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Efficacy of pre and post-emergence herbicides on weed density, weed dry weight and growth and yield of direct seeded puddled wet rice under Cauvery command area of Karnataka

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Abstract
A field experiment entitled "Efficacy of pre and post-emergence herbicides on weed density, weed dry weight and growth and yield of direct seeded puddled wet rice under Cauvery command area of Karnataka" was conducted during *Kharif* 2015 at Zonal Agricultural research station, V. C. Farm, Mandya, Karnataka. The experiment involved 13 treatments laid out in randomized complete block design replicated thrice consisting of two pre-emergence herbicides (pendimethalin and Pretilachlor + Bensulfuron methyl) and three post-emergence herbicides (Penoxsulam, Bispyribac sodium and Azimsulfuron) along with l hand weeding. These herbicide treatments were compared with hand weeding and weedy check under direct seeded puddle wet-rice. The major weed flora observed in the experimental field were, *Alternenthera sessalis, Eclipta alba, Monochoria vaginalis, Marsilia quadrifolia and* among broad-leaved weeds; *Echinochloa colona,* and *Echinochloa crusgalli* among the grassy weeds and *Cyperus iria, Cyperus difformis* and *FImbristylis miliaceae* among sedges. The results revealed that pre-emergence application of Pendimethalin750 g *a.i.*/ha at 3 DAS followed by Penoxsulam 22.5 g *a.i.*/ha at 30 DAS, recorded significantly higher grain yield and straw yield (6328 and 7432 kg/ha), lower weed population and dry weight (9.20/m^2 and 3.70g/m^2).

Keywords: Wet direct seeded rice, days after sowing, pre emergence herbicide, post emergence herbicide, introduction

1. Introduction
India has the largest area under rice cultivation of 41.85 mha accounting for 26 per cent of rice area in the world (161.3 m ha) during 2012-13 (Anon., 2014). However, the rice production was about 153.09 mt accounted for 21.40 per cent. This was because of comparatively lower productivity of 3195 kg ha^{-1} as against the world average of 4329 kg ha^{-1}. Rice is also a staple food crop in Karnataka and is cultivated in an area of 1.28 m ha producing about 5.01 m t with a productivity of 4126 kg ha^{-1}.

The crop is grown in all the 30 districts of the state under varied soil and climatic conditions. Around 44 per cent of the total area is under irrigation and rest is under rainfed situation. The rice is the principle crop in Mandya district of Karnataka and it occupies an area of 88,657 ha with a production of 2, 66, 775 tonnes and productivity of 3143 kg/ha. In Cauvery command area, the rice is establishing through transplanting method, which is more laborious and time consuming operation. Further, timely availability and efficiency of labourers for transplanting operation makes the rice cultivation more difficulty. In order to overcome these problems, the other method of rice establishment such as direct seeded rice (DSR) method can be used. In DSR, there two method wet DSR an dry DSR seeds are directly sown in the field as like other arable crops. Since, crop is establishing thorough seed which induce more menace of weeds. Hence for better weed management by using pre and post emergent herbicides in DSR may become need of the hour. By keeping these points view the investigation are made to know the Efficacy of pre and post-emergence herbicides on weed density, weed dry weight and growth and yield of direct seeded puddled wet rice under Cauvery command area of Karnataka.

Materials and Method
A Field experiment was conducted at Zonal Agricultural research station, V. C. Farm, Mandya during 2015. The experiment was laid out in a randomized complete block design replicated

thrice with 13 treatments. The soil fertility status was low available nitrogen (230 kg ha^{-1}), medium phosphorus (30 kg ha^{-1}) and medium in available potassium (148 kg ha^{-1}). The variety tested was CTH-3. The treatments consists of T_1: Pretilachlor + Bensulfuronmethyl (6.6 % G) 660 g *a.i.*/ha 3 DAS fb one HW at 30 DAS, T_2: Bispyribac-sodium (10 % SC) 25 g *a.i*/ha at 15 DAS fb one HW at 30 DAS,T_3: Penoxsulam (24 % SC) 22.5 g *a.i.*/ha) at15 DAS fb one HW at 30 DAS, T_4: Azimsulfuron (50 % DF) 26.25 g *a.i.*/ha at 15 DAS fb one HW at 30 DAS, T_5: Pretilachlor + Bensulfuronmethyl (6.6 % G) 660 g *a.i.*/ha at 3 DAS fb Bispyribac-sodium (10 per cent SC) 25 g *a.i.*/ha at 30 DAS, T_6: Pretilachlor + Bensulfuronmethyl (6.6 % G) 660 g *a.i.*/ha at 3 DAS fb Penoxsulam (24 per cent SC) 22.5 g *a.i.*/ha at 30 DAS, T_7: Pretilachlor + Bensulfuronmethyl (6.6 % G) 660 g *a.i.*/ha at 3 DAS fb Azimsulfuron (50 per cent DF) 26.25 g *a.i.*/ha at30 DAS, T_8: Pendimethalin 750 g *a.i.*/ha at 3 DAS fb one hand weeding at 30 DAS, T_9: Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Bispyribac-sodium (10 % SC) 22.25 g *a.i.*/ha at 30 DAS, T_{10}: Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Penoxsulam (24 % SC) 22.5 g *a.i.*/ha at 30 DAS, T_{11}: Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Azimsulfuron (50 %DF) 26.25g a.i./ha at 30 DAS, T_{12}: Two hand weedings at 20 and 40 DAS and T_{13}: Unweeded check. A seed rate of 80 kg/ha was adopted. The pre germinated seeds were uniformly broadcasted in the puddled soil.

Recommended dose of fertilizer of 100:50:50 kg N, P_2O_5 and K_2O per ha was adopted. Nitrogen in the form of urea was applied in three splits as basal, tillering and panicle initiation stages. The entire quantity of phosphorus in the form of SSP and potassium in the form of muriate of potash was applied as basal. The farm yard manure was applied @ 10 t/ha at ploughing, incorporated and then levelled as per the treatment. The quantity of pre and post-emergence herbicides dosage was calculated as per the treatment. The pre-emergence herbicides pendimethalin and pretilachlor + bensulfuronmethyl were applied at 3 DAS and post-emergence herbicides such as bispyribac-sodium, penoxsulam and azimsulfuron were applied at 15 and 30 DAS as per the treatment.

Results and Discussion

Weed flora associated with DSR: The weed flora noticed in the experimental site comprised of grasses, sedges and broad leaved weeds. The major weed flora observed in the experimental site were, *Alternenthera sessalis, Eclipta alba, Monochoria vaginalis, Marsilia quadrifolia and Mollugo distica* among broad-leaved weeds; *Echinochloa colona, Echinochloa crusgalli* and *Leptochloa chinensis* among the grassy weeds *Cyperus iria, Cyperus differmis* and *FImbristylis miliaceae* among sedges.

The different authors (Charan Teja *et al.*, 2015; Anay Rawat *et al.*, 2011: Khaliq *et al.*, 2011 and Mohan *et al.*, 2010) [2, 1, 5, 6] also reported the variation in the weed flora in DSR rice field grown under different situation. According to them the type and intensity of these weed flora in DSR fields generally varied with the type of soil, varieties, season and place of growth. At Zonal Agriculture Research Station Mandya UAS (Bangalore Karnataka) direct seeded puddled rice field was infested with *Echinochloa crusgalli, Echinochloa colona,* and *Leptochloa chinensis* among monocots; *Marsilia quadrifolia, Eclipta alba, Centella asiatica, Monochoria vaginalis* among dicots and *Cyperus iria, Cyperus differmis and Fimbristylis miliaceae* among sedges (Mohan *et al.*, 2010) [6].

Density and dry weight of weeds: pre-emergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Penoxsulam (24 % SC) 22.5 g *a.i.*/ha at 30 DAS, recorded significantly lower weed population (9.20 m^{-2}) and weed dry weight (3.07 g m^{-2}), It was at par with pre-emergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Bispyribac-sodium (10 % SC) 22.25 g *a.i.*/ha at 30 DAS (23.90 m^{-2}& 5.58 g m^{-2}). But unweeded check recorded significantly higher weed population (139.40 m^{-2}) and weed dry weight at 60 DAS (42.40 g m^{-2}) these findings are in line with Pratap Singh *et al.*, 2009; Gulshan Mahajan and Bhagirath Singh Chauhan (2013) [7, 4].

Higher weed control efficiency and lower weed index was significantly recorded with pre-emergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Penoxsulam (24 % SC) 22.5 g *a.i.*/ha at 30 DAS (88.36 % and 0.30) followed by pre-emergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Bispyribac-sodium (10 % SC) 22.25 g *a.i.*/ha at 30 DAS (78.93 % and 3.20). This was due to better control of weeds growth even upto harvest resulting lower weed dry weight. The results are in conformity with findings of Walia *et al.*, 2011 [9].

Growth parameters: pre-emergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Penoxsulam (24 % SC) 22.5 g *a.i.*/ha at 30 DAS recorded significantly taller plant height more number of tillers and higher dry matter production (78.77 cm, 48.33 per hill and 45.7 g 0.25 /m^2) It was stastistically on par with pre-emergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Bispyribac-sodium (10 % SC) 22.25 g *a.i.*/ha at 30 DAS (75.0 cm, 43.33 per hill and 42.7 g 02/ m^2) (Walia *et al.* 2011) [9] also reported similar results in direct seeded rice. Unweeded check registered significantly least plant height, number tillers and dry matter production (58.17 cm, 1.90 per hill and 22.5 0.25 g/ m^2) at 60 DAS, as due to severe competition of rice plant with weeds for available resources.

Yield and yield attributing characters: the yield attributing parameters *viz,* number of panicles, panicle length, panicle weight, number grains per panicle, percentchaffyness and 1000 grain weight were found significantly higher with (60.5, 20.5 cm, 4.22 g, 183.7, 9.3 % and 23.60 g) pre-mergence application of of pendimethalin @ 750 g *a.i.*/ha at 3 DAS fb post-emergence application of penoxsulam @ 22.5 g *a.i.*/ha at 30 DAS. However it was on par with pre-emergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Bispyribac-sodium (10 % SC) 22.25 g *a.i.*/ha at 30 DAS (51.1, 19.6 cm, 3.45 g, 170.7, 14.3 % and 21.80 respectively). Increase in yield attributing parameters in was mainly due to better crop growth and yield attributing character as compared unweeded check (32.3, 16.7 cm, 3.01 g, 104.2, 26.1 % and 18.83 g respectively). The results are in conformity with findings of Walia *et al.*, 2011 [9].

All the weed control treatments registered significantly higher yield than weedy check the higher grain and straw yield among the treatments was recorded under (6328 and 7432 kg/ha) pre-mergence application of pendimethalin @ 750 g *a.i.*/ha at 3 DAS fb post-emergence application of penoxsulam @ 22.5 g *a.i.*/ha at 30 DAS. It was on par with pre-mergence application of Pendimethalin 750 g *a.i.*/ha at 3 DAS fb Bispyribac-sodium (10 % SC) 22.25 g *a.i.*/ha at 30 DAS (6148 and 7049 kg/ha) the results are in agreement with Gaurav *et al.*, 2015; Walia *et al.*, 2012: Khaliq et al., 2011 and Simerjeet *et al.* (2015) [3, 5, 8]. Unweeded check recorded lesser

grain and straw yield. This was due to less number of tillers, panicle length, filled grains per panicle, and test weight. Greater competition offered by weeds throughout crop growth period suppressed the crop, severely affecting plant height and dry matter production led to poor yield components and thus lower grain yield.

Table 1: Effect of weed control treatments on weed density (No. m^{-2}) and dry weight (gm^{-2})

Treatment	Weed density at harvest (No. m^{-2})				Weed dry weight at harvest (g m^{-2})				WCE (%)	WI (%)
	Grasses	Sedges	BLW	Total weeds	Grasses	Sedges	BLW	Total weeds		
T_1	3.5 (12.1)	2.3 (4.90)	4.7 (22.0)	6.5 (42.33)	2.2 (4.43)	2.2 (4.52)	4.7 (22.0)	4.0 (15.69)	62.06	7.28
T_2	3.5 (12.0)	2.8 (7.30)	5.3 (27.7)	7.5 (56.37)	2.2 (4.50)	2.5 (5.68)	5.3 (27.7)	4.3 (18.43)	55.38	10.39
T_3	3.2 (9.7)	2.6 (6.47)	4.8 (22.4)	6.9 (46.70)	2.3 (4.73)	2.5 (5.65)	4.8 (22.4)	4.2 (17.56)	57.49	10.22
T_4	3.7 (13.0)	2.9 (7.80)	5.3 (28.0)	7.6 (57.63)	2.7 (6.63)	2.3 (4.87)	5.3 (28.0)	4.4 (19.26)	53.51	13.19
T_5	3.7 (13.0)	2.0 (3.37)	4.6 (20.4)	6.2 (37.40)	2.2 (4.53)	1.9 (3.14)	4.6 (20.4)	3.7 (13.18)	68.12	5.83
T_6	3.2 (10.3)	1.9 (3.17)	4.1 (16.4)	5.4 (28.90)	2.1 (4.00)	1.6 (2.17)	4.1 (16.4)	3.3 (10.20)	75.26	4.73
T_7	3.6 (12.4)	2.1 (3.97)	4.8 (22.5)	6.5 (41.33)	2.2 (4.43)	2.2 (4.45)	4.8 (22.5)	3.8 (13.97)	66.16	7.43
T_8	3.4 (11.4)	1.8 (2.87)	4.4 (18.6)	5.7 (31.63)	2.1 (4.00)	2.0 (3.51)	4.4 (18.6)	3.6 (12.27)	70.33	5.35
T_9	3.1 (10.1)	1.9 (2.97)	4.0 (15.8)	5.3 (28.10)	2.0 (3.43)	1.5 (1.67)	4.0 (15.8)	3.0 (8.73)	78.93	3.20
T_{10}	3.4 (11.7)	1.5 (1.87)	3.8 (14.0)	4.6 (20.80)	1.6 (1.97)	1.3 (1.14)	3.8 (14.0)	2.3 (4.78)	88.36	0.37
T_{11}	3.5 (12.0)	1.7 (2.53)	4.3 (17.9)	5.5 (30.30)	2.0 (3.37)	1.6 (2.31)	4.3 (17.9)	3.1 (9.50)	77.16	4.65
T_{12}	1.2 (1.1)	1.1 (0.80)	1.9 (3.1)	2.3 (4.63)	0.7 (0.00)	1.1 (0.74)	1.9 (3.1)	1.8 (2.58)	93.71	0.00
T_{13}	6.0 (36.0)	4.4 (18.50)	8.4 (70.2)	11.8 (138.53)	3.4 (11.03)	3.6 (12.83)	8.4 (70.2)	6.5 (14.43)	0.00	29.11
S.Em.±	0.38	0.11	0.14	0.16	0.08	0.11	0.14	0.12	-	-
CD (P=0.05)	1.12	0.32	0.42	0.46	0.24	0.31	0.42	0.34	-	-
CV %	19.13	8.56	5.33	4.37	6.79	9.10	5.33	5.40	-	-

T1: Pretilachlor + Bensulfuronmethyl @ 660 g *a.i.*/ha (PRE) fb one HW at 30 DAS	T8: Pendimethalin 750 g *a.i.*/ha (PRE) fb one hand weeding at 30 DAS
T2: Bispyribac-sodium @ 25 g *a.i*/ha (POST) fb one HW at 30 DAS	T9: Pendimethalin 750 g *a.i.*/ha (PRE) fbBispyribac-sodium 22.25g *a.i.*/ha (POST)
T3: Penoxsulam @ 22.5 g *a.i.*/ha (POST) fb one HW at 30 DAS	T10: Pendimethalin750 g *a.i.*/ha (PRE) fbPenoxsulam 22.5g *a.i.*/ha (POST)
T4: Azimsulfuron @ 26.25 g *a.i.*/ha (POST) fb one HW at 30 DAS	T11: Pendimethalin 750 g *a.i.*/ha (PRE) fbAzimsulfuron 26.25g *a.i.*/ha (POST)
T5: Pretilachlor + Bensulfuronmethyl @ 660 g *a.i.*/ha (PRE) fbBispyribac-sodium (POST) 25 g *a.i.*/ha	T12: Two hand weeding at 20 and 40 DAS
T6: Pretilachlor+ Bensulfuronmethyl 660 g a.i./ha (PRE) fbPenoxsulam 22.5 g *a.i.*/ha (POST)	T13: Unweeded check **Note:** HW- Hand weeding, fb- Followed by
T7: Pretilachlor + Bensulfuronmethyl @ 660 g *a.i.*/ha (PRE) fbAzimsulfuron 26.25 g *a.i.*/ha (POST)	

Figures indicating ($\sqrt{x}$+0.5) transformed values, Figures in parenthesis indicate original value

Table 2: Effect of weed control treatments on growth, yield and yield attributing parameters of DSR

Treatment	Plant height	Number of tillers	Dry matter production	No. of panicles	Panicle length	Panicle weight	No. of grains per panicle	Percent chaffyness	1000 grain weight	Grain yield (Kg/ha)	Straw yield (Kg/ha)	Harvest index (%)
T_1	99.83	45.33	184.9	49.6	18.5	3.60	168.9	16.3	21.47	5889	7066	0.46
T_2	97.24	43.33	*187.3*	42.3	17.8	*3.18*	159.2	13.7	20.70	5691	6675	0.46
T_3	98.50	42.33	185.9	42.3	18.1	3.18	158.2	12.7	21.30	5702	6638	0.46
T_4	98.97	42.67	190.6	42.7	17.7	3.17	160.1	1.7	20.77	5514	6634	0.46
T_5	94.33	42.67	166.5	41.7	18.5	3.76	167.7	12.3	21.50	5979	7123	0.46
T_6	102.33	47.33	185.9	51.8	20.5	3.46	171.9	14.0	22.17	6190	7332	0.46
T_7	97.50	43.33	175.1	45.3	19.3	3.45	174.7	13.7	21.33	5880	7077	0.46
T_8	96.50	43.33	186.7	47.3	18.6	3.30	169.3	14.3	22.17	6012	7232	0.46
T_9	98.93	43.67	160.1	51.1	19.6	3.45	170.7	14.3	21.80	6148	7049	0.46
T_{10}	106.87	48.67	291.1	60.5	20.5	4.22	183.7	9.3	23.60	6328	7432	0.46
T_{11}	97.70	43.67	207.1	58.7	19.1	3.42	171.3	17.3	22.17	6056	6974	0.47
T_{12}	111.50	50.67	279.7	59.3	21.6	4.45	193.7	9.7	23.17	6352	7589	0.46
T_{13}	81.43	34.33	104.3	32.3	16.7	3.01	104.2	26.1	18.83	4503	5400	0.44
S.Em.±	4.64	1.49	17.71	1.83	0.57	0.11	6.02	1.10	0.74	208.91	205.24	0.03
CD @ 5%	13.55	4.35	51.69	5.34	1.65	0.32	17.58	3.21	NS	609.40	598.96	NS
CV %	8.15	5.88	15.9	6.59	5.16	5.36	6.30	13.38	5.95	6.05	5.12	10.67

T1: Pretilachlor + Bensulfuronmethyl @ 660 g *a.i.*/ha (PRE) fb one HW at 30 DAS	T8: Pendimethalin 750 g *a.i.*/ha (PRE) fb one HW at 30 DAS
T2: Bispyribac-sodium @ 25 g *a.i*/ha (POST) fb one HW at 30 DAS	T9: Pendimethalin 750 g *a.i.*/ha (PRE) fbBispyribac-sodium 22.25g *a.i.*/ha (POST)
T3: Penoxsulam @ 22.5 g *a.i.*/ha (POST) fb one HW at 30 DAS	T10: Pendimethalin750 g *a.i.*/ha (PRE) fbPenoxsulam 22.5 g *a.i.*/ha (POST)
T4: Azimsulfuron @ 26.25 g *a.i.*/ha (POST) fb one HW at 30 DAS	T11: Pendimethalin 750 g *a.i.*/ha (PRE) fbAzimsulfuron 26.25 g *a.i.*/ha (POST)

T5: Pretilachlor + Bensulfuronmethyl @ 660 g *a.i.*/ha (PRE) fbBispyribac-sodium (POST) 25 g *a.i.*/ha	T12: Two HW at 20 and 40 DAS
T6: Pretilachlor+ Bensulfuronmethyl 660 g a.i./ha (PRE) fbPenoxsulam 22.5 g *a.i.*/ha (POST)	T13: Unweeded check
T7: Pretilachlor + Bensulfuronmethyl @ 660 g *a.i.*/ha (PRE) fbAzimsulfuron 26.25 g *a.i.*/ha (POST)	

Note: HW- hand weeding

Conclusion

The above study concludes that pre-mergence application of of pendimethalin @ 750 g *a.i./*ha at 3 DAS fb post-emergence application of penoxsulam @ 22.5 g *a.i./*ha at 30 DAS found effective in control of weeds and recorded lower weed population and dry weight, however, it was statistically on par with pre-emergence application of Pendimethalin 750 g *a.i./*ha at 3DAS fb Bispyribac-sodium (10%SC) 22.25 g *a.i./*ha at 30 DAS.

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