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RESEARCH ARTICLE

Efficacy of XR-848 benzyl ester + penoxsulam (ready-mix) in managing weeds in dry direct-seeded rice

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ABSTRACT

A field study was conducted during rainy *(Kharif)* seasons of 2016 and 2017 at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka, India to study the efficacy of XR-848 benzyl ester + penoxsulam (ready-mix) in managing weeds in dry direct-seeded rice. The dominant weeds in the field were: *Echinochloa colona, Panicum repens, Cynodon dactylon, Brachiaria mutica, Digitaria sanguinalis* and *Leptochloa chinensis* among grasses, *Eclipta alba, Commelina communis* and *Ludwigia parviflora* among broad-leaved weeds and the sedge, *Cyperus iria*. The post-emergence application (PoE) of XR-848 benzyl ester + penoxsulam (ready-mix) 48.8 g/ha significantly reduced weed biomass, recorded higher weed control efficiency and rice grain yield during 2016 and 2017 *Kharif* seasons. It was on par with XR-848 benzyl ester + penoxsulam (ready-mix) 40.6 g/ha PoE and hand weeding twice at 20 and 40 days after sowing.

Key words: Dry direct-seeded rice, Hand weeding, Herbicides, Weed control efficiency, Weed management.

INTRODUCTION

In India, rice (*Oryza sativa* L.) is cultivated over an area of 43.8 Mha with a production of 116.4 Mt which contributes to 40.86% of total food grain production of our country. The average rice productivity in India is 2.66 t/ha (GOI, 2020). In Karnataka, rice is cultivated in 0.99 Mha with a production of 4.53 Mt and a productivity of 4.56 t/ha (Pathak *et al.* 2020). Among several reasons for low rice productivity, the loss due to weeds competition is one of the most important reasons. 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 may be as high as direct-seeded rice. Weeds can reduce the grain yield of dry direct-seeded rice (DSR) by 75.8%, wet-seeded rice (WSR) by 70.6% and transplanted rice (TPR) by 62.6% (Singh *et al.* 2004). Weeds by virtue of their high adaptability and faster growth dominate the crop habitat and reduce the rice yield potential. Hence, effective weed management in DSR is critical for attaining optimum rice productivity (Rao *et al*, 2015). Thus, the present study was undertaken to assess the efficacy of XR-848 benzyl ester 12.5 g/l + penoxsulam 20 g/l OD (w/v) (ready-mix) and compare it with other weed management treatments in managing weeds in dry direct-seeded rice.

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MATERIALS AND ETHODS

A field experiment was conducted during rainy *(Kharif)* seasons of 2016 and 2017 at Agricultural Research Station, Dhadesugur, Raichur, Karnataka. The soil of the experimental site was medium deep black and neutral in pH (8.04) with an EC of 0.47 dS/m. It was 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 seven treatments, *viz.* post-emergence application (PoE) of XR-848 benzyl ester 12.5 g/l + penoxsulam 20 g/l OD (w/v) [XR-848 benzyl ester + penoxsulam (ready-mix)] 32.5 g/ha, XR-848 benzyl ester + penoxsulam (ready-mix) 40.6 g/ha, XR-848 benzyl ester + penoxsulam (ready-mix) 48.8 g/ha PoE, XR-848 benzyl ester 2.5 % EC (w/v) [XR-848 benzyl ester] 31.25 g/ha PoE, penoxsulam 25.6 g/ha PoE, hand weeding twice at 20 and 40 days after sowing (DAS) and weedy check. The randomized complete block design (RCBD) was used with three replications having each plot of 6 x 4 m (24 m^2). All the herbicides were applied at 20 DAS using a knapsack sprayer fitted with a flat-fan nozzle at a spray volume of 500 l/ha. Rice seeds were sown on well prepared dry soil by tractor drawn seed-drill at a spacing of 20 cm (between the rows). Soon after irrigation was given in order to ensure proper germination of seeds. Recommended dose of fertilizers (150:75:75 kg N:P:K/ha) were 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 during the crop growth were followed as per the recommendation. The efficacy of different treatments on weeds was evaluated at crop maturity.

Quadrat (0.25 m^2) was placed in each of the plots at random to determine the weed density. Weeds within this quadrat were counted and the efficacy of weed control treatments was calculated by comparing the weed density in treatment plot with the weedy check. Weeds were cut at the 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 as given by Tawaha *et al*. (2002). After harvest and threshing of crop, grain yield was recorded in net plot and converted to grain yield per hectare.

The data of each year was analyzed separately. Microcomputer Statistical Programme (MSTAT) was used for statistical analysis of data and means were separated using least significant difference (LSD) at p=0.05. The data on weeds were transformed by square root transformation by adding one before being subjected to ANOVA (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on weeds, weed density and biomass

The grassy weeds predominant in the experimental field were *Echinochloa* colona, *Panicum repens*, *Cynodon dactylon*, *Brachiaria mutica*, *Digitaria sanguinalis* and *Leptochloa chinensis. The* post-emergence application of XR-848 benzyl ester + penoxsulam (ready-mix) 48.8 g/ha and hand weeding twice at 20 and 40 DAS recorded significantly lower grassy weeds at 30, 45 and 60 DAS, compared to other weed control treatments and weedy check during both the years of study. The reduction in weed density is attributed to effective suppression of grassy weeds with XR-848 benzyl ester + penoxsulam (ready-mix). The efficacy of early post-emergence and post-emergence application of penoxsulam on grassy weed density in rice was reported by Singh *et al*. (2007). The predominant broad-leaved weeds in the experimental field were: *Eclipta alba*, *Commelina communis* and *Ludwigia parviflora*. XR-848 benzyl ester + penoxsulam (ready-mix) 48.8 g/ha PoE and hand weeding twice at 20 and 40 DAS were found to be significantly superior in lowering the density of broad-leaved weeds and sedges (**Table 1**) and total weed biomass (**Table 2**). Further, weedy check recorded significantly higher density of broad-leaved weeds,

Table 1. Effect of weed control treatments on weed density (no./m^2) in dry direct-seeded rice

Treatment	Grasses						Broad-leaved weeds						Sedges					
	30 DAS		45 DAS		60 DAS		30 DAS		45 DAS		60 DAS		30 DAS		45 DAS		60 DAS	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
XR-848 benzyl ester + penoxsulam RM 32.5 g/ha PoE	2.70 (6.4)	2.88 (7.30)	3.32 (10.1)	3.35 (10.2)	3.50 (11.3)	3.53 (11.5)	1.95 (2.80)	2.07 (3.28)	2.23 (3.98)	2.25 (4.07)	2.34 (4.46)	2.35 (4.52)	1.40 (0.95)	1.41 (0.98)	1.69 (1.85)	1.70 (1.89)	1.76 (2.10)	1.76 (2.10)
XR-848 benzyl ester + penoxsulam RM 40.6 g/ha PoE	2.20 (3.9)	2.08 (3.33)	2.66 (6.06)	2.68 (6.18)	2.79 (6.79)	2.82 (6.93)	1.63 (1.66)	1.64 (1.69)	1.85 (2.42)	1.86 (2.47)	1.93 (2.74)	1.94 (2.77)	1.17 (0.38)	1.17 (0.38)	1.43 (1.05)	1.44 (1.07)	1.48 (1.20)	1.48 (1.20)
XR-848 benzyl ester + penoxsulam RM 48.8 g/ha PoE	2.00 (3.2)	1.70 (1.90)	2.56 (5.57)	2.58 (5.68)	2.69 (6.23)	2.71 (6.36)	1.50 (1.25)	1.46 (1.14)	1.80 (2.25)	1.82 (2.30)	1.87 (2.48)	1.90 (2.61)	1.12 (0.25)	1.12 (0.25)	1.42 (1.02)	1.43 (1.04)	1.45 (1.10)	1.48 (1.20)
XR-848 benzyl ester 31.25 g/ha PoE	3.60 (12.0)	3.62 (12.1)	3.99 (15.0)	4.03 (15.3)	4.21 (16.7)	4.25 (17.1)	2.36 (4.58)	2.37 (4.63)	2.69 (6.22)	2.71 (6.34)	2.83 (7.02)	2.85 (7.11)	1.61 (1.58)	1.61 (1.60)	1.94 (2.78)	1.96 (2.84)	2.02 (3.10)	2.05 (3.20)
Penoxsulam 25.6 g/ha PoE	3.40 (10.9)	3.47 (11.1)	3.90 (14.2)	3.93 (14.5)	4.11 (15.9)	4.15 (16.2)	2.29 (4.26)	2.30 (4.30)	2.62 (5.84)	2.64 (5.96)	2.75 (6.57)	2.77 (6.66)	1.50 (1.25)	1.50 (1.26)	1.91 (2.65)	1.92 (2.70)	2.00 (3.00)	2.00 (3.00)
Hand weeding twice at 20 and 40 DAS	1.00 (0.0)	1.00 (0.00)	1.41 (1.00)	1.42 (1.02)	1.46 (1.12)	1.47 (1.16)	1.00 (0.00)	1.00 (0.00)	1.24 (0.53)	1.24 (0.54)	1.27 (0.62)	1.27 (0.62)	1.00 (0.00)	1.00 (0.00)	1.11 (0.24)	1.11 (0.24)	1.14 (0.30)	1.14 (0.30)
Weedy check	5.40 (27.9)	5.64 (30.8)	7.41 (53.9)	7.48 (55.0)	8.91 (78.4)	8.99 (79.8)	3.49 (11.2)	3.83 (13.6)	5.47 (28.9)	5.51 (29.4)	6.51 (41.4)	6.57 (42.2)	2.69 (6.3)	2.70 (6.3)	3.54 (11.5)	3.56 (11.7)	4.11 (15.9)	4.15 (16.2)
LSD (p=0.05)	0.57	0.95	0.65	0.61	0.64	0.64	0.41	0.52	0.41	0.35	0.35	0.38	0.25	0.22	0.21	0.22	0.22	0.23

Note: Figures in outside the parentheses are square root transformed values ($\sqrt{x+1}$); RM: Ready-mix; DAS: Days after sowing

Table 2. Effect of weed control treatments on total weed biomass and weed control efficiency in dry direct-seeded rice

Treatment	Total weed biomass (g/m^2)						Weed control efficiency (%)					
	30 DAS		45 DAS		60 DAS		30 DAS		45 DAS		60 DAS	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
XR-848 benzyl ester + penoxsulam RM 32.5 g/ha PoE	4.15 (16.2)	4.30 (17.5)	5.11 (25.1)	5.39 (28.1)	5.75 (32.1)	5.93 (34.2)	77.3	78.7	77.8	78.4	78.9	80.5
XR-848 benzyl ester + penoxsulam RM 40.6 g/ha PoE	3.39 (10.5)	3.54 (11.5)	4.37 (18.1)	4.53 (19.5)	5.05 (24.5)	5.12 (25.2)	85.3	86.0	84.0	85.0	83.9	85.6
XR-848 benzyl ester + penoxsulam RM 48.8 g/ha PoE	3.19 (9.2)	3.35 (10.2)	4.00 (15.0)	4.18 (16.5)	4.81 (22.1)	4.89 (22.9)	87.1	87.6	86.7	87.3	85.5	86.9
XR-848 benzyl ester 31.25 g/ha PoE	4.67 (20.8)	4.80 (22.0)	5.52 (29.5)	5.93 (34.2)	6.29 (38.6)	6.60 (42.5)	70.9	73.2	73.9	73.7	74.7	75.7
Penoxsulam 25.6 g/ha PoE	4.59 (20.1)	4.72 (21.3)	5.32 (27.3)	5.74 (32.0)	6.23 (37.8)	6.41 (40.1)	71.9	74.1	75.9	75.4	75.2	77.1
Hand weeding twice at 20 and 40 DAS	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	2.63 (5.9)	2.94 (7.7)	100	100	100	100	96.1	95.6
Weedy check	8.51 (71.5)	9.12 (82.2)	10.69 (113.2)	11.45 (130.2)	12.38 (152.3)	13.27 (175.1)	0	0	0	0	0	0
LSD (p=0.05)	0.81	0.74	0.94	0.98	0.65	0.95	-	-	-	-	-	-

Note**:** Figures in outside the parentheses are square root transformed values (sq. root of x+1); RM: Ready-mix; DAS: Days after sowing

Table 3. Growth and yield parameters of dry direct-seeded rice as influenced by different weed control treatments

Treatment	Plant height (cm)		No. of productive tillers/m^2		Grain yield t/ha)	
	2016	2017	2016	2017	2016	2017
XR-848 benzyl ester + penoxsulam RM 32.5 g/ha PoE	103	105	202	204	5.42	5.57
XR-848 benzyl ester + penoxsulam RM 40.6 g/ha PoE	108	109	208	210	5.68	5.87
XR-848 benzyl ester + penoxsulam RM 48.8 g/ha PoE	110	110	210	212	5.84	5.93
XR-848 benzyl ester 31.25 g/ha PoE	101	101	190	191	5.04	5.15
Penoxsulam 25.6 g/ha PoE	101	102	191	200	5.08	5.12
Hand weeding twice at 20 and 40 DAS	113	113	212	215	6.14	6.21
Weedy check	92	94	174	175	3.80	3.82
LSD (p=0.05)	4.25	3. 32	6.25	5.42	0.34	0.29

sedges and total weed biomass. These results are in conformity with the findings of Yadav *et al.* (2007), Jabusch and Tjeerdema (2005), Jason *et al.* (2007), Mishra *et al.* (2007) and Nandal *et al.* (1999).

Effect on weed control efficiency (WCE)

Among different weed control treatments, higher weed control efficiency was recorded with XR-848 benzyl ester + penoxsulam (ready mix) 48.8 g/ha PoE and hand weeding twice at 20 and 40 DAS followed by XR-848 benzyl ester + penoxsulam (ready-mix) 40.6 g/ha PoE, XR-848 benzyl ester + penoxsulam (ready-mix) 32.5 g/ha PoE and penoxsulam 25.6 g/ha PoE (**Table 2**). The lowest weed control efficiency was noticed in weedy check due to significantly higher weed density and weed biomass accrued due to uncontrolled weed growth. These results were in conformity with the findings of Jabusch and Tjeerdema (2005) and Jason *et al.* (2007).

Effect on rice growth and grain yield

During both the years of study, hand weeding twice at 20 and 40 DAS recorded significantly higher rice grain yield (6.14 and 6.21 t/ha during 2016 and 2017, respectively) and which was at par with XR-848 benzyl ester + penoxsulam (ready-mix) 48.8 g/ha PoE (5.84 and 5.93 t/ha during 2016 and 2017, respectively) (**Table 3**). The higher rice yield with these treatments might be attributed to effective suppression of weeds and improved growth and yield attributes like higher plant height (110 and 109 cm in 2016 and 2017, respectively) and number of productive tillers/m^2 (210 and 212 in 2016 and 2017, respectively). The correlation studies indicated that, there was negative correlation between grain yield and total weed biomass at 30 DAS (r^2 = -0.970 and -0.965 during 2016 and 2017, respectively), 45 DAS (r^2 = -0.956 and -0.960 during 2016 and 2017, respectively) and at 60 DAS (r^2 = -0.947 and -0.946 during 2016 and 2017, respectively). Further, there was positive correlation between grain yield and number of productive tillers/m^2 (r^2 = 0.979 and 0.978 during 2016 and 2017, respectively) indicating decrement of grain yield with increase in weed biomass and enhancement of grain yield with increase in number of productive tillers/m^2 of rice plants. The regression equations also indicated that, quantum of rice grain yield decreased with each g/m^2 increase in weed biomass which was to the tune of

31.9 and 28.5 kg/ha at 30 DAS, 19.8 and 17.9 kg/ha at 45 DAS and 14.89 and 13.3 kg/ha at 60 DAS in 2016 and 2017, respectively. However, the regression equations revealed that with increase in tillers/m^2 would increase the grain yield of rice by 54.3 and 55.5 kg/ha in 2016 and 2017, respectively. These observations were in conformity with the findings of Yadhav *et al.* (2007), Ramesha *et al.* (2017).

Thus, post-emergence application of XR-848 benzyl ester 12.5 g/l + penoxsulam 20 g/l OD (w/v) (ready-mix) 48.8 g/ha was most effective treatment for the management of weeds and increasing yield in dry direct-seeded rice.

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