Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 959-962
Received: 24-09-2020
Accepted: 27-10-2020

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Effect of pre and post emergence herbicide on weed control in diect seeded lowland rice

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Abstract
A field experiment was conducted during *Kharif* season of 2019-20 at Agronomy Research Farm, College of Agriculture, Nagpur, to study the effect of pre and post emergence herbicides on weed control in direct seeded lowland rice. Among the weed control treatment, the lowest dry matter of weeds and highest weed control efficiency was recorded by weed free treatment (T_2) over rest of the treatments. Among herbicidal treatments, pre emergence application of Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* post emergence application of Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) and pre emergence application of Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* post emergence application of Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) were found to reduce weed population thereby increasing weed control efficiency. Weed free check treatment being at par with herbicidal treatment provided most effective control of weeds throughout the crop growth period of direct seeded lowland rice, thereby improving growth and yield contributing characters and consequently recorded highest grain and straw yield.

Keywords: Pretilachlor, Oxydiargyl, Bispyribac sodium, weed control

Introduction
Rice is one of the most important staple food grain crop of the world, which constitute the principle food for about 60% of the world's human population and two third of Indian population. Rice cultivation has placed India on the world map in recent past. Rice has not only gained the vital importance in Indian Agriculture, but also plays a decisive role in oil (rice bran oil) economy of India.

Rice being *kharif* season and slow growing crop, in early growth stages faces severe weed competition, resulting in a loss of about 40-60% of the potential yield, depending on the intensity, nature and duration of weed competition. It is heavily infested with grasses, sedges and broad leaf weeds which proliferate intensively due to slow crop growth during the initial period. The losses comprised of direct yield loss resulting from crop-weed competition and indirect losses from reduced crop quality, increased cost of cultivation, incidence of insect, pest and diseases. Ghosh *et al*., (2016) [3] indicated that in DSR cultivation, weed is the major constraint mainly due to absence of puddling in field. The yield loss due to weed interference is huge, may be up to 100%. Experimental results revealed that pre-emergence herbicide effectively controlled the germination of grassy weeds.

IWM approach based on the critical period of crop-weed competition, involving different direct and indirect control measures, has been developed and widely adopted by farmers to overcome weed problem in DSR in a sustainable way. Arunbabu and Jena (2018) [1] observed that the losses occurred due to weeds in rice crop in India is 15-90 % in different environments and under various establishment methods. Studies reported that ineffective weed management practices with respect to time and method led to total crop failure under direct seeded rice.

Pre and post emergence application of herbicides is becoming popular and regarded as one of the most labour saving innovation in modern agriculture which helps to minimize the crop-weed competition during critical growth stages resulting in higher crop yields. Recently some new molecular selective pre-emergence herbicides *viz*., Oxydiargyl, Pretilachlor and Pendimethalin and post emergence herbicide *viz*., Bispyribac sodium are being marketed with the assurance of selective control of pre and post emergence weeds in rice. Hence, present investigation was conducted to study the "Effect of pre and post emergence herbicide on weed control in direct seeded lowland rice" with the object to find out suitable pre and post emergence herbicide for weed control in direct seeded lowland rice.

Material and Methods
A field experiment was conducted during *Kharif* season of 2019-20 at Agronomy Research Farm, College of Agriculture, Nagpur, with 9 weed management treatments i.e.,

T_1 (Weedy check), T_2 (Weed free check), T_3 (PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} *fb* hoeing at 35 DAS), T_4 (PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* hoeing at 35 DAS), T_5 (PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* hoeing at 35 DAS), T_6 (PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS), T_7 (PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS), T_8 (PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS), T_9 (PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS), in Randomized Block Design with 3 replications. The soil of experimental plot was silty clay in texture having slightly alkaline to neutral pH. As regards to fertility status, it was low in available nitrogen, moderate in available phosphorus, fairly rich in available potassium and moderate in organic carbon content. The variety "Sindewahi 1" was sown in lines on 06/07/2019 and harvested on 05/11/2019. The weed management treatments were imposed as per treatments. Weed index indicates decrease in yield due to presence of weeds as compared to weed free plot. It is expressed as the competition offered by the weeds and is measured in terms of % reduction in yield due to their presence. The weed index was calculated by the formula,

$$WI = \frac{X - Y}{X} \times 100$$

Where, WI = Weed index
X = Yield from weed free plot
Y = Yield from treatment plot, for which WI is to be calculated

Weed control efficiency denotes the efficacy of different treatment to control weeds. It is expressed in percentage. It was calculated by using following formula,

$$WCE\ (\%) = \frac{DMC - DMT}{DMC} \times 100$$

Where, WCE = Weed control efficiency
DMC = Dry matter production of weed in control plot
DMT = Dry matter production of weed in treated plot

Results and Discussion

Weed studies:- Weed count, weed dry matter, weed control efficiency and weed index

Total weed count m^{-2} was significantly influenced at all the periodical intervals due to different weed control treatments. The treatment weedy check (T_1) showed more weed population over all the treatments and the treatment weed free check (T_2) was statistically superior in controlling weed population over all the treatments at all the growth stages. In respect of herbicidal treatments, treatment PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) reduced the total weed count m^{-2} significantly over all other treatments at all the periodical intervals. However, it was found at par with treatment of PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) and PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_7) at all the growth stages of crop and also with PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_6) at 60 and 90 DAS.

Weed population was reduced significantly due to various weed control treatments at all growth stages due to the sequential use of pre and post emergence herbicides and hoeing operations under herbicidal and weed free treatment than control treatment. Similar results were reported by Ramana *et al.,* (2007) [6] who concluded that lowest weed density and dry weight of weeds was recorded with weed free check, which was at par with application of metsulfuron methyl 10% + chlorimuron ethyl 10%, oxadiargyl + working with star weeder at 40 DAS and pretilachlor + working with star weeder. The highest weed dry weight was recorded with weedy check in rice.

All the weed control treatments brought significant reduction in weed dry matter as compared to weedy check treatment. The highest reduction of weed dry matter was found in weed free treatment (T_2) and was significantly superior over all other treatments. Amongst various herbicidal treatments, treatment PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) recorded significantly lowest weed dry matter accumulation m^{-2} than the weedy check (T_1) and other herbicidal treatments at all the periodical observations except treatments PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) and PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_7) at all the growth stages of crop and also PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_6) which were found comparable to treatment PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) at all the growth stages of crop except at 60 DAS. The lowest weed dry matter accumulation m^{-2} under herbicidal treatments may be attributed due to sequential application of pre and post emergence herbicides and hoeing operation which reduced the weed population significantly.

The findings correlate with the findings of Raj and Syriac (2017) [5] who revealed that bispyribac sodium + metamifop @ 70, 80 and 90 g ha^{-1} was found more effective in reducing the density and dry weight of weeds.

The highest weed control efficiency (WCE) was recorded under weed free treatment (T_2) followed by treatment PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) and PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1}*fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) at all the growth stages. The lowest WCE was found in treatment weedy check (T_1). These could be attributed due to better control of weeds by hand weeding, hoeing and application of Pretilachlor, Oxydiargyl and Bispyribac sodium. These results were in agreement to that of Kachroo and Bazaya (2011) [4], who conducted the field experiment to study the effect of pretilachlor @ 0.5 kg ha^{-1} at 6 DAS and recorded highest WCE (70.4%).

Weed index was computed as the yield reduction comparative to highest yielding treatment i.e. weed free (T_2). Among the weed management practices, treatment PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) showed minimum weed index (6.73) over all theother treatments followed by PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) (9.03). Weedy check treatment (T_1) recorded maximum weed index i.e. (51.52) indicating the reduction in paddy grain yield due to presence of weeds throughout crop growth period.

Lower weed index in herbicidal treatments might be due to better weed control which provides favourable condition for

crop growth that ultimately increased the grain yield of paddy crop as compared to weedy check treatment (T_1). These findings correlate with the findings of Das *et al*., (2017) [2] they reported that Bispyribac sodium @ 30 g a.i. ha^{-1} applied at 25 DAT gives lowest weed index (5.61%) of rice among chemical herbicide treated plots.

Crop studies- Grain yield, straw yield and harvest index

The treatment weed free check (T_2) produced significantly maximum paddy grain yield (3541 kg ha^{-1}) as compared to all other treatments. As regards herbicidal treatments, the treatment PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) and PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) produced significantly higher grain yield (3224 kg ha^{-1} and 3156 kg ha^{-1}, resp.) over all other herbicidal treatments and were found at par with each other. The treatment weedy check (T_1) recorded minimum grain yield of paddy (1971 kg ha^{-1}) as compared to all other treatments.

Mechanical as well as chemical treatment in combination with mechanical practices were effective in reducing weed population, weed dry matter production and increasing grain yield of paddy. Beneficial effect of mechanical method and pre-emergence application of Pretilachlor and Oxydiargyl and post-emergence application of Bispyribac sodium in combination with mechanical method might be due to suppression of monocot and dicot weeds which helped in reducing soil moisture and nutrient losses by weeds and making it available to the paddy crop thereby increasing yield of crop. Similar results were found by Sindhu *et al*., (2010) [7] that, pretilachlor + hand weeding recorded the highest grain yield of 3.20 t ha^{-1} over the weed control treatment.

The treatment weed free check (T_2) produced significantly maximum straw yield (5041 kg ha^{-1}) as compared to all other treatments. The treatments comprising of PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) and PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) recorded significantly higher straw yield of paddy ha^{-1} as compared to all other herbicidal treatments and were at par with each other. Least paddy straw yield (3807 kg ha^{-1}) was recorded in weedy check treatment (T_1).

Increase in straw yield of paddy might be due to luxurious crop growth and less crop weed competition in the weed free plot and in the cultural and herbicidal treatments. The results are in accordance to findings of Das *et al*., (2017) [2] who inferred that bispyribac sodium @ 30 g a.i. ha^{-1} applied at 25 DAT recorded maximum grain yield (5549 kg ha^{-1}) and straw yield (5991 kg ha^{-1}) of rice.

Maximum harvest index recorded by the treatment weed free check (T_2) was 41.26 followed by PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_8) and PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb* hoeing at 35 DAS (T_9) whereas least harvest index was observed in weed check treatment (T_1) (34.11).

Table 1: Mean total weed count and mean weed dry matter accumulation as influenced by different weed control treatments

Treatments		Total weed count m^{-2}				Weed dry matter m^{-2}			
		30 DAS	60DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	Weedy check	4.97 (24.16)	6.20 (37.89)	6.62 (43.27)	6.79 (45.67)	10.25 (104.49)	11.68 (136.02)	13.12 (171.76)	13.48 (181.31)
T_2	Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_3	PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} fb hoeing at 35 DAS	4.16 (16.81)	4.94 (23.93)	5.38 (28.47)	5.58 (30.64)	6.12 (36.97)	7.11 (50.10)	8.13 (65.52)	8.76 (76.23)
T_4	PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} fb hoeing at 35 DAS	3.96 (15.16)	4.71 (21.65)	5.16 (26.11)	5.36 (28.21)	5.61 (30.98)	6.61 (43.15)	7.58 (57.02)	8.18 (66.35)
T_5	PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} fb hoeing at 35 DAS	4.09 (16.20)	4.82 (22.77)	5.17 (26.20)	5.44 (29.11)	5.89 (34.19)	6.89 (47.00)	7.97 (63.10)	8.52 (72.11)
T_6	PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	1.92 (3.19)	3.61 (12.55)	4.32 (18.17)	4.82 (22.70)	5.27 (27.26)	6.13 (37.11)	6.98 (48.18)	7.47 (55.34)
T_7	PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} fb PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	1.49 (1.73)	3.49 (11.65)	4.18 (16.96)	4.68 (21.37)	5.08 (25.34)	5.85 (33.68)	6.76 (45.20)	7.31 (52.96)
T_8	PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} fb PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	1.25 (1.07)	3.02 (8.62)	3.76 (13.67)	4.06 (15.97)	4.29 (17.93)	5.07 (25.22)	6.05 (36.07)	6.47 (41.37)
T_9	PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} fb PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	1.35 (1.33)	3.15 (9.42)	3.83 (14.21)	4.11 (16.40)	4.40 (18.88)	5.15 (25.99)	6.13 (39.26)	6.52 (42.07)
	SE (m)±	0.10	0.31	0.20	0.22	0.38	0.27	0.34	0.34
	CD at 5 %	0.29	0.94	0.60	0.65	1.15	0.81	1.01	1.03
	GM	3.06 (8.86)	4.12 (16.50)	4.16 (20.79)	4.88 (23.34)	5.78 (32.89)	6.69 (44.25)	7.66 (58.21)	8.11 (65.30)

Fig in parentheses is actual values; Upper values are transformed values $\sqrt{X+0.5}$

Table 2: Mean weed control efficiency, weed index, yield and harvest index as influenced by different weed control treatments

Treatments		Weed control efficiency				Weed index	Grain yield (kg ha^{1})	Straw yield (kgha^{-1})	Harvest Index (%)
		30DAS	60DAS	90DAS	At harvest				
T_1	Weedy check	-	-	-	-	44.34	1971	3807	34.11
T_2	Weed free check	100	100	100	100	-	3541	5041	41.26
T_3	PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} fb hoeing at 35 DAS	64.62	63.17	61.85	57.96	25.36	2643	4343	37.85
T_4	PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} fb hoeing at 35 DAS	70.35	68.28	66.80	63.41	18.16	2898	4536	38.98
T_5	PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} fb hoeing at 35 DAS	67.28	65.45	63.26	60.23	21.99	2762	4487	38.10
T_6	PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	73.91	72.72	71.95	69.48	15.90	2978	4613	39.23

T_7	PE Pendimethalin 30 EC @ 1.5 kg a.i. ha^{-1} fb PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	75.75	75.24	73.68	70.79	13.08	3078	4734	39.40
T_8	PE Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} fb PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	82.84	81.46	79.00	77.18	8.95	3224	4903	39.67
T_9	PE Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} fb PoE Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS fb hoeing at 35 DAS	81.93	80.90	78.42	76.79	10.87	3156	4845	39.45
	SE (m)±	-	-	-	-	-	35	23	-
	CD at 5 %	-	-	-	-	-	105	70	-
	GM	68.52	67.47	66.11	63.98	17.62	2917	4590	-

Conclusion

In direct seeded lowland rice, pre-emergence application of Pretilachlor 50 EC @ 0.75 kg a.i. ha^{-1} or Oxydiargyl 6 % EC @ 100 g a.i. ha^{-1} *fb* post-emergence Bispyribac sodium 10 SC @ 20 g a.i. ha^{-1} at 20 DAS *fb*1 hoeing at 35 DAS reduced the weed population and increase weed control efficiency thereby increasing the grain and straw yield of rice.

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