Mysore J. Agric. Sci., 56 (1) : 186-192 (2022)

Effect of Different Weed Management Practices on Weed Growth, Yield and Economics of Direct Seeded Rice in Eastern Dry Zone of Karnataka

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ABSTRACT

Field experiments were conducted at Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore during *rabi* 2020 and *summer* 2021 coming under eastern dry zone of Karnataka to study the efficiency of different herbicides and allelochemicals for weed management in direct seeded rice. The experiment consisted of 12 treatments replicated thrice in RCBD design. Among various herbicide treatments, significantly lowest total weed density and dry weight was recorded with Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence (17.3 no. m^{-2} and 5.1 g m^{-2}, respectively) and found on par with Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence (19.3 no. m^{-2} and 6.9 g m^{-2}, respectively). Significantly higher paddy grain and straw yield was recorded with Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence (4987 and 6844 kg ha^{-1}, respectively) followed by Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence (4866 and 6716 kg ha^{-1}, respectively) and it was on par with hand weeding at 20 and 40 DAS (5139 and 6960 kg ha^{-1}, respectively). Lowest grain and straw yield was recorded in unweeded control (688 and 1485 kg ha^{-1}, respectively). Application of Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence has recorded higher net returns (Rs.54581 ha^{-1}) with B : C ratio of 2.61.

Keywords : Weed management practices, Herbicides, Allelochemicals, Weed density, Direct seeded rice

RICE (*Oryza sativa* L.) is a leading cereal food crop of the world grown over 161 million hectares in more than 100 countries of the world and is principle food for about 62 per cent of the world's population (FAO, 2020). It is also known as the grain of life and that too major food for Asians. It is a semi-aquatic annual grass native to tropical Asia and is grown under diverse agro-ecosystems. Traditionally, rice is grown under puddled transplanted conditions which have huge water demand for continuous flooding, high labour inputs and destroyed soil structure. In India, rice is grown over an area of about 44 m. ha with a lion share under puddle transplanting (PT) conditions. However, due to shortage of water and labour, the alternative crop establishment method *i.e*., direct seeded rice (DSR) is being evaluated and adopted in specific regions having the heavy soil type. DSR is an upland rice cultivation technique wherein the crop is established by directly sowing the seeds under non-puddled and non-saturated soils. DSR offers several advantages like easier planting, less water and labour requirement, high water use efficiency, reduced greenhouse gas emission and early maturity by 7-10 days over transplanted conditions (Roy, 2016).

Weeds are the major constraint for DSR as aerobic soil environment coupled with heavy fertilization for rice will aggravate the weed emergence and growth. The critical period of crop weed competition in DSR is upto 41 DAS, yet weed free conditions till 70 DAS is desirable for higher crop productivity (Chauhan and Johnson, 2011). The yield losses due to weeds in the DSR treatments ranged from 91.4 to 99.0 per cent, compared to 16.0 to 42.0 per cent in the transplanting treatments (Chhokar *et al*., 2014). Though manual weeding is very effective, it is tedious, time consuming and non-economical in large scale cultivation. Therefore, timely weed management in direct seeded rice either by using herbicides or other alternate sources like allelochemicals offers a great advantage and scope to successful direct seeded rice cultivation.

Material and Methods

A field investigation was carried out during *rabi*, 2020 and *summer,* 2021 in red sandy loam soil at Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore coming under Eastern Dry Zone of Karnataka. The present investigation was taken up to study the efficiency of different herbicides and allelochemicals for weed management in direct seeded rice. The field experiment was laid out in RCBD replicated thrice with 12 treatments *viz*., T_1: Bensulfuron methyl + Pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence; T_2: Pyrazosulfuron ethyl 10 WP @ 40 g a.i. ha^{-1} as pre emergence; T_3: Oxadiargyl 80 WP @ 100 g a.i. ha^{-1} pre emergence; T_4: Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence; T_5: Quizolofop-p-ethyl 15 EC @ 37.5 g a.i. ha^{-1} as post emergence; T_6: Cyhalofop-p-butyl 10 EC @ 100 g a.i. ha^{-1} as post emergence; T_7: Metamifop 10 EC @ 100 g a.i. ha^{-1} as post emergence; T_8: *Leucas aspera* plant extract; T_9: *Eucalyptus* leaf extract; T_{10}: *Hyptis saveolensis* plant extract; T_{11}: Hand weeding at 20 and 40 DAS and T_{12}: Unweeded control. The herbicides were applied using spray volume of 750 L / ha for pre emergence and 500 L / ha for post emergence with knapsack sprayer having flood jet nozzle. The allelochemical plant extracts were applied at 10 per cent w/v as post emergence application.

Seeds of rice variety, '*MAS 946-1'* were line sown with 30 cm space between the lines and the recommended dose of fertilizer *i.e*., 100-50-50 kg of N, P_2O_5 and K_2O was applied with three splits of nitrogen. Observations on weed density and weed dry matter were recorded in an area of 0.25 m^2 and converted to 1 m^2. The data on weed density (no. m^{-2}) and weed dry weight (g m^{-2}) were transformed by using square root ($\sqrt{x+1}$) when the data consists of small whole numbers and log (x+2) transformation when the data of whole numbers cover a wide range of values as suggested by Gomez and Gomez (1984). The transformed data were subjected to Fisher's method of 'Analysis of Variance' (ANOVA) as outlined by Panse and Sukhatme (1954). Wherever F-test was significant, for comparison between the treatment means, an appropriate value of critical difference (CD) was worked out. Yield parameters and yield were recorded at harvest and the economics were worked out based on the cost of inputs, labour charges and prices of outputs during the course of investigation. All the data presented in this paper was the mean of two seasons and the results are presented and discussed at a probability level of five per cent.

Results and Discussion

Weed Density

The herbicides differed in their ability in controlling different categories of weeds (Table 1) *i.e*., sedges were most effectively controlled by T_1 *i.e*., Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence (1.7 no. m^{-2}) and T_4 *i.e*., Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence (3.7 no. m^{-2}); grasses by T_7 *i.e.*, Metamifop 10 EC @ 100 g a.i. ha^{-1} as post emergence (4.3 no. m^{-2}), T_5 (5.3 no. m^{-2}), T_6 (5.7 no. m^{-2}) and T_4 (6.3 no. m^{-2}); broad leaved weeds by T_4 *i.e*., Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence (7.3 no. m^{-2}), T_1 (8.3 no. m^{-2}), T_2 (9.0 no. m^{-2}) and T_3 (9.8 no. m^{-2}).

With respect to total weed density, T_4 *i.e*., Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence (17.3 no. m^{-2}) was significantly superior and was at par with T_1 *i.e*., Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence (19.3 no./ m^2). Hand weeding at 20 and 40 DAS recorded the lowest (1.8 no. m^{-2}) and unweeded control recorded highest weed density (98 no. m^{-2}) and the results are in conformity with the findings of Jayadeva *et al.,* 2010.

Weed Dry Weight

The herbicides also differed in their ability in reducing dry weight of different category of weeds similar to that of weed density (Table 2). Among herbicide treatments, T_4 *i.e*., Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence has recorded significantly lower total weed dry weight (5.1 g m^{-2}) which was on par with T_1 *i.e*., Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence (6.9 g m^{-2}).

TABLE 1

Category wise weed density (no. m^{-2}) at 45 DAS in direct seeded rice (DSR) as influenced by weed management practices

Treatments	Weed density			
	Sedges +	Grasses #	Broad leaf weeds +	Total #
T_1 : Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence	1.62 (1.7)	1.05 (9.3)	3.06 (8.3)	1.33 (19.3)
T_2 : Pyrazosulfuron ethyl 10 WP @ 40 g a.i. ha^{-1} as pre emergence	2.36 (4.7)	1.09 (10.4)	3.17 (9.0)	1.41 (24.0)
T_3 : Oxadiargyl 80 WP @ 100 g a.i. ha^{-1} pre emergence	2.51 (5.4)	1.15 (12.0)	3.28 (9.8)	1.46 (27.1)
T_4 : Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence	2.15 (3.7)	0.92 (6.3)	2.89 (7.3)	1.28 (17.3)
T_5 : Quizolofop-p-ethyl 15 EC @ 37.5 g a.i. ha^{-1} as post emergence	3.65 (12.4)	0.86 (5.3)	5.25 (26.7)	1.67 (44.3)
T_6 : Cyhalofop-p-butyl 10 EC @ 100 g a.i. ha^{-1} as post emergence	3.56 (11.7)	0.88 (5.7)	4.67 (20.9)	1.60 (38.3)
T_7 : Metamifop 10 EC @ 100 g a.i. ha^{-1} as post emergence	3.51 (11.4)	0.79 (4.3)	4.71 (21.3)	1.59 (36.9)
T_8 : *Leucas aspera* plant extract	3.36 (10.3)	1.49 (29.0)	4.67 (20.9)	1.79 (60.2)
T_9 : *Eucalyptus* leaf extract	3.05 (8.3)	1.44 (25.7)	4.31 (17.6)	1.73 (51.6)
T_{10} : *Hyptis saveolensis* plant extract	3.16 (9.0)	1.46 (26.6)	4.53 (19.6)	1.76 (55.2)
T_{11} : Hand weeding at 20 and 40 DAS	1.30 (0.7)	0.48 (1.1)	1.02 (0.0)	0.57 (1.8)
T_{12} : Unweeded control	3.78 (13.4)	1.70 (48.4)	6.09 (36.3)	2.00 (98.0)
S.Em±	0.19	0.06	0.20	0.04
CD at 5 %	0.55	0.18	0.58	0.12

Data within parentheses are original values; # - data analyzed using log (x+2) transformation, + - square root (x+1) transformation
DAS= Days after sowing; NA=Not Analyzed

Bispyribac sodium and Bensulfuron methyl + pretilachlor are broad spectrum herbicides hence, they reduced the dry weight of sedges, grasses and broad leaved weeds together and aided in lower total weed density. Lowest total weed dry weight was recorded in hand weeding at 20 and 40 DAS (0.3 g m^{-2}) and highest total weed dry weight in unweeded control (101.7 g m^{-2}).

Weed Control Efficiency

Among various weed management practices, hand weeding at 20 and 40 DAS recorded higher WCE of 99.66 per cent (Table 2) due to higher efficiency of manual labour in removing weeds followed by T_4 *i.e.*, Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence (95.0 %) and T_1 *i.e.*, Bensulfuron methyl + pretilachlor 6.6 per cent G @ 660 g a.i. ha^{-1} as pre emergence (93.16 %). Higher weed control efficiency indicates better suppression of weed dry weight and similar results were obtained by Anay Rawat *et al.,* 2013 and Teja *et al*., 2015.

Yield and Yield Attributes

Grain yield and straw yield of DSR are influenced by the different weed management practices and the data is presented in Table 3. Among the different herbicide treatments, T_4 *i.e.*, Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence recorded higher grain

TABLE 2

Category wise weed density (g m^{-2}) at 45 DAS in direct seeded rice (DSR) as influenced by weed management practices

Treatments	Weed dry weight				WCE (%)
	Sedges +	Grasses #	Broad leaf weeds #	Total #	
T_1 : Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence	1.14 (0.3)	0.77 (3.9)	0.68 (2.7)	0.95 (6.9)	93.16
T_2 : Pyrazosulfuron ethyl 10 WP @ 40 g a.i. ha^{-1} as pre emergence	1.23 (0.5)	0.83 (4.8)	0.75 (3.7)	1.04 (9.0)	91.12
T_3 : Oxadiargyl 80 WP @ 100 g a.i. ha^{-1} pre emergence	1.29 (0.7)	0.92 (6.3)	0.80 (4.3)	1.12 (11.3)	88.96
T_4 : Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence	1.19 (0.4)	0.64 (2.3)	0.64 (2.3)	0.85 (5.1)	95.00
T_5 : Quizolofop-p-ethyl 15 EC @ 37.5 g a.i. ha^{-1} as post emergence	3.94 (14.6)	0.53 (1.4)	1.34 (19.8)	1.57 (35.8)	64.98
T_6 : Cyhalofop-p-butyl 10 EC @ 100 g a.i. ha^{-1} as post emergence	3.54 (11.6)	0.55 (1.5)	1.28 (17.0)	1.51 (30.1)	70.42
T_7 : Metamifop 10 EC @ 100 g a.i. ha^{-1} as post emergence	3.22 (9.4)	0.48 (1.0)	1.33 (19.3)	1.50 (29.6)	70.83
T_8 : *Leucas aspera* plant extract	1.51 (1.3)	1.38 (22.2)	1.26 (16.1)	1.62 (39.6)	61.08
T_9 : *Eucalyptus* leaf extract	1.31 (0.7)	1.32 (19.0)	1.19 (13.8)	1.55 (33.5)	67.22
T_{10} : *Hyptis saveolensis* plant extract	1.38 (0.9)	1.32 (19.3)	1.25 (15.8)	1.58 (36.0)	64.71
T_{11} : Hand weeding at 20 and 40 DAS	1.06 (0.1)	0.34 (0.2)	0.30 (0.0)	0.37 (0.3)	99.66
T_{12} : Unweeded control	4.42 (18.6)	1.64 (41.9)	1.63 (41.2)	2.01 (101.7)	0.00
S.Em±	0.05	0.08	0.05	0.06	NA
CD at 5 %	0.16	0.22	0.15	0.17	

Data within parentheses are original values; **#** - data analyzed using log (x+2) transformation, + - square root (x+1) transformation
DAS= Days after sowing; NA=Not Analyzed

yield (4987 kg ha^{-1}) and straw yield (6844 kg ha^{-1}) compared to all other treatments and found to be statistically at par with T_1 *i.e.*, Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence (4866 and 6716 kg ha^{-1}, respectively) and hand weeding at 20 and 40 DAS (5139 and 6960 kg ha^{-1}, respectively).

Significantly higher grain yield in Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence was attributed to significantly higher yield parameters *viz.,* productive tillers per meter row length (170.85), panicle weight per meter row length (105.41 g), total number of grains per panicle (64.42) and 1000 grain weight (21.40 g). All those yield parameters were on par with Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} (166.61, 102.56 g, 61.87 and 21.37 g, respectively) and hand weeding at 20 and 40 DAS (175.14, 107.49 g, 66.06 and 21.44 g, respectively). Similar improvement in yield and yield attributing parameters due to application hand weeding was also reported by Teja *et al.* (2015). Abhishek (2016) and Yogananda *et al*., 2017 reported that herbicides, Bispyribac sodium and Bensulfuron methyl + pretilachlor was highly effective in weed control in rice for higher yield and productivity.

Economics

The higher mean cost of cultivation was recorded with hand weeding at 20 and 40 DAS (Table 4) due to high

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TABLE 3

Yield attributes and yield of direct seeded rice (DSR) as influenced by weed management practices

	Treatments	Productive tillers per meter row length	Panicle weight (g) per meter row length	Total number of grains per panicle	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
T_1:	Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence	166.61	102.56	61.87	21.31	4866	6716	0.420
T_2:	Pyrazosulfuron ethyl 10 WP @ 40 g a.i. ha^{-1} as pre emergence	164.03	99.51	61.43	21.30	4751	6592	0.419
T_3:	Oxadiargyl 80 WP @ 100 g a.i. ha^{-1} pre emergence	162.91	95.86	60.55	21.30	4526	6513	0.410
T_4:	Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence	170.85	105.41	64.42	21.40	4987	6844	0.422
T_5:	Quizolofop-p-ethyl 15 EC @ 37.5 g a.i. ha^{-1} as post emergence	138.59	86.37	51.01	21.19	3817	5910	0.392
T_6:	Cyhalofop-p-butyl 10 EC @ 100 g a.i. ha^{-1} as post emergence	151.63	90.75	51.23	21.21	3871	5851	0.398
T_7:	Metamifop 10 EC @ 100 g a.i. ha^{-1} as post emergence	157.05	91.53	61.08	21.29	4216	5998	0.413
T_8:	*Leucas aspera* plant extract	121.34	80.10	48.58	20.80	2141	4128	0.341
T_9:	*Eucalyptus* leaf extract	138.41	85.52	46.73	21.09	3484	5350	0.394
T_{10}:	*Hyptis saveolensis* plant extract	126.35	82.83	48.04	20.92	2832	4478	0.387
T_{11}:	Hand weeding at 20 and 40 DAS	175.14	107.49	66.06	21.44	5139	6960	0.425
T_{12}:	Unweeded control	70.88	54.49	49.82	20.07	688	1485	0.314
	S.Em±	3.76	2.60	1.67	NS	118	122	NS
	CD at 5 %	11.02	7.64	4.91		347	358	

DAS= Days after sowing; NS=Non-Significant

TABLE 4

Economics of weed management practices in direct seeded rice (DSR)

Treatments	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 : Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence	86423	33578	52846	2.57
T_2 : Pyrazosulfuron ethyl 10 WP @ 40 g a.i. ha^{-1} as pre emergence	84452	33432	51021	2.53
T_3 : Oxadiargyl 80 WP @ 100 g a.i. ha^{-1} pre emergence	80919	33520	47399	2.41
T_4 : Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence	88492	33911	54581	2.61
T_5 : Quizolofop-p-ethyl 15 EC @ 37.5 g a.i. ha^{-1} as post emergence	69072	33813	35260	2.04
T_6 : Cyhalofop-p-butyl 10 EC @ 100 g a.i. ha^{-1} as post emergence	69767	32275	37493	2.16
T_7 : Metamifop 10 EC @ 100 g a.i. ha^{-1} as post emergence	75233	33409	41825	2.25
T_8 : *Leucas aspera* plant extract	40366	32268	8098	1.25
T_9 : *Eucalyptus* leaf extract	62966	32268	30699	1.95
T_{10} : *Hyptis saveolensis* plant extract	51441	32268	19173	1.59
T_{11} : Hand weeding at 20 and 40 DAS	90999	38668	52331	2.35
T_{12} : Unweeded control	13290	29168	-15877	0.46

DAS= Days after sowing

labour wages for weeding and with the benefit of higher yield, the same treatment recorded highest gross returns (Rs.90999 ha^{-1}). But, if net returns and B:C ratio is considered then T_4 *i.e.*, Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence (Rs.54581 ha^{-1} and 2.61, respectively) was superior followed by T_1 *i.e.*, Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence (Rs.52846 ha^{-1} and 2.57, respectively). The results are in accordance with Anay Rawat *et al.* (2011). The lowest B:C ratio (0.46) was obtained in the weedy check along with negative net returns (Rs.-15877 ha^{-1}).

In direct seeded rice, the initial 45 DAS should be considered most critical to avoid crop weed completion. Based on the present study, application of Bispyribac sodium 10 SC @ 40 g a.i. ha^{-1} as post emergence or Bensulfuron methyl + pretilachlor 6.6 G @ 660 g a.i. ha^{-1} as pre emergence were found to be best in controlling weeds along with obtaining higher weed control efficiency, yield and economic benefit in direct seeded rice.

Acknowledgement : I would like to acknowledge KSTEPS, DST, Govt. of Karnataka for providing support and financial assistance to the research work.

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(*Received :* August 2021 *Accepted :* November 2021)