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RESEARCH ARTICLE

Management of weeds in transplanted rice with XR-848 benzyl ester + cyhalofop-butyl (ready-mix)

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ABSTRACT

A field experiment was conducted during rainy *(Kharif)* seasons of 2015 and 2016 at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka, India to evaluate the efficacy of XR-848 benzyl ester 20 g/l + cyhalofop-butyl 100 g/l EC (ready-mix) on weeds in transplanted rice. The dominant grassy weeds in the experimental field were: *Echinochloa colona, Panicum repens, Cynodon dactylon, Brachiaria mutica, Digitaria sanguinalis* and *Leptochloa chinensis*; broad-leaved weeds were: *Eclipta alba* and *Ludwigia parviflora* and the sedge was *Cyperus rotundus*. The post-emergence application (PoE) of XR-848 benzyl ester 20 g/l + cyhalofop butyl 100 g/l EC (ready-mix) 180 g/ha recorded significantly lower weeds biomass, higher weed control efficiency at 30, 45 and 60 days after transplanting (DAT) and higher rice grain yield during both the years and it was at par with XR-848 benzyl ester 20 g/l + cyhalofop butyl 100 g/l EC (ready-mix) 150 g/ha. The hand weeding twice at 20 and 40 DAT recorded significantly higher weed control efficiency and grain yield compared to other herbicide treatments.

Keywords: Cyhalofop-butyl, Transplanted rice, XR-848 benzyl ester, Weed management, Weed control efficiency

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereal crop grown in India as well as in Asia. It is being cultivated in the country over an area of 43.79 Mha with a production of 116.42 MT, which contributes to 40.86% of total food grain production of our country. The average productivity of rice in India is 2.66 t/ha (Anonymous 2020), which is lower than China and Egypt. In Karnataka, rice is cultivated in 0.99 Mha with a production of 4.53 MT and productivity of 4.56 t/ha (Pathak *et al*. 2020). The attainment of optimal productivity in rice is hindered by several factors, of which weeds are recognized as the major biological constraint. The yield loss caused by weeds resulted from their competition for growth factors, *viz.* nutrients, soil moisture, light, space, *etc.* (Walia 2006, Rao and Nagamani 2010). In order to achieve higher use efficiency of applied inputs, weeds must be kept below the economic threshold level through effective management practices (Rao *et al*. 2015). The optimal land preparation, effective water management and use of herbicides at correct dose and right time are often considered as cost-effective alternatives to manual weeding (Rao *et al*. 2017). This study was conducted to evaluate the efficacy of XR-848 benzyl ester 20 g/l + cyhalofop-butyl 100 g/l EC (ready-mix) in managing weeds and to increase the yield of transplanted rice.

MATERIALS AND METHODS

An experiment was undertaken during rainy *(Kharif)* seasons of 2015 and 2016 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, 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.* post-emergence application (PoE) of XR-848 benzyl ester 20g/l + cyhalofop-butyl 100 g/l EC (w/v) (ready-mix) 120 g/ha; XR-848 benzyl ester + cyhalofop-butyl (ready-mix) 150 g/ha PoE; XR-848 benzyl ester + cyhalofop-butyl (ready-mix) 180 g/ha PoE; XR-848 benzyl ester 2.5 % EC (ready-mix) 31.25 g/ha PoE; cyhalofop-butyl 150 g/ha PoE; bispyribac-sodium 25 g/ha PoE; hand weeding twice at 20 and 40 days after transplanting (DAT) and weedy check. The size of each plot was 6 x 4 m (24

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m²) and the design followed for the experiment was randomized complete block design (RCBD) with three replications. All the herbicides were applied at 20 DAT using a knapsack sprayer fitted with a flat-fan nozzle at a spray volume of 500 l/ha.

The recommended dose of fertilizer (150:75:75 kg N:P:K/ha) was applied uniformly in three equal splits. Other agronomic and plant protection measures were followed as per the recommendation during the crop growth. The efficacy of different herbicides on weeds was evaluated at crop maturity. A quadrat of 0.25 m² was placed in each plot at random to estimate the weed density by counting the weeds within each plot of quadrat. 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 recording weed 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 the 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 weed density and biomass

The weeds in experimental field were: *Echinochloa colona*, *Panicum repens, Cynodon dactylon, Leptochloa chinensis, Brachiaria mutica, Digitaria sanguinalis* among grasses; *Eclipta alba, Ludwigia parviflora* and *Commelina communis* among broad-leaved weeds and the sedge, *Cyperus rotundus*. The hand weeding twice at 20 and 40 DAT recorded significantly lower density of grasses, broad-leaved weeds and the sedge at 30, 45 and 60 DAT during both the years (**Table 1**). Among herbicide treatments, lower density and biomass of grasses, broad-leaved weeds and the sedge was observed with the application of XR-848 benzyl ester + cyhalofop butyl 180 g/ha PoE and was found on par with XR-848 benzyl ester + cyhalofop butyl 150 g/ha PoE in transplanted rice. The hand weeding twice and application of XR-848 benzyl ester + cyhalofop butyl (ready-mix) 180 g/ha PoE have recorded more than 80% weed control efficiency. The weedy check recorded significantly higher density of grasses, broad-leaved weeds and the sedge due to uncontrolled growth.

Similarly, the weed biomass was also influenced significantly by different weed management treatments. The hand weeding twice at 20 and 40 DAT recorded significantly lower weed biomass at 30, 45 and 60 DAT during both the years closely followed by XR-848 benzyl ester + cyhalofop-butyl 180 g/ha and XR-848 benzyl ester + cyhalofop-butyl 150 g/ha. The hand weeding twice at 20 and 40 DAT and application of XR-848 benzyl ester + cyhalofop butyl (ready-mix) 180 g/ha have recorded higher weed control efficiency due to lower weed biomass observed with these treatments as compared to other herbicide treatments and weedy check (**Table 2**). Similar results on WCE with broad-spectrum herbicides was reported by Abraham *et al.* (2010), Jabusch and Tjeerdema (2005), Jason *et al.* (2007), Mishra *et al.* (2007).

Table 1. Effect of weed control treatments on weed density in transplanted rice

Treatment	Weed density (no./m²)																	
	Grasses						Broad-leaved weeds						Sedge					
	30 DAT		45 DAT		60 DAT		30 DAT		45 DAT		60 DAT		30 DAT		45 DAT		60 DAT	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
XR-848 benzyl ester + cyhalofop-butyl (ready-mix) 120 g/ha PoE	2.10 (3.41)	2.09 (3.36)	1.66 (1.77)	1.64 (1.68)	1.69 (1.85)	1.68 (1.83)	2.37 (4.62)	2.35 (4.54)	1.81 (2.26)	1.79 (2.22)	1.74 (2.02)	1.73 (2.00)	2.88 (7.31)	2.87 (7.21)	2.14 (3.56)	2.13 (3.52)	1.82 (2.33)	1.82 (2.32)
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 150 g/ha PoE	2.03 (3.13)	2.02 (3.08)	1.62 (1.62)	1.61 (1.59)	1.68 (1.81)	1.67 (1.78)	2.31 (4.33)	2.29 (4.24)	1.77 (2.12)	1.76 (2.09)	1.74 (2.02)	1.73 (2.01)	2.77 (6.67)	2.76 (6.61)	1.95 (2.79)	1.94 (2.76)	1.83 (2.34)	1.82 (2.31)
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 180 g/ha PoE	1.87 (2.51)	1.86 (2.46)	1.57 (1.48)	1.57 (1.46)	1.62 (1.64)	1.62 (1.63)	2.15 (3.64)	2.14 (3.59)	1.72 (1.96)	1.71 (1.94)	1.68 (1.82)	1.67 (1.80)	2.70 (6.29)	2.69 (6.26)	2.05 (3.20)	2.04 (3.16)	1.77 (2.15)	1.77 (2.14)
XR-848 benzyl ester 31.25 g/ha PoE	3.21 (9.29)	3.19 (9.20)	2.02 (3.07)	2.09 (3.35)	2.06 (3.26)	2.06 (3.24)	3.68 (12.5)	3.66 (12.4)	2.15 (3.63)	2.28 (4.19)	2.20 (3.86)	2.20 (3.84)	3.79 (13.4)	3.78 (13.3)	2.44 (4.95)	2.44 (4.93)	2.29 (4.26)	2.29 (4.25)
Cyhalofop-butyl 150 g/ha PoE	3.13 (8.81)	3.12 (8.72)	2.32 (4.36)	2.59 (5.71)	2.06 (3.25)	2.06 (3.24)	3.52 (11.4)	3.51 (11.3)	3.20 (9.23)	3.69 (12.6)	2.17 (3.72)	2.17 (3.70)	3.67 (12.5)	3.67 (12.5)	3.54 (11.5)	4.30 (17.5)	2.23 (3.99)	2.23 (3.97)
Bispyribac-sodium 25 g/ha PoE	2.18 (3.74)	2.16 (3.68)	1.76 (2.11)	1.75 (2.07)	1.77 (2.14)	1.77 (2.14)	2.43 (4.92)	2.42 (4.86)	1.90 (2.61)	1.89 (2.57)	1.82 (2.31)	1.82 (2.30)	2.93 (7.60)	2.91 (7.46)	2.22 (3.93)	2.21 (3.90)	1.91 (2.63)	1.90 (2.61)
Hand weeding twice at 20 and 40 DAT	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)	1.00 (0.00)	2.17 (3.70)	2.17 (3.70)	1.62 (1.64)	1.62 (1.62)	1.39 (0.93)	1.39 (0.93)
Weedy check	4.35 (17.9)	4.30 (17.5)	2.61 (5.80)	2.59 (5.73)	2.67 (6.12)	2.66 (6.10)	5.95 (34.4)	5.92 (34.0)	4.37 (18.1)	4.33 (17.8)	3.29 (9.85)	3.28 (9.79)	6.64 (43.1)	6.63 (42.9)	4.81 (22.1)	4.83 (22.3)	3.55 (11.6)	3.56 (11.7)
LSD (p=0.05)	0.21	0.20	0.08	0.05	0.05	0.04	0.21	0.20	0.07	0.05	0.04	0.04	0.15	0.15	0.06	0.07	0.03	0.03

Note: Figures in outside the parenthesis are square root transformed values (sq. root of x+1), DAT = days after transplanting; PoE = post-emergence application

Table 2. Effect of weed control treatments on total weed biomass and weed control efficiency in transplanted rice

Treatment	Total weed biomass (g/m^2)						Weed control efficiency (%)					
	30 DAT		45 DAT		60 DAT		30 DAT		45 DAT		60 DAT	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 120 g/ha PoE	3.94 (14.5)	3.81 (13.5)	4.69 (21.0)	4.49 (19.2)	5.22 (26.2)	5.24 (26.5)	80.1	81.8	81.3	83.0	82.9	82.8
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 150 g/ha PoE	3.66 (13.1)	3.66 (11.8)	4.42 (16.7)	4.42 (16.2)	4.85 (21.5)	4.85 (21.0)	82.0	84.0	85.1	85.7	85.9	86.4
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 180 g/ha PoE	3.16 (11.5)	3.16 (10.5)	4.15 (16.1)	4.15 (15.1)	4.38 (19.8)	4.38 (18.9)	84.2	85.8	85.7	86.6	87.0	87.7
XR-848 benzyl ester 31.25 g/ha PoE	4.72 (20.8)	4.72 (19.1)	4.94 (27.4)	4.94 (27.4)	6.16 (36.7)	6.16 (36.0)	71.4	74.1	75.6	75.9	75.9	76.7
Cyhalofop-butyl 150 g/ha PoE	4.16 (17.9)	4.16 (18.5)	4.65 (24.0)	4.65 (24.9)	6.00 (32.9)	5.92 (33.0)	78.2	75.0	78.7	78.1	78.4	78.6
Bispyribac-sodium 25 g/ha PoE	4.02 (15.9)	4.02 (16.6)	4.90 (23.3)	4.80 (24.3)	5.83 (31.3)	6.00 (31.8)	78.1	77.6	79.2	78.5	79.5	79.4
Hand weeding twice at 20 and 40 DAT	1.00 (0.0)	1.00 (0.00)	1.00 (0.0)	1.00 (0.00)	2.57 (5.4)	2.57 (5.40)	100	100	100	100	96.4	96.5
Weedy check	8.69 (72.8)	8.69 (74.0)	10.7 (112)	10.7 (113)	12.5 (153)	12.5 (154)	0	0	0	0	0	0
LSD (p=0.05)	0.52	0.56	0.34	0.36	0.61	0.57	-	-	-	-	-	-

Note: Figures in outside the parenthesis are square root transformed values (sq. root of x+1), DAT = days after transplanting; PoE = post-emergence application

Effect on rice grain yield

The herbicide treatments did not cause any phytotoxicity to transplanted rice. The maximum number of productive tillers/hills, grains/panicle and grain yield were recorded with hand weeding twice at 20 and 40 DAT followed by XR-848 benzyl ester + cyhalofop butyl (ready-mix) 180 g/ha and 150 g/ha (**Table 3**). The reduced competition due to weeds for growth resources throughout the critical growth resulted in the enhanced crop performance in the treatments effective to manage weeds. The weedy check recorded significantly lower number of productive tillers/hills, number of grains/panicle and grain yields due to extreme crop-weed competition caused by the excessive presence of weeds.

The higher rice crop growth and yield attributes achieved in effective herbicidal treatments was due to effective control of weeds as it is envisaged from negative correlation between grain yield and total weed biomass through correlation and regression analysis. There was negative correlation between grain yield and total weed biomass at 30 DAT (-0.975 and -0.978 during 2015 and 2016, respectively), 45 DAT (-0.968 and -0.973 during 2015 and 2016, respectively) and at 60 DAT (-0.963 and -0.967 during 2015 and 2016, respectively) as indicated from the regression studies. Whereas, there was positive correlation between grain yield and grains/ panicle (0.936 and 0.939 during 2015 and 2016, respectively) indicating decrement of grain yield with increase in weed biomass and enhancement of grain yield with increase in grains/panicle of rice plants. The regression equations also indicated that, quantum of rice grain yield decrease with each g/m^2 increase in weed biomass was to the tune of 33.5 and 32.3 kg/ha at 30 DAT, 21.3 and 20.9 kg/ha at 45 DAT and 15.6 and 15.3 kg/ha at 60 DAT, in 2015 and 2016, respectively. The regression equations also revealed that with increase in number of grains/panicles would increase the grain yield of rice by 74 kg/ha and 70 kg/ ha during 2015 and 2016, respectively. The results of the present study are indicative of the importance and significance of efficient weed management for enhancing growth and yield parameters of rice crop. These results are in conformity with the findings of Nithya *et al.* (2012), Raj and Syriac (2016).

The manual weeding was effective but being tedious, time consuming and expensive in large scale rice cultivation, farmers are increasingly looking for efficient herbicides for weed management in rice. It may be concluded that the post-emergence application of XR-848 benzyl ester 20 g/l + cyhalofop-butyl 100 g/l EC (w/v) (ready-mix) 150 g/ ha was most effective in control of grassy weeds, broad-leaved weeds and the sedge and also recorded higher grain yield in transplanted rice.

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Table 3. Effect of weed control treatments on grain yield and yield parameters of transplanted rice.

Treatment	Productive tillers/ hill		Grains/ panicle		Grain yield (t/ha)	
	2015	2016	2015	2016	2015	2016
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 120 g/ha PoE	9.02	8.62	176	174	5.604	5.487
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 150 g/ha PoE	9.31	8.90	182	180	5.870	5.670
XR-848 benzyl ester + cyhalofop-butyl (ready- mix) 180 g/ha PoE	9.43	9.02	183	182	5.957	5.758
XR-848 benzyl ester 31.25 g/ha PoE	8.62	8.25	170	167	5.214	5.035
Cyhalofop-butyl 150 g/ha PoE	8.72	8.34	169	168	5.421	5.269
Bispyribac-sodium 25 g/ha PoE	8.79	8.41	173	170	5.504	5.451
Hand weeding twice at 20 and 40 DAT	9.63	9.21	189	186	6.319	6.134
Weedy check	7.93	7.59	159	155	3.814	3.662
LSD (p=0.05)	0.25	0.24	7.23	5.68	0.339	0.236

*PoE = post-emergence application

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