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Evaluation of bioefficacy and residues of pretilachlor in transplanted rice

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ABSTRACT

Field and laboratory experiments were conducted to study the bioefficacy and residues of pre emergence herbicide pretilachlor in transplanted rice with eight treatments involving two doses of pretilachlor *viz*., 0.75 and 1.5 kg/ha, and with green leaf manure and gypsum as well as the farmer's practice of two hand weeding and unweeded control. The results had indicated that the application of pretilachlor at 1.5 kg/ha *fb* HW registered higher weed control efficiency and numerically lower weed dry matter at all the stages. Removal of nutrients by weeds was also significantly differed with different treatments. The analysis of terminal residues of pretilachlor in rice grain, straw and post harvest soil indicated that the residues were below detectable limit.

Key words: Pretilachlor, Bioefficacy, Residues, Transplanted rice, Nutrient removal

Despite the significant achievement in food grain production since independence, Indian agriculture continues to face challenges from ever increasing population. India would need about 300 million tons of food grains by 2020. The cultivation of dwarf high yielding crop varieties responsive to fertilizers and irrigation and the intensive cropping system has aggravated the problem of weeds. Weeds have been persistent problems in rice since the beginning of the settled agriculture. For Asia as a whole, weeds cause an estimated 10-15 per cent reduction in rice yield equivalent to about 50 million tons of rice annually (Pingali and Roger 1995). Besides reduction in yield, weeds remove a large amount of plant nutrients from the soil. An estimate shows that weeds can deprive the crops by 47 per cent N, 42 per cent P, 50 per cent K, 39 per cent Ca and 24 per cent Mg of their nutrient uptake as well as reduce the yield potential by harbouring number of crop pests (Balasubramaniyan and Palaniappan 2001). Hence successful weed control is essential for obtaining optimum yield of rice (Hussain *et al*. 2008, Kumar *et al.* 2007, Sathyamoorthy *et al*. 2004). The mechanical and cultural methods are not possible to be adopted on account of scarcity of labour in the peak period of transplanting. In these situation herbicides plays a major role in increasing rice production by decreasing weed intensity. The use of proper herbicide at the correct dose, at the appropriate time and in appropriate manner is essential for avoiding any possible build up of toxic residues in soil. The soil is an area of our environment which may be seriously affected by the application of herbicides. Pretilachlor (2-chloro 2-6-diethyl N (2-propoxyethyl) acetanilide) is recommended as selective herbicide for weed control in rice crop (Wendy *et al*. 2007). In view of the current availability of the herbicide in the Indian market and their effectiveness against grasses, sedges and broad leaf weeds, pre emergence herbicide, pretilachlor was taken to study the bioefficacy, NPK removal by weeds and their residues under transplanted rice ecosystem.

MATERIALS AND METHODS

A field experiment was conducted with transplanted rice (variety *ADT 43*) in the farm soils of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal in the Union Territory of Puducherry. The soil is sandy clay loam in texture belonging to the Sorakudy soil series, taxonomically *Fluventic Haplustept*. It was seen from the initial soil analysis that the soil of the experimental site was alkaline in pH (8.60) with an EC of 0.56 dS/m. The cation exchange capacity (CEC) was 26.4 cmol (p^+)/kg with Ca as the dominating cation followed by Mg, Na and K. The organic carbon content was 0.53 per cent. The $KMnO_4$-N, Olsen-P and NH_4OAC-K status indicated that the soil possesses relatively low N, high P and K.

The treatments were replicated in randomized block design. The crop was transplanted at spacing of 20 x10 cm with a fertilizer dose of 120 kg N, 38 kg P_2O_5 and 38 kg K_2O per hectare. The entire quantity of P_2O_5 and K_2O and 1/3 N was applied at planting as basal and the remaining N was applied in equal splits at maximum tillering and panicle initiation stage. The eight treatments are pretilachlor at 0.75 kg/ha , pretilachlor at 1.5 kg/ha , green leaf manure *fb* pretilachlor at 0.75 kg/ha, green leaf manure *fb* pretilachlor at 1.5 kg/ha, gypsum *fb* pretilachlor at 0.75 kg/ha, gypsum *fb* pretilachlor at 1.55 kg/ha, two hand weeding (HW) and unweeded control as a check. Green leaf manure (*Pillipesera* sp) was incorporated into the respective plots 3 days before transplanting at the rate of 6.25 t/ha. Gypsum was applied before the last ploughing at the rate of 500 kg/ha as per the crop production guide of Tamil Nadu. Green leaf manure and gypsum were used in the treatments to know the nutrient uptake and dissipation pattern of pretilachlor with the above amendments. Pre emergence herbicide pretilachlor with the application rate of 0.75 kg/ha and 1.5 kg/ha was diluted in 500 liter of water and sprayed with knapsack sprayer at 3 days after transplanting (DAT) keeping thin film of water in the field. The field was neither drained nor irrigated for 3 days after application of herbicides. One hand weeding was given for all the herbicide treated plots at 45 DAT. The hand weeding treatment (T2) received two hand weeding at 20 and 45 DAT. The unweeded control was kept undisturbed for the entire cropping period. Four quadrats were placed at random outside the net plot in each plot at active tillering, panicle initiation and at harvest stages of the crop and the weeds falling within the quadrat were removed, shade dried and then oven dried at 70°C for 72 hours. The dry weight of total weeds was expressed in kg/ha. Weed control efficiency (WCE) was calculated by using the formula suggested by Mani *et al.* (1973) and expressed in per cent.

$$WCE = \frac{WPC - WPT}{WPC} \times 100$$

The weed samples collected at three stages *viz*., active tillering, panicle initiation and harvest stages were shade dried and then oven dried and powdered in a Wiley mill. The processed weed samples were analysed for total N, P and K content using standard procedures (Bremner 1965 and Jackson 1973).

The rice grain (50 g), straw (25 g) and soil (50 g) samples were also collected at harvest and analyzed for terminal residues. The samples were extracted by dichloromethane and a silica gel column was prepared and after washing it with dichloromethane, the dried sample was loaded onto the column. The sample was eluted with (90:10) dichloromethane and acetone mixture and evaporated. The residue was finally made upto 5 ml in the mobile phase. The reference standard of pretilachlor of 95 per cent purity obtained from Syngenta India Ltd. was used for quantification, recovery and determination of the retention time of herbicide. The soil, grain and straw samples were fortified with 0.1 and 0.2 µg/g levels for assessing the percentage recovery. 10 ATVP Shimadzu model high performance liquid chromatography equipped with UV detector, Rheodyne injector, 100 A pump and (150C4.5 mm) packed with 5 micro metre silica bonded with C18 column used for determination of residues. The following parameters were maintained for analysis. Mobile phase: 80:20 (acetonitrile: water), flow rate: 1.0 ml/min, wavelength: 210 nm, AUFS 0.01 and attenuation 10 mV.

RESULTS AND DISCUSSION

Weed dry weight and weed control efficiency

The major weeds observed in the experimental plots were *Cyperus rotundus, Cyperus difformis, Cyperus iria, Sphenoclea zeylanica, Echinochloa colonum* and *Echinochloa crusgalli*. The results of weed control efficiency and weed dry matter production are presented (Table 1). Application of pretilachlor at 1.5 kg/ha *fb* HW recorded lower weed dry weight, which was on par with pretilachlor at 0.75 kg/ha *fb* HW and gypsum *fb* pretilachlor at 1.5 kg/ha *fb* HW at active tillering stage (30 DAT). The highest dry matter was recorded in unweeded control (6.89 g/m^2). Lower dry weight of 10.30 g/m^2 was recorded in pretilachlor at 1.5 kg/ha *fb* HW at panicle initiation stage (60 DAT). The highest weed dry weight (36.87 g/m^2) was recorded when weeds were left uncontrolled. The weed dry weight ranged from 4.85 to 62.12 g/m^2 at harvest stage (90 DAT). The weed dry weight was lower in pretilachlor at 1.5 kg/ha *fb* HW and was comparable with all other weed control treatments including two hand weeding. The highest weed dry weight of 62.12 g/m^2 was recorded in unweeded control. There was a marked difference in weed control efficiency among the different treatments. At all the stages, pretilachlor at 1.5 kg/ha *fb* HW recorded higher weed control efficiency than the other treatments.

The weed control efficiency of pretilachlor at 1.5 kg/ha was 70 per cent compared to unweeded control at early stages of plant growth. The higher weed control efficiency of this treatment can be attributed to the effective, long term, broad-spectrum action of the herbicide against the grasses, sedges and broad leaved weeds. Similar findings were reported by Narayanan *et al*. (2000), Suganthi *et al*. (2005) and Kumar *et al*. (2008). Lower weed control efficiency was recorded in green leaf manure applied plots, which could due to the faster degradation of pretilachlor in soil. Irrespective of the weed control methods, the weed control efficiency increased after panicle initiation and is ascribed to the hand weeding at 45 DAT, which might have checked the weed growth, even though there was degradation of herbicides.

Table 1. Effect of treatments on weed dry matter production and weed control efficiency

Treatments	Active tillering (30 DAT)		Panicle initiation (60 DAT)		Harvest stage (90 DAT)	
	WDM (g/m^2)	WCE (%)	WDM (g/m^2)	WCE (%)	WDM (g/m^2)	WCE (%)
T_1	6.89	-	36.87	-	62.12	-
T_2	6.30	-	15.46	58.07	6.21	90.00
T_3	2.20	67.91	13.84	62.46	5.46	91.21
T_4	2.09	69.61	10.30	72.06	4.86	92.18
T_5	3.47	49.56	13.89	62.32	6.92	88.86
T_6	2.93	57.34	10.59	71.28	6.66	89.28
T_7	2.86	58.43	12.06	67.28	5.39	91.33
T_8	2.68	61.08	10.94	70.33	4.98	91.99
LSD (P= 0.05)	0.61	-	1.80	-	2.56	-

WDM- Weed dry matter production, WCE – Weed Control Efficiency, DAT - Days after transplanting
T_1- Unweeded control, T_2- Two hand weeding, T_3- Pretilachlor 0.75 kg/ha *fb* hand weeding, T_4- Pretilachlor 1.5 kg/ha fb hand weeding, T_5 - Green leaf manure *fb* T_3, T_6 - Green leaf manure *fb* T_4, T_7 - Gypsum *fb* T_3, T_8 - Gypsum *fb* T_4.

Nutrient removal by weeds

More quantum of nutrients were taken up by weeds resulting in the reduction of availability of nutrients to the crop, which adversely affect the crop growth by creating greater competition and finally the reduction in yield of rice and this was evidenced from the poor yield obtained in unweeded control. The results of nutrient removal by weeds are presented in (Table 2).

Nitrogen removal by weeds varied from 0.283 to 0.900 kg/ha at active tillering stage. At panicle initiation stage, the N removal by weeds ranged from 0.973 to 3.800 kg/ha. Pretilachlor at 1.5 kg/ha *fb* HW recorded lower N removal and the unweeded control removed the highest N (3.800 kg/ha) which was significantly higher over all the other treatments. At harvest stage, gypsum *fb* pretilachlor at 1.5 kg/ha *fb* HW recorded lower N removal, which was comparable with all the other weed control treatments. Significantly, higher N removal (5.55 kg/ha) was recorded in unweeded control, which was 13.4 times higher than that recorded in gypsum *fb* pretilachlor at 1.5 kg/ha *fb* HW.

Phosphorus removal was the highest (1.087 kg/ha) in control plot which was 3.6 times higher than that recorded in pretilachlor at 1.5 kg/ha *fb* HW that resulted in the lowest P removal by weeds (0.303 kg/ha) at panicle initiation stage. However, the P depletion by weeds with pretilachlor at 1.5 kg/ha *fb* HW was on par with all other

Table 2. Effect of treatments on nutrient removal by weeds (kg/ha)

Treatments	Active tillering (30 DAT)			Panicle initiation (60 DAT)			Harvest stage (90 DAT)		
	N	P	K	N	P	K	N	P	K
T_1	0.900	0.270	0.923	3.800	1.087	4.570	5.553	1.697	8.783
T_2	0.817	0.267	0.827	1.513	0.453	1.943	0.527	0.167	0.830
T_3	0.287	0.100	0.310	1.237	0.373	1.710	0.507	0.147	0.643
T_4	0.283	0.087	0.283	0.973	0.303	1.250	0.440	0.123	0.573
T_5	0.477	0.140	0.483	1.423	0.397	1.723	0.657	0.173	0.977
T_6	0.383	0.137	0.400	1.090	0.360	1.313	0.587	0.147	0.850
T_7	0.397	0.133	0.403	1.217	0.373	1.480	0.490	0.140	0.640
T_8	0.367	0.113	0.360	1.120	0.310	1.337	0.413	0.120	0.543
LSD (P= 0.05)	0.087	0.031	0.099	0.294	0.106	0.185	0.281	0.108	0.649

Treatment details as given in Table-1

weed management practices except two hand weeding. At harvest stage 1.697 kg/ha of phosphorus removed from the field when weeds were not controlled and the P removal was 14.1 times higher than that depleted in gypsum *fb* pretilachlor at 1.5 kg/ha*fb* HW.

Potassium removal by weeds at active tillering ranged from 0.283 to 0.923 kg/ha. Pretilachlor at 1.5 kg/ha *fb* HW registered lower K removal. The K removal by weeds was found to be the highest (4.570 kg/ha) with unweeded control at panicle initiation stage. Pretilachlor at 1.5 kg/ha *fb* HW recorded the lowest K removal by weeds, which resulted in 3.7 times lower K depletion by weeds than that recorded in unweeded control. At harvest stage, the K removal ranged from 0.543 to 8.783 kg/ha. Unweeded control registered the highest K removal, which was significantly superior to other treatments. The K depletion was 16.2 times higher in unweeded control than that recorded with application of gypsum *fb* pretilachlor at 1.5 kg/ha *fb* HW.

When weed growth was not controlled, it depleted as high as 5.55, 1.70, 8.78 kg/ha of N, P, K, respectively at harvest stage. The weed control treatments significantly recorded lower N, P and K removal than unweeded control at harvest stage. This was attributed to the lesser weed dry matter production and aiding in the reduced quantum of weed N, P and K removal. These findings are in line with Prakash *et al*. (1995). It is also noticed that the N, P and K removal by weeds in green leaf manure fb pretilachlor treated plots is numerically higher than the other pretilachlor treatments, which may be due to the reduced weed control efficiency in green leaf manure applied plots and mineralisation of nutrients from the applied green leaf manure which resulted in higher dry matter production and higher nutrient removal. Lower nutrient removal at harvest stage in herbicide treated plot compared to panicle initiation stage is due to hand weeding operation at 45 DAT, which resulted in decreased weed population and weed dry matter production at harvest stage.

Residues of pretilachlor

An ideal herbicide should persist in the soil up to the critical period of weed competition and then should degrade fast to innocuous products without any environment hazards. The retention time of pretilachlor under the present experimental conditions was found to be 8.6 minutes (Fig. 1). The recovery of herbicide for soil, straw and grain was 86.9, 87.7 and 88.8%, respectively. The results of the experiment indicated that pretilachlor residues was below detectable level in grain, straw and post harvest soil irrespective of treatments and doses (Table 3). These findings are close conformity with

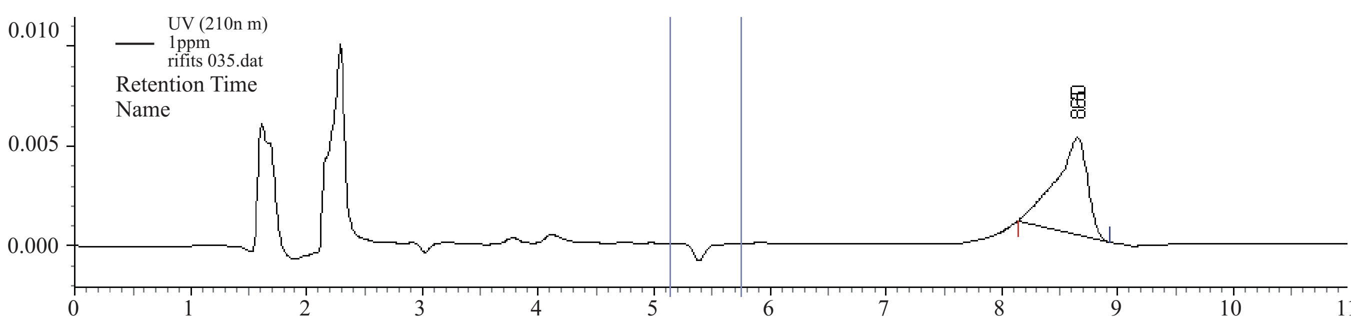

Fig. 1. Chromatograph of pretilachlor 1 µg/g

Table 3. Terminal residues of pretilachlor in rice plant produces and post harvest soil

Treatments	Grain	Straw	Post harvest soil
T_3 - Pretilachlor 0.75 kg/ha *fb* hand weeding	BDL	BDL	BDL
T_4 - Pretilachlor 1.5 kg/ha *fb* hand weeding	BDL	BDL	BDL
T_5 - Green leaf manure *fb* T3	BDL	BDL	BDL
T_6 - Green leaf manure *fb* T4	BDL	BDL	BDL
T_7 - Gypsum *fb* T3	BDL	BDL	BDL
T_8 - Gypsum *fb* T4	BDL	BDL	BDL

BDL: Below detectable limit (0.005 µg/gfor soil and grain, 0.0025 µg/gfor straw)
MRL: Maximum residue limit (Straw -10 µg/g; Grain - 0.1 µg/g)

Asokaraja and Mohamed Ali (1995) and Deepa (2002) who reported a faster rate of pretilachlor dissipation under tropical conditions.

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