.50 (1.25)	1.50 (1.26)	1.50 (1.26)	1.52 (1.32)	1.52 (1.31)	1.82 (2.31)	1.81 (2.28)	1.52 (1.32)	5.99 (34.9)	76.7
Cyhalofop butyl 10% EC 150 g/ha (1500 ml/ha)	1.59 (1.52)	1.55 (1.39)	1.54 (1.36)	1.54 (1.37)	1.54 (1.37)	1.54 (1.37)	1.83 (2.35)	1.84 (2.38)	1.83 (2.35)	1.57 (1.45)	6.15 (36.9)	75.4
Hand weeding	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	100
Weedy check	3.20 (9.21)	3.20 (9.25)	3.52 (11.4)	3.50 (11.2)	3.52 (11.4)	3.62 (12.1)	3.67 (12.5)	3.33 (10.1)	3.35 (10.2)	3.75 (13.1)	12.2 (150)	-
LSD (P=0.05)	0.31	0.32	0.33	0.31	0.28	0.31	0.28	0.29	0.31	0.31	3.05	10.5
2nd season- summer 2016												
BAS 9548 H 840 g/ha (2270 ml/ha)	1.40 (0.98)	1.40 (0.96)	1.49 (1.24)	1.46 (1.15)	1.49 (1.23)	1.48 (1.21)	1.46 (1.15)	1.48 (1.21)	1.46 (1.15)	1.45 (1.13)	4.09 (15.8)	89.6
BAS 9548 H 925 g/ha (2500 ml/ha)	1.35 (0.84)	1.36 (0.86)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.41 (0.98)	1.40 (0.95)	1.40 (0.95)	3.80 (12.5)	91.7
BAS 9548 H 1110 g/ha (3000 ml/ha)	1.36 (0.87)	1.31 (0.71)	1.40 (0.95)	1.31 (0.71)	1.31 (0.71)	1.39 (0.92)	1.39 (0.92)	1.36 (0.85)	1.36 (0.86)	1.36 (0.86)	3. 50 (11.8)	92.2
Bentazone 480 g/l SL 960 g/ha (2000 ml/ha)	1.64 (1.72)	1.60 (1.56)	1.66 (1.74)	1.66 (1.74)	1.66 (1.74)	1.66 (1.74)	1.93 (2.74)	1.90 (2.61)	1.91 (2.65)	1.67 (1.78)	6.40 (40.2)	73.5
Penoxsulam 21.7% SC 18 g/ha (83.3 ml/ha)	1.51 (1.31)	1.51 (1.28)	1.50 (1.25)	1.50 (1.26)	1.50 (1.26)	1.52 (1.32)	1.52 (1.31)	1.82 (2.31)	1.81 (2.28)	1.52 (1.32)	5.99 (35.9)	76.3
Cyhalofop-butyl 10% EC 150 g/ha (1500 ml/ha)	1.58 (1.52)	1.55 (1.39)	1.54 (1.36)	1.54 (1.37)	1.54 (1.37)	1.54 (1.37)	1.83 (2.35)	1.84 (2.38)	1.83 (2.35)	1.57 (1.45)	6.15 (37.9)	75.0
Hand weeding	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	100
Weedy check	3.20 (9.25)	3.21 (9.35)	3.53 (11.5)	3.49 (11.2)	3.54 (11.6)	3.61 (12.1)	3.61 (12.1)	3.33 (10.1)	3.43 (10.8)	3.75 (13.1)	12.3 (152)	-
LSD (p=0.05)	0.35	0.32	0.33	0.31	0.28	0.31	0.28	0.29	0.31	0.31	3.05	10.8

Figures in the parentheses are square root transformed values $(\sqrt{x+1})$

Table 2. Effect of weed control treatments on yield and economics of direct seeded rice (1st season- *Kharif* 2015 and 2nd season- summer 2016)

Treatment	1st season- *Kharif* 2015					2nd season- summer 2016				
	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x10^3 `/ha)	Gross returns (x10^3 `/ha)	B:C ratio	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x10^3 `/ha)	Gross returns (x10^3 `/ha)	B:C ratio
BAS 9548 H 840 g/ha (2270 ml/ha)	5.08	5.24	31.75	106.94	3.36	4.96	5.14	31.75	104.44	3.28
BAS 9548 H 925 g/ha (2500 ml/ha)	5.37	5.84	32.50	113.25	3.48	5.17	5.54	32.50	108.94	3.35
BAS 9548 H 1110 g/ha (3000 ml/ha)	5.62	6.05	34.00	118.39	3.48	5.42	5.95	34.00	114.29	3.36
Bentazone 960 g/ha (2000 ml/ha)	4.41	4.85	33.25	93.05	2.80	4.21	4.75	33.25	88.95	2.68
Penoxsulam 18 g/ha (83.3 ml/ha)	4.80	5.16	33.00	101.26	3.07	4.50	5.06	33.00	95.16	2.88
Cyhalofop-butyl 150 g/ha (1500 ml/ha)	4.74	5.12	33.25	99.89	3.00	4.44	4.92	33.25	93.68	2.82
Hand weeding	6.05	6.56	38.00	127.55	3.36	5.80	6.16	38.00	122.24	3.22
Weedy check	3.46	3.72	31.00	72.85	2.35	3.15	3.42	31.00	66.46	2.14
LSD (p=0.05)	0.68	1.11	6.17	19.50	0.15	0.67	1.01	6.17	17.62	0.13

Materials	Urea	DAP	MOP	Bentazone	Combi product	Clincher	Penoxsulam	Grain	Straw
Prices (`/kg/litre)	5.0	20.0	15.0	1500	1500	1500	1500	20.0	1.0

Table 3. Phytotoxicity of herbicides applied in rice on the germination and growth of succeeding blackgram crop (mean data)

Treatment	Phytotoxic effect (%)			Germi-nation per cent
	7 DAG	15 DAG	21 DAG	
BAS 9548 H 840 g/ha (2270 ml/ha)	0.0	0.0	0.0	94.5
BAS 9548 H 925 g/ha (2500 ml/ha)	0.0	0.0	0.0	93.3
BAS 9548 H 1110 g/ha (3000 ml/ha)	0.0	0.0	0.0	93.1
Bentazone 960 g/ha (2000 ml/ha)	0.0	0.0	0.0	92.0
Penoxsulam 18 g/ha (83.3 ml/ha)	0.0	0.0	0.0	94.5
Cyhalofop-butyl 150 g/ha (1500 ml/ha)	0.0	0.0	0.0	93.5
Hand weeding	0.0	0.0	0.0	96.1

Effect on succeeding blackgram crop

Phytotoxicity effect (rating 0) was not noticed both on germination and growth of succeeding mungbean crop in all the plots (**Table 3**) during both the season.

BAS 9548 H (penoxsulam 10 g/l + bentazone 360 g/l SC) 2500 to 3000 ml/ha could be recommended for post-emergence application at 20-25 DAS to achieve effective control of weeds and toget higher grain yield in irrigated dry-seeded rice.

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