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Studies on Bio efficacy and Phytotoxicity of Pretilachlor 30.7% EC in Direct Seeded Rice

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Abstract
The experiment was conducted during late *kharif* season of 2015 and 2016 at Central Research Farm, Gayeshpur, Nadia, West Bengal to study the effect of Pretilachlor 30.7% EC at different doses of application for weed management in direct seeded rice. Eight different weed control treatments *viz.* four different doses of Pretilachlor 30.7% EC (TP) applied at 300, 450, 600 and 1200 g a.i. ha^{-1}, Pretilachlor 30.7% EC (SC) at 600 g a.i. ha^{-1}, Oxyflourfen 23.5% EC at 240 g a.i. ha^{-1}, hand weeding twice at 20 and 40 DAS and unweeded control. The experiment was laid out in a randomized block design (RBD) replicated thrice. From the results, it was revealed that so far as population of weeds, weed dry weight, weed control efficiency, yield parameters and rice yield concerned, the treatment Pretilachlor 30.7 % EC 1200 g a.i. ha^{-1} came out as the best one being statistically at par with rest of the treatment but Pretilachlor 30.7 % EC 600 g a.i. ha^{-1} was found cost effective among all the treatments so it can be recommended for sufficient management of weeds as well as significant increase in grain yield. There was no phytotoxicity effect on rice, physico-chemical properties of soil also no significant differences observed in any of the doses of the testing herbicide in direct seeded rice crop.

Keywords: Pretilachlor, Direct-seeded rice, Herbicide, Weeds, Grain yield

1. Introduction
Rice is one of the three major food crops of the world and forms the staple diet of about half of the world's population. Rice is the staple food for more than 65 per cent of the Indian population. Rice is the major Kharif crop of India covering 42.8 M ha amounting to 85.7 M t of production (India.gov.in, 2012). West Bengal ranks first in the area (5.63 M ha) and production (14.34 M t) of rice (Reddy, 2012). Among the states with considerable area under rice cultivation, Punjab has the highest rice productivity (4010 kg ha^{-1}) in the country followed by Tamil Nadu (3070 kg ha^{-1}) (Reddy, 2012). Direct seeding rice, a common practice before green revolution in India, is becoming popular once again because of its potential to save water and labour (Gupta *et al*., 2006). The demand of cereals to meet the food requirements of the burgeoning population is increasing while on the other hand most vital inputs of agriculture viz. labour and water are depleting day by day. Labour required for nursery raising, uprooting and transplanting of seedlings are saved to the extent of about 40% and also saving of water (up to 60%) as nursery raising, puddling, seepage and percolation are eliminated in direct seeded rice (Pathak *et al.*, 2011). The conventional system of rice production (CT-TPR) in this region is basically water, labour and energy intensive, adversely affecting the environment Therefore, to sustain the long term production of rice, more efficient alternative methods of rice productions are needed. For this, Dry direct Seeded Rice (DSR) is the technology which is water, labour and energy efficient along with eco-friendly characteristics and can be a potential alternative to CT-TPR (Kumar and Ladha, 2011). DSR is both cost and labour-saving technology and similar or even higher yields (Hayashi *et al.* 2007) of DSR can be obtained with good management practices. The higher grain yield of direct seeding rice as compared to puddle transplanted rice was obtained mainly because of higher panicle number, higher thousand grain weight and lower sterility percentage (Sarkar *et al.* 2003). Weeds are the most important biological constraint to the success of DSR in general and to Dry-DSR in particular (Singh *et al.* 2006, Rao *et al.* 2007). It has been estimated that high weed infestation causes grain yield losses up to 90% (Kaur and Singh 2015). A weed-free period for the first 25-45 DAS is required to avoid any loss in yield in dry direct-seeded rice (Chauhan and Johnson 2011, Singh *et al.* 2012). The recent trend of herbicide use is to find out an effective weed control measure by using low dose high efficiency herbicides which will not only reduce the

total volume of herbicide use but also the application become easier and economical (Pal and Banerjee 2007). Pretilachlor is selective herbicide absorbed by hypocotyls and coleoptiles and roots of germinating weeds. It is applied as pre-emergence for controlling annual grasses, broadleaved and sedges (Pathak *et al.*, 2011). It controls *Echinochloa crusgalli, Echinochloa colona, Cyperus iria, Cyperus difformis, Eclipta alba, Ludwigia parviflora/octavalvis, Monochoria vaginalis, Panicum repens* in transplanted rice (Das, 2013).

Materials and methods

The field experiment was conducted during late *kharif* season of 2015 and 2016 to study the effect of Pretilachlor 30.7% EC at different doses of application for weed management in direct seeded rice at Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The farm where the experiment was conducted is located at 23 ^{0} N latitude, 89 ^{0} E longitudes and at an elevation of 9.75 meters above mean sea level (MSL) and the land topography is technically known as medium land. The maximum temperature was observed above 36.6° C during late *kharif*. The total rainfall of 119.8 mm was received throughout the crop period respectively. The experimental soil of Central Research Farm, Gayeshpur is under the series Inceptisols and the great group is under Fluvaquents. The Gayeshpur series is a member of sandy loam and neutral (pH 7.10) in reaction. The soil of experimental plot was high in organic carbon (0.65%), medium in nitrogen (0.45%), high in available P (45 kg ha^{-1}) and available K (243 kg ha^{-1}). The experiment was laid out in randomized block design (RBD) with three replications comprising eight different weed control treatments *viz.* four different doses of Pretilachlor 30.7% EC (TP) applied at 300, 450, 600 and 1200 g a.i. ha^{-1}, Pretilachlor 30.7% EC (SC) at 600 g a.i. ha^{-1}, Oxyflourfen 23.5% EC at 240 g a.i. ha^{-1}, hand weeding twice at 20 and 40 DAS and unweeded control. Fertilizers were applied uniformly @ 60-30-30 kg ha^{-1} of N-P_2O_5-K_2O in the form of from urea, single superphosphate, muriate of potash, respectively. The whole amount of P and K was applied as basal dose while N was top-dressed in three equal installments at 20, 40 and 60 DAS. Rice variety *'IET- 4786 (Satabdi)'* was sown in 20 cm spacing using 60 kg seed ha^{-1}. Herbicidal treatments were applied as pre emergence 2 days after sowing at their respective doses as per treatments. Spraying was done with the help of knapsack sprayer fitted with a flat fan nozzle with the spray volume of water 500 L ha^{-1} while hand weeding treatment was practiced twice at 20 and 40 DAS. Species-wise and total weed counts (no. m^{-2}) were recorded from three places selected at random in each plot at various stages. A quadrate of 0.25 m^2 size was used for recording the weed density and weed dry weight was recorded in the laboratory. The weeds inside each quadrate were uprooted, cleaned and dried. After air drying, weeds were dried in hot air oven at 70 ± 1 ^{0}C for 48 hours to obtain a constant weight. As wide variation existed in data, number and biomass of weeds were transformed through square-root $(\sqrt{X+0.5})$ method before analysis of variance. After drying, dry weight and weed control efficiency was calculated using standard formula. The treatments were allocated randomly to different plots with the help of random number table (Fisher, R. A. 1958) and the data were analysed by ANOVA, and ranked by using the critical differences (CD) at 5% level. Data on grain yield were recorded from the net plot.

Results and discussion

Effect on weeds

The density (no. m^{-2}) of population of grassy, broad leaved and sedges weeds was significantly reduced by the application of Pretilachlor 30.7% EC on direct seeded rice (Table 1). The lowest weed density (no. m^{-2}) of population of grassy, broad leaved and sedges weeds, at 15, 30 and 60 DAS was recorded in experimental plot treated with Pretilachlor 30.7% EC 1200 g a.i. ha^{-1} followed by Pretilachlor 30.7% EC 600 g a.i. ha^{-1} among all the herbicidal treatments.

The total weed density (no. m^{-2}) was significantly reduced by the application of Pretilachlor 30.7% EC on direct seeded rice. Among all the herbicide treatments the lowest weed density (Table 1) was recorded in experimental plot treated with Pretilachlor 30.7% EC 1200 g a.i. ha^{-1} (1.96, 3.19 & 4.22 no. m^{-2} respectively) at 15, 30, and 60 DAS followed by Pretilachlor 30.7% EC 600 g a.i. ha^{-1} (2.20, 3.24 & 4.42 no. m^{-2} respectively) and Pretilachlor 30.7% EC 450 g a.i. ha^{-1} (3.03, 3.85 & 5.05 no. m^{-2} respectively). Among all the treatments, the lowest weed density was recorded in hand weeding (20 & 40 DAS).

The highest weed density was observed under the unwedded control treatment. The experimental field was predominantly infested with *Echinochloa crusgalli, Echinochloa colonum, Cyperus difformis, Cyperus iria, Phyllanthus niruri and Commelina benghalensis* etc.

The lowest weed dry matter (g m^{-2}) production of grassy, broad leaved and sedges weeds at 15, 30 and 60 DAS was recorded in experimental plot treated with Pretilachlor 30.7% EC 1200 g a.i. ha^{-1} followed by Pretilachlor 30.7% EC 600 g a.i. ha^{-1} among all the herbicidal treatments. Similarly, among the different herbicidal treatments, The lowest total dry matter accumulation (1.98, 7.1 & 3.91 g m^{-2}) respectively was recorded with application of Pretilachlor 30.7% EC 1200 g a.i. ha^{-1} followed by Pretilachlor 30.7% EC 600 g a.i. ha^{-1} (2.15, 7.55 &16.9 g m^{-2}) respectively followed by Pretilachlor 30.7% EC 450 g a.i. ha^{-1} (4.9, 11.6 & 21.7 g m^{-2}). The highest total dry matter accumulation (26.05, 56 & 97.4 g m^{-2}) respectively was found in unweeded control treatment.

Weed control efficiency (%) derived from the weed dry weight (Table 2) revealed that Pretilachlor 30.7% EC 1200 g a.i. ha^{-1} showed higher weed control efficiency of (92.40, 87.32 & 84.40 %) at 15, 30 and 60 DAS respectively followed by application of 600 (91.75, 86.52 & 82.65 %) and 450 g a.i./ha (81.19, 79.29 and 77.72%) respectively at 15, 30 and 60 DAS.

The lowest weed control efficiency was observed under the unwedded control treatment. Oxyflourfen 23.5% EC 240 g a.i. ha^{-1} has showed the lowest WCE than all other doses of herbicide and hand weeding in all the dates of observation. New formulation has higher WCE than the supplied commercial product in direct seeded rice during 2015 and 2016 late *kharif* season.

Effect on crops

Among the different growth and yield parameters (Table 3) there was significant difference in plant height among hand weeding twice and all other treatments but there was no significant difference in plant height among all the herbicide application treatments. Also, there was no significant difference found in numbers of effective tillers per m^2 and panicle length.

In the herbicide applied plot without showing phytotoxicity, higher grain yield was observed in Pretilachlor 30.7% EC 600 g a.i. ha^{-1} produced 4.63 t ha^{-1} which is statistically at par with

application of Pretilachlor 30.7% EC 1200 g a.i. ha^{-1}. However, among all the treatments, rice yield was found to be higher in hand weeded treated plot.

Among the herbicidal treatment, the maximum straw yield (6.12 t ha^{-1}) found with application of Pretilachlor 30.7% EC 1200 g a.i. ha^{-1} followed by Pretilachlor 30.7% EC 600 g a.i. ha^{-1} (6.11 t ha^{-1}). However, among the treatment the highest straw yield (6.20 t ha^{-1}) was recorded to be higher in hand weeding treatment plot.

Phytotoxicity

In Table 3, it was shown that Pretilachlor 30.7 % EC at any dose did not show any phyto-toxicity symptoms of epinasty, hyponasty, necrosis and vein clearing, wilting and leaf mortality at any stage of the direct seeded rice crop.

Table 1: Efficacy of Pretilachlor 30.7% EC against weed density (no. m^{-2}) in direct seeded rice (pooled data of two years).

Treatments	Dose (g a.i. ha^{-1})	Grasses			Sedges			Broad leaved weeds			Total Weeds Density		
		15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
Pretilachlor 30.7% EC (TP)	300	1.78 (2.67)	2.48 (5.67)	4.26 (17.67)	1.96 (3.33)	2.97 (8.33)	3.67 (13.00)	2.61 (6.33)	2.92 (8.00)	3.85 (14.33)	3.58 (12.33)	4.74 (22.0)	6.75 (45.0)
Pretilachlor 30.7% EC (TP)	450	1.47 (1.67)	2.20 (4.33)	3.24 (10.00)	1.78 (2.67)	2.27 (4.67)	2.68 (6.67)	2.20 (4.33)	2.41 (5.33)	2.97 (8.33)	3.03 (8.67)	3.85 (14.33)	5.05 (25.0)
Pretilachlor 30.7% EC (TP)	600	1.35 (1.33)	2.04 (3.67)	2.97 (8.33)	1.35 (1.33)	1.96 (3.33)	2.12 (4.00)	1.47 (1.67)	1.87 (3.00)	2.68 (6.67)	2.20 (4.33)	3.24 (10.0)	4.42 (19.0)
Pretilachlor 30.7% EC (TP)	1200	1.22 (1.00)	1.96 (3.33)	2.74 (7.00)	1.22 (1.00)	1.87 (3.00)	2.04 (3.67)	1.35 (1.33)	1.96 (3.33)	2.68 (6.67)	1.96 (3.33)	3.19 (9.66)	4.22 (17.34)
Pretilachlor 30.7% EC (SC)	600	1.58 (2.00)	2.27 (4.67)	3.19 (9.67)	1.87 (3.00)	2.35 (5.00)	3.03 (8.67)	2.48 (5.67)	2.68 (6.67)	3.24 (10.00)	3.34 (10.67)	4.10 (16.34)	5.37 (28.34)
Oxyflourfen 23.5% EC	240	1.78 (2.68)	2.41 (5.33)	3.58 (12.33)	2.04 (3.67)	2.68 (6.67)	3.14 (9.33)	2.55 (6.00)	2.86 (7.67)	3.49 (11.67)	3.58 (12.35)	4.49 (19.67)	5.82 (33.33)
Hand weeding (20 & 40 DAS)	-	0.91 (0.33)	0.91 (0.33)	1.08 (0.67)	1.08 (0.67)	1.22 (1.00)	1.68 (2.33)	1.22 (1.00)	1.47 (1.67)	1.96 (3.33)	1.58 (2.0)	1.87 (3.0)	2.61 (6.33)
Unweeded control	-	4.81 (22.67)	5.96 (35.00)	6.54 (42.33)	4.34 (18.33)	4.92 (23.67)	5.49 (29.67)	4.02 (15.67)	5.43 (29.00)	6.23 (38.33)	7.56 (56.67)	9.39 (87.67)	10.53 (110.33)
S. Em±		0.005	0.005	0.053	0.017	0.035	0.041	0.037	0.042	0.053	0.037	0.046	0.054
LSD (0.05)		0.014	0.015	0.164	0.052	0.107	0.124	0.113	0.130	0.161	0.113	0.139	0.164

* Values in parentheses are original, and transformed to log $(\sqrt{X+0.5})$ for analysis, EC- Emulsifiable concentrate, TP- Test product, SC- Standard check, a.i.= Active ingredient, L= Litre, DAS- Days after seeding

Table 2: Efficacy of Pretilachlor 30.7% EC against weed dry weight (g m^{-2}) and weed control efficiency (%) in direct seeded rice (pooled data of two years).

Treatments	Dose (g a.i. ha^{-1})	Grasses			Sedges			Broad leaved weeds			Total weed dry matter		Weed control efficiency		
		15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS	15 DAS	30 DAS	60 DAS
Pretilachlor 30.7% EC (TP)	300	1.55 (1.9)	2.16 (4.15)	3.83 (14.2)	1.64 (2.2)	2.41 (5.3)	4.15 (16.7)	1.90 (3.1)	2.59 (6.2)	4.53 (20.02)	2.77 (7.2)	4.02 (15.65)	7.17 (50.92)	72.36	72.05	47.72
Pretilachlor 30.7% EC (TP)	450	1.30 (1.2)	1.84 (2.9)	2.30 (4.8)	1.45 (1.6)	2.00 (3.5)	2.76 (7.1)	1.61 (2.1)	2.39 (5.2)	3.21 (9.8)	2.32 (4.9)	3.48 (11.6)	4.71 (21.7)	81.19	79.29	77.72
Pretilachlor 30.7% EC (TP)	600	0.97 (0.45)	1.52 (1.8)	2.10 (3.9)	1.12 (0.75)	1.77 (2.65)	2.32 (4.9)	1.20 (0.95)	1.90 (3.1)	2.93 (8.1)	1.63 (2.15)	2.84 (7.55)	4.17 (16.9)	91.75	86.52	82.65
Pretilachlor 30.7% EC (TP)	1200	0.92 (0.35)	1.48 (1.7)	2.00 (3.5)	1.07 (0.65)	1.73 (2.5)	2.21 (4.4)	1.22 (0.98)	1.84 (2.9)	2.72 (6.9)	1.57 (1.98)	2.76 (7.1)	3.91 (14.8)	92.40	87.32	84.80
Pretilachlor 30.7% EC (CP)	600	1.52 (1.8)	1.90 (3.1)	2.83 (7.5)	1.61 (2.1)	2.30 (4.8)	3.18 (9.6)	1.82 (2.8)	2.83 (7.5)	3.52 (11.9)	2.68 (6.7)	3.99 (15.4)	5.43 (29)	74.28	72.50	70.23
Oxyflourfen 23.5% EC	240	1.07 (0.65)	1.90 (3.1)	2.90 (7.9)	1.30 (1.2)	2.41 (5.3)	3.48 (11.6)	1.82 (2.8)	2.90 (7.9)	3.78 (13.8)	2.27 (4.65)	4.10 (16.3)	5.81 (33.3)	70.29	67.99	65.81
Hand weeding (20 & 40 DAS)	-	0.84 (0.2)	0.87 (0.25)	1.64 (2.2)	0.91 (0.32)	1.07 (0.65)	2.14 (4.1)	0.98 (0.47)	1.34 (1.3)	2.70 (6.8)	1.22 (0.99)	1.64 (2.2)	3.69 (13.1)	91.47	89.86	86.55
Unweeded control	-	2.73 (6.95)	3.96 (15.2)	5.22 (26.8)	3.07 (8.9)	4.40 (18.9)	5.56 (30.4)	3.27 (10.2)	4.73 (21.9)	6.38 (40.2)	5.15 (26.05)	7.52 (56)	9.89 (97.4)	-	-	-
S. Em±		0.04	0.05	0.03	0.04	0.03	0.04	0.07	0.04	0.03	0.03	0.04	0.05	-	-	-
LSD (0.05)		0.12	0.15	0.10	0.13	0.10	0.13	0.21	0.13	0.10	0.10	0.13	0.16	-	-	-

* Values in parentheses are original, and transformed to log $(\sqrt{X+0.5})$ for analysis, EC- Emulsifiable concentrate, TP- Test product, SC- Standard check, a.i.= Active ingredient, L= Litre, DAS- Days after seeding

Table 3: Efficacy of Pretilachlor 30.7 % EC against weeds in direct seeded rice crop with reference to plant and yield attributes and phytotoxicity observation (pooled data of two years)

Treatments	Dose (g a.i. ha^{-1})	Plant height (cm)	Effective tillers (m^2)	Panicle length (cm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Phytotoxicity observation			
							7 DAHA	14 DAHA	21 DAHA	28 DAHA
Pretilachlor 30.7% EC (TP)	300	62.05	198.00	27.05	4.05	5.62	0	0	0	0
Pretilachlor 30.7% EC (TP)	450	66.40	218.33	28.04	4.42	6.01	0	0	0	0
Pretilachlor 30.7% EC (TP)	600	71.25	229.67	28.11	4.63	6.11	0	0	0	0
Pretilachlor 30.7% EC (TP)	1200	72.00	236.67	28.10	4.61	6.12	0	0	0	0
Pretilachlor 30.7% EC (CP)	600	63.10	210.00	28.05	4.10	5.79	0	0	0	0
Oxyflourfen 23.5% EC	240	72.50	212.67	28.14	4.28	5.83	0	0	0	0
Hand weeding (20 & 40 DAS)	-	82.31	255.33	28.26	4.74	6.20	-	-	-	-
Unweeded control	-	55.12	168.00	27.90	3.49	4.25	-	-	-	-
S. Em. (±)		4.10	15.15	4.02	0.17	0.18	-	-	-	-
LSD (0.05)		11.90	NS	NS	1.57	1.83	-	-	-	-

EC- Emulsifiable concentrate, TP- Test product, SC- Standard check, a.i.= Active ingredient, L= Litre, DAHA- Days after herbicide application

Conclusion

On the basis of this study, it was revealed that so far as population of weeds, weed dry weight, weed control efficiency, yield parameters and paddy yield concerned, the treatment Pretilachlor 30.7 % EC 1200 g a.i. ha^{-1} came out as the best one being statistically at par with rest of the treatment but Pretilachlor 30.7 % EC 600 g a.i. ha^{-1} was found cost effective among all the treatments So it can be recommended for sufficient management of weeds as well as significant increase in grain yield. There was no phytotoxicity effect and significant changes, physico-chemical properties of soil observed in any of the doses of the testing herbicide in direct seeded rice crop.

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