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Weed management in direct-seeded rice through herbicidal mixtures under diverse agroecosystems

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ABSTRACT

A present experiment was conducted during the *kharif* season 2019 at the Research Farm, JNKVV, Jabalpur (M.P.) to study the efficacy of herbicidal mixtures against weed flora in direct-seeded rice under rainfed and irrigated agroecosystems. The experiment was laid out in a split-plot design with rainfed and irrigated agroecosystems in main plot treatments and eight weed control herbicides in sub-plot treatments. Among all kinds of dicot as well as monocot weeds *Echinochloa colona* and *Alternanthera sessilis* were the most dominant with a mean relative density of (30 and 28.6%) and (26 and 25%) respectively, under rainfed and irrigated agroecosystems. The maximum weed control efficiency under both rainfed and irrigated rice was observed in plots receiving hand weeding which was closely followed by bispyribac sodium at 25 g *a.i.*/ha. Growth parameters, yield attributes as well as grain yield of direct-seeded rice were higher in plots receiving bispyribac sodium 10% SC at 25 g *a.i.*/ha at 20 DAS except for hand weeding twice which registered the maximum values of these parameters.

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is a major *kharif* season crop of eastern Madhya Pradesh. It provides half of the total dietary carbohydrate, especially in Asian countries and it is suitable for more than three billion people that supplied 50-80% of their daily calorie intake [1]. 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 [2]. In Madhya Pradesh, it is grown in an area of 2.02 million ha area with a production of 3.58 million tons and with an average yield of 1.768 tons/ha [3]. In future, rice farmers may likely have limited access to irrigate fields due to less availability of water resources [4]. This may threaten the sustainability of rice in irrigated environments [5]. Dry direct-seeded rice saves irrigated water by 12-35%, labour by 60% and provides higher net returns with similar or slightly lower yields from transplanted rice. Besides this, labour's availability for transplanting is also a concern because of increasing wages

resulting from the migration of labours from rural to urban areas [6]. Direct seeding allows for the early establishment of the succeeding wheat crop and reduces methane emissions with less use of required water [7]. Direct-seeding is cost-effective, saves water through rice crop establishment and allows early sowing of wheat but the major concern under direct-seeded rice are weeds, which are more in numbers and emerge and compete for nutrients, moisture and space with rice plants thereby causing considerable yield reduction. The yield loss due to weed interference is huge, and maybe up to 100% [8]. The critical weed-free period in direct-seeding ranges from 12 to 83 days after sowing, which is longer than transplanting rice [9]. As much work has been done under herbicide application in direct-seeded rice for controlling weeds and more research is needed with the use of a combination of other herbicides to get weed control for longer durations. As direct-seeded rice technology is generally used in upland rainfed conditions, the efficacy of herbicides can also be evaluated and compared under irrigated environments. Keeping these points in view, the present study was conducted to evaluate the efficacy of herbicidal mixtures against weed flora in direct-seeded rice under rainfed and irrigated agroecosystems.

2. MATERIAL AND METHODS

A field experiment was conducted at Research Farm, JNKVV, Jabalpur (M.P.) during the *kharif* season 2019 in a split-plot design with three replication. The experiment was comprised of main plot treatments were rainfed and irrigated agroecosystems and the subplot treatments were eight comprising of bispyribac sodium 10% SC at 25 g *a.i.*/ha (ready mix), fenoxaprop-p-ethyl 6.7% EC at 60 g *a.i.*/ha (ready mix), fenoxaprop-p-ethyl 6.7% EC + penoxsulam 24% SC at 60 + 26.7 g *a.i* /ha (tank mix), cyhalofop 10% EC + penoxsulam 24% SC at 135 + 26.7 g *a.i.*/ha (ready mix), bispyribac sodium 10% SC + metsulfuron methyl 10% WP + chlorimuron ethyl 10% WP at 25+4 g *a.i.*/ha (tank mix), triafamone 20% WG + ethoxysulfuron 10% WG at 40+20 g *a.i.*/ha (ready mix) as post-emergence herbicides, hand weeding twice at 20 and 40 DAS and weedy check. The soil of the experimental field was sandy clay loam in texture, medium in organic carbon (0.72%) and available nitrogen (293.65 kg/ha), available phosphorus (17.50 kg/ha) and available potassium (257.47 kg/ha). It was a neutral soil reaction (6.48 pH) and low in electrical conductivity (0.08 ds/m). The rice variety *MTU 1010* was sown on 12 July 2019 by line sowing keeping a seed rate of 60 kg/ha at 20 cm row to row distance. Fertilizer of nitrogen was applied at the rate of 120 kg/ha in the form of urea, phosphorus applied at the rate of 60 kg/ha in the form of single super phosphate (SSP) and potash applied at the rate of 40 kg/ha in the form of murate of potash (KCL). The measured quantity of herbicide and water for each plot was mixed thoroughly in the bucket before spraying, and later on, sprayed in the plot uniformly with the help of a knapsack sprayer using a flat-fan nozzle separately. The data on the density of weeds were subjected to square root transformation before statistical analysis to improve the homogeneity of the variance. All the data were subjected to the analysis of variance (ANOVA) separately for each year.

3. RESULTS AND DISCUSSION

3.1 Weed flora

The weed flora of the experimental field was mainly dominated by grasses, sedges and broad-leaved weeds (Table 1). Among the grassy weeds *Echinochloa colona* (30 and 28.6%), *Cynodon dactylon* (18.4 and 17.9%), whereas sedges include *Cyperus iria* (18.9 and 18%). Similarly, broad-leaved weeds comprised of *Alternanthera sessilis* (26 and 25%) were dominant under both rainfed and irrigated agroecosystems (figure 1). The density of weeds found maximum in rainfed rice as compared to irrigated rice due to aerobic conditions presented in rainfed rice which is favourable for weed growth. These results were similar to that mentioned by [10].

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Table 1. Infesting species of weeds in the direct seeded rice under different agroecosystems.

S. No.	Local Name	English Name	Scientific Name	Family	Morphological type
1.	Jungle rice	Water grass	*Echinochloa colona*	Poaceae	Grass
2.	Sessile Joyweed	Spiny pigweed	*Alternanthera sessilis*	Amaranthaceae	Broad leaved
3.	Motha	Rice flat sedge	*Cyperus iria*	Cyperaceae	Sedge
4.	Doub Grass	Bermuda grass	*Cynodon dactylon*	Poaceae	Grass



Fig 1. Dominant weeds under rainfed and irrigated rice agroecosystems

3.2 Density of weeds

Among all the herbicidal treatments, there was a diminishing pattern in weed density with the increase in crop age. Herbicides reduced the density of grasses, sedges and broad-leaved weeds significantly as compared to the untreated weedy check (Table 2). The total weed density was minimum in bispyribac sodium at 25 g *a.i./*ha, followed by fenoxaprop-p-ethyl + penoxsulam at 60+26.7 g *a.i/* ha and cyhalofop + penoxsulam at 135+26.7 g *a.i/* ha under both the agroecosystems due to their broad-spectrum nature for controlling grasses, sedges and broad-leaved weeds. Bispyribac sodium is used to alleviate narrow weeds, broad-leaved weeds and sedges in DSR till eight weeks after its post-emergent application with no phytotoxic impact on rice plants [11]. However, hand weeding was superior among all the treatments in lessening weed growth and it might be because of the removal of most weed flora. Similar views were also endorsed by [12], [13].

Table 2. Effect of different herbicidal treatments on density of weeds at 60 DAS under different agroecosystems

Treatment	Density of weeds (No./m^2)			
	Echinochloa colona	***Alternanthera sessilis***	***Cyperus iria***	***Cynodon dactylon***
Agroecosystems	**60 DAS**	**60 DAS**	**60 DAS**	**60 DAS**
Rainfed	2.95 (10.5)	2.83 (9.4)	2.69 (8.0)	2.44 (6.8)
Irrigated	2.80 (9.3)	2.68 (8.3)	2.58 (7.2)	2.32 (6.0)
LSD (P=0.05)	NS	NS	NS	NS
Weed control treatments				
Bispyribac sodium 10% SC at 25 g *a.i.*/ha	2.05 (3.9)	1.91 (3.3)	1.96 (3.5)	1.70 (2.6)
Fenoxaprop-p-ethyl 6.7% EC at 60 g *a.i.*/ha	2.98 (8.5)	2.98 (8.5)	2.76 (7.3)	2.34 (5.2)
Fenoxaprop-p-ethyl 6.7% EC + penoxsulam 24% SC at 60+26.7 g *a.i.*/ha	2.38 (5.3)	2.28 (4.8)	2.25 (4.7)	2.06 (3.9)
Cyhalofop 10% EC + penoxsulam 24% SC at 135+26.7 g *a.i.*/ha	2.53 (6.1)	2.45 (5.7)	2.46 (5.8)	2.16 (4.4)
Bispyribac sodium 10% SC + metsulfuon methyl 10% WP + chlorimuron ethyl 10% WP at 25+4 g *a.i.*/ha	2.91 (8.1)	2.77 (7.3)	2.70 (7.0)	2.28 (4.9)
Triafamone 20% WG + ethoxysulfuron 10% WG at 40+20 g *a.i.*/ha	2.69 (6.9)	2.58 (6.4)	2.58 (6.4)	2.22 (4.7)
Twice and weeding	1.18 (0.9)	1.24 (1.1)	1.32 (1.3)	1.38 (1.5)
Weedy check	6.28 (39.1)	5.84 (33.8)	5.03 (24.9)	4.93 (24.0)
LSD (P=0.05)	0.42	0.43	0.48	0.52

3.3 Dry weight of weeds

All the herbicides reduced the dry weight of grassy, sedges and broad-leaf weeds significantly as compared to the untreated weedy check (Table 3). Application of bispyribac sodium at 25 g *a.i.*/ha as post-emergence exhibited minimum weed population as well as total biomass of weeds from the early growth stage to the end of the critical period for crop-weed competition. Among the herbicidal application, at 60 DAS, the minimum dry weight of *Echinochloa colona, Alternanthera sessilis, Cyperus iria* and *Cynodon dactylon* was observed in treatment bispyribac sodium at 25 g *a.i.*/ha which was at par with fenoxaprop-p-ethyl + penoxsulam at 60+26.7 g *a.i*/ha and was differ significantly from all the other treatments. The magnitude of suppression of weeds was higher in plots treated with bispyribac sodium at 25 g *a.i.*/ha and exhibited maximum weed control efficiency among all the herbicidal applications followed by fenoxaprop-p-ethyl + penoxsulam at 60+26.7 g *a.i.*/ha and cyhalofop + penoxsulam at 135+26.7 g *a.i*/ha. These findings are in agreement with the findings of [14].

Table 3. Effect of different herbicidal treatments on dry weight of weeds at 60 DAS under different agroecosystems

Treatment	Dry weight of weeds (g/m^2)			
	Echinochloa colona	***Alternanthera sessilis***	***Cyperus iria***	***Cynodon dactylon***
Agroecosystems	**60 DAS**	**60 DAS**	**60 DAS**	**60 DAS**
Rainfed	3.14 (11.8)	3.08 (11.2)	2.96 (10.0)	2.70 (8.1)
Irrigated	3.06 (11.2)	3.01 (10.6)	2.86 (9.4)	2.60 (7.5)
LSD (P=0.05)	NS	NS	NS	NS

Weed control treatments				
Bispyribac sodium 10% SC at 25 g *a.i.*/ha	2.36 (5.2)	2.29 (4.9)	2.20 (4.5)	2.05 (3.8)
Fenoxaprop-p-ethyl 6.7% EC at 60 g *a.i.*/ha	3.29 (10.5)	3.21 (10.0)	2.98 (8.6)	2.80 (7.5)
Fenoxaprop-p-ethyl 6.7% EC + penoxsulam 24% SC at 60+26.7 g *a.i.*/ha	2.65 (6.7)	2.58 (6.3)	2.48 (5.9)	2.31 (5.0)
Cyhalofop 10% EC + penoxsulam 24% SC at 135+26.7 g *a.i.*/ha	2.75 (7.3)	2.70 (7.0)	2.63 (6.7)	2.38 (5.5)
Bispyribac sodium 10% SC + metsulfuon methyl 10% WP + chlorimuron ethyl 10% WP at 25+4 g *a.i.*/ha	3.09 (9.1)	3.04 (8.8)	2.95 (8.3)	2.55 (6.1)
Triafamone 20% WG + ethoxysulfuron 10% WG at 40+20 g *a.i.*/ha	2.83 (7.7)	2.78 (7.4)	2.70 (6.9)	2.43 (5.7)
Twice hand weeding	1.16 (0.9)	1.29 (1.2)	1.38 (1.5)	1.46 (1.7)
Weedy check	6.68 (44.2)	6.48 (41.5)	5.96 (35.3)	5.25 (27.0)
LSD (P=0.05)	0.47	0.48	0.49	0.54

3.4 Weed control efficiency

Results showed that the hand weeding twice at 20 and 40 DAS was superior amongst all weed control treatments in reducing weed growth and exhibited maximum weed control efficiency (96.1% and 96.3%) in rainfed and irrigated agroecosystems, respectively at 60 DAS than all the other treatments because of less dry matter production of the weeds over weedy check treatment (figure 2 & 3). Therefore, the trend of treatments for increased weed control efficiency was in the order of weed biomass. In both agroecosystems, the magnitude of suppression of weeds viz. *Echinochloa colona*, *Alternanthera sessilis*, *Cyperus iria* and *Cynodon dactylon* was higher in plots treated with bispyribac sodium at 25 g *a.i.*/ha at 60 DAS and exhibited maximum weed control efficiency among all the herbicidal application, suggest that it may control maximum weed besides hand weeding. It was followed by fenoxaprop-p-ethyl + penoxsulam at 60+26.7 g *a.i.*/ha and cyhalofop + penoxsulam at 135+26.7 g *a.i.*/ha for controlling weeds among the other herbicidal treatments. [15], [16] also reported similar results in direct-seeded rice.

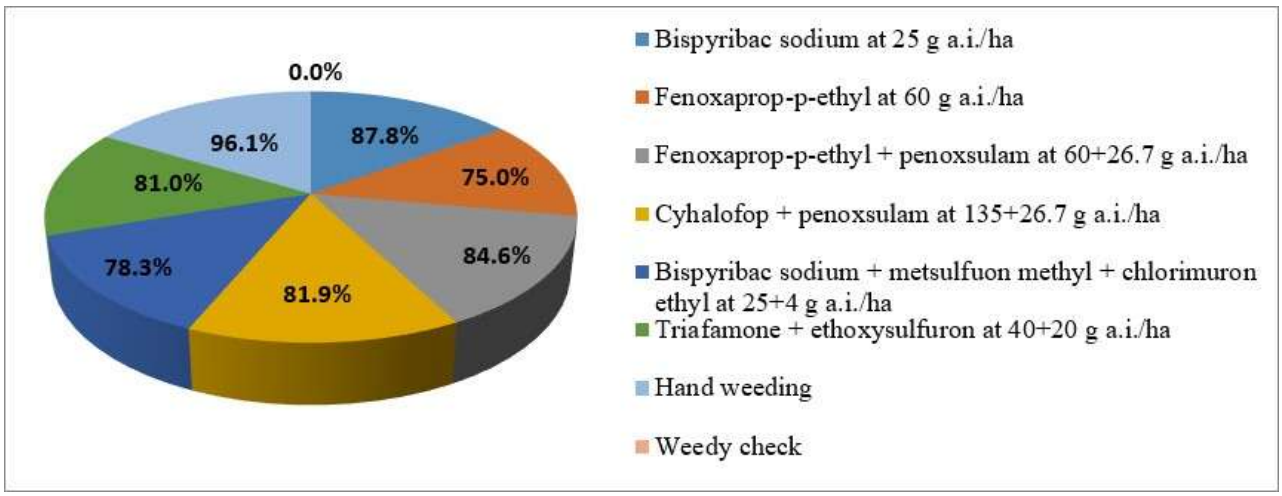


Fig 2: Weed control efficiency under rainfed agroecosystem

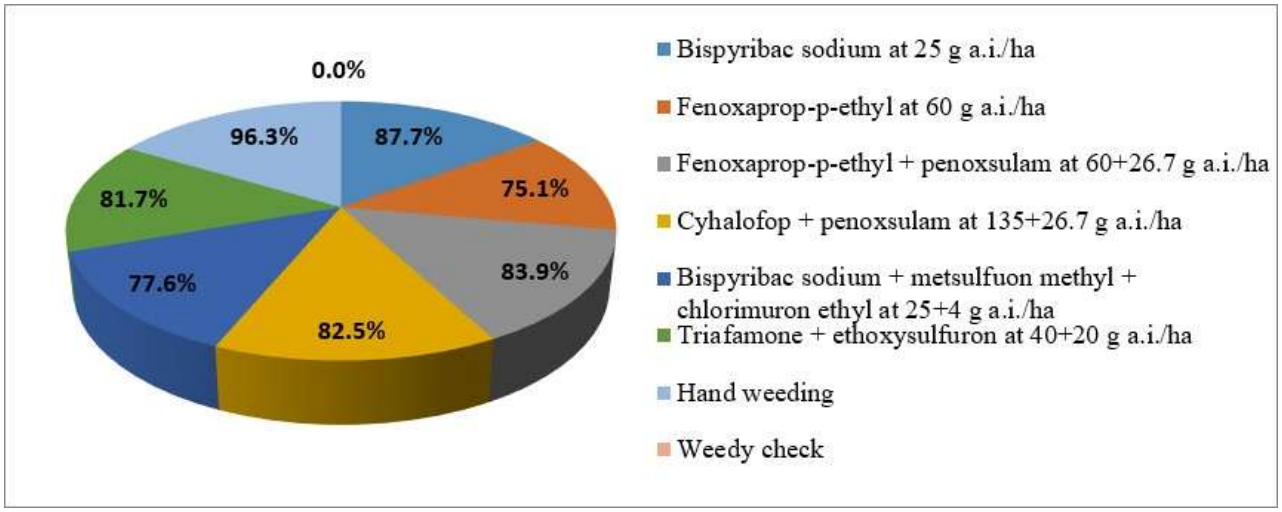


Fig 3: Weed control efficiency under irrigated agroecosystem

3.5 Crop growth parameters and yield

Herbicides treatments exhibited a marked influence on plant population, plant height and tillers/m^2 indicating that they did affect the establishment and further growth of rice plants. Yield attributing traits and grain yield was varied significantly under different agroecosystems and weed control treatments. Irrigated rice exhibited maximum plant growth parameters and high yield attributing traits (plant height, number of panicle/m^2, panicle length) and grain yield than rainfed rice among different agroecosystems (Table 4). Maximum values of these parameters were recorded under hand weeding twice (20 and 40 DAS) due to the complete removal of weeds. Among weed control treatments, bispyribac sodium 10% SC at 25 g *a.i.*/ha resulted in the highest number of panicles (369/m^2), plant height (65.6 cm), panicle length (21.2 cm) and grain yield (3686 kg/ha). This was due to effective control of weeds, which facilitated better growth of crops and ultimately increased the grain yield. The yield losses due to weeds in weedy check plots were in a range from 49.8 to 56.4% as compared to hand weeding twice and reduce up to 10.3 to 11.0% in case of bispyribac sodium at 25 g *a.i.*/ha under different agroecosystems. Growth parameters and grain yield under the treatments led to inferior yield attributing traits. These results are in close conformity with the earlier findings of [17- 19].

Table 4. Effect of different herbicidal treatments on growth parameter, yield attributes and yield of direct-seeded rice under different agroecosystems

Treatment	Plant height (cm) 60 DAS		Number of panicle/m^2		Panicle length (cm)		Grain yield (kg/ha)	
	RF	IR	RF	IR	RF	IR	RF	IR
Bispyribac sodium 10% SC at 25 g *a.i.*/ha	63.2	65.6	331	369	20.6	21.2	1850	3686
Fenoxaprop-p-ethyl 6.7% EC at 60 g *a.i.*/ha	59.3	60.3	291	308	19.0	19.4	1390	2590
Fenoxaprop-p-ethyl 6.7% EC + penoxsulam 24% SC at 60+26.7 g *a.i.*/ha	62.0	64.0	320	362	20.3	20.9	1740	3266
Cyhalofop 10% EC + penoxsulam 24% SC at 135+26.7 g *a.i.*/ha	61.5	63.0	310	351	20.1	20.7	1640	2966

Bispyribac sodium 10% SC + metsulfuon methyl 10% WP + chlorimuron ethyl 10% WP at 25+4 g *a.i.*/ha	60.0	61.5	296	313	19.3	19.7	1420	2765
Triafamone 20% WG + ethoxysulfuron 10% WG at 40+20 g *a.i.*/ha	60.7	62.2	304	337	19.9	20.5	1495	2871
Twice hand weeding	65.5	67.0	333	383	21.2	22.4	2080	4110
Weedy check	58.0	59.0	283	288	18.8	19.0	1043	1790
LSD (P=0.05)	1.60		1.97		0.33		116.3	

RF= Rainfed, IR= Irrigated

4. CONCLUSION

Based on this field experimentation, it might be concluded that bispyribac sodium 10% SC at 25 g *a.i.*/ha under irrigated and rainfed rice agroecosystems proved effective to control of complex weed flora in direct-seeded rice with higher grain yields.

5. ACKNOWLEDGEMENT

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