Indian Journal of Weed Science 43 (3&4) : 199-202, 2011

Persistence and dissipation of pretilachlor in soil, plant and water of coastal rice ecosystem

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ABSTRACT

Field and laboratory experiments were conducted to study the persistence and dissipation of pretilachlor in soil, straw and flood water. In soil, pretilachlor at 0.75 kg/ha dissipated to below detectable level (BDL) within 30 days after application (DAA) when applied along with green leaf manure, while in other treatments *viz*., pretilachlor at 0.75, 1.5 kg/ha alone and gypsum + pretilachlor at 1.5 kg/ha persisted up to 45 DAA (DAA). In the case of plant, pretilachlor at 0.75 kg/ha dissipated to below detectable limit at 30 DAA, while 1.5 kg/ha persisted up to 60 DAA. Irrespective of the treatments, pretilachlor dissipated to below detectable limit at 10 DAA in flood water. The half-life of pretilachlor varied from 3.9-10.0, 3.4-8.5, 0.87-1.52 days for soil, rice plant and flood water, respectively.

Key words: Pretilachlor, Persistence, Dissipation, Residue

Weeds have been persistent problem in rice since the beginning of the settled agriculture. For Asia as a whole, weeds cause an estimated 10-15% reduction in rice yield equivalent to about 50 mt + 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 47% N, 42% P, 50% K, 39% Ca and 24% Mg of their nutrient uptake as well reduce the yield potential by harbouring number of crop pests (Balasubramanian and Palaniappan 2001). The mechanical and cultural methods are not always possible on account of scarcity of labour, in the peak period of transplanting. In these situation, herbicides play a major role in increasing rice production by decreasing weed intensity. With widespread application of herbicides in rice, questions have often posed about the movement and length of time these herbicides remain toxic in soil. The soil is an area of our environment which may be seriously affected by the application of herbicides (Wendy *et al.* 2007). The residual activity of herbicides depends upon the soil type, soil moisture and temperature. Organic matter and clay content affect the persistence of herbicides in soil colloids. Pretilachlor (2-chloro-2'6'diethyl-N-(2-propoxyethyl) acetanilide) is recommended as selective herbicide for weed control in rice crop. Pretilachlor dissipates readily in rice fields by photodecomposition, microbial degradation and volatilization at recommended rate and pretilachlor does not affect soil properties or pose a serious problem for environmental pollution (Adachi *et al*. 2007, Murata *et al*. 2004). Quantitative determination of herbicide residues helps in understanding the dissipation pattern of herbicides in the soil. Hence, an experiment was undertaken to study dissipation pattern of pretilachlor in soil, plant and water.

MATERIALS AND METHOD

A field experiment was conducted with transplanted rice (*var. 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 neutral in pH (7.60) 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 status.

The treatments were replicated in randomized block design. The crop was transplanted at spacing of 20 x 10 cm with a fertilizer dose of 120 kg N, 38 kg P and 38 kg K per hectare. The entire quantity of P and K 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 six treatments involving two doses of pretilachlor *viz.,* 0.75 and 1.5 kg/ha with hand weeding and with green leaf manure and gypsum as well as farmers

practice of two hand weeding (HW) and unweeded control as a check. Green leaf manure (*Pillipesera* sp) (GLM) 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 was used in the treatments to know the herbicide dissipation pattern of pretilachlor with the above amendments. Pre-emergence herbicide pretilachlor 0.75 kg/ha and 1.5 kg/ha was diluted in 500 litre 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 representative soil and plant and flood water samples were collected at 0 (1 hr), 1, 3, 5, 7, 10, 15, 30, 45 and 60 days after application of herbicide for analysis of residues. Like soil and plant samples, flood water samples also collected from the field (under flooded condition) in different intervals for residue analysis.

Soil, plant and water samples were extracted by dichloromethane. 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 up to 5 ml in the mobile phase. The reference standard of pretilachlor of 95 per cent purity 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 (1504.5 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 10mv.

RESULTS AND DISCUSSION

The retention time of pretilachlor under the present experimental conditions was found to be 8.6 minutes. The recovery of herbicide for soil, straw and water was 86.9, 87.7 and 91.5%, respectively (Table 1). The dissipation rate and persistence of herbicide mainly decide the bioefficacy and the period of weed control. 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 an environment hazards.

The results of dissipation studies of pretilachlor showed that pretilachlor at 0.75 and at 1.5 kg/ha dissipated to below detectable level at 60 days after application of herbicide. The treatment GLM + pretilachlor at 0.75 kg/ha dissipated below BDL at 30 DAA and GLM + pretilachlor at 1.5 kg/ha dissipated below BDL 45 DAA (Table 2). This lower persistence may be due to higher microbial population involved in the decomposition of green leaf manure, which might have favored the dissipation of pretilachlor. Similar inferences are made by other researchers who had reported lower persistence of herbicide with high soil organic matter (Rai *et al.* 1999, Fajardo *et al*. 2000). The estimated half-life of pretilachlor ranged from 3.92 to 10.02 days. Almost a similar trend of findings was observed by Fajardo *et al*. (2000) who had reported that the dissipation of pretilachlor was quite rapid during first three weeks but slowed down there after with the half life between 7 and 10 days.

Table 1. Recovery studies of pretilachlor

Substrate	Concentration fortified (µg/g or µg/ml)	Concentration recovered (µg/g or µg/ml)	Recovery (%)
	1	0.9176	91.76
Soil	2	1.6400	82.00
	mean	-	86.88
	1	0.9050	90.50
Water	2	1.8520	92.6
	mean	-	91.50
	1	0.9479	94.79
Plant	2	1.6200	80.50
	mean	-	87.64

Table 2. Degradation and persistence of pretilachlor (µg/g) in soil

Treatments	Residues (µg/g)										
	0 (1 hr)	1	3	5	7	10	15	30	45	60	At harvest
T_1	0.3654	0.2370	0.1695	0.1230	0.1030	0.0645	0.0516	0.0094	0.0061	BDL	BDL
T_2	0.8890	0.4920	0.2400	0.2260	0.1990	0.1470	0.1098	0.0780	0.0176	BDL	BDL
T_3	0.3020	0.1710	0.145	0.1290	0.0605	0.0380	0.0196	BDL	BDL	BDL	BDL
T_4	0.7560	0.4630	0.2860	0.1830	0.1300	0.1130	0.0522	0.0106	BDL	BDL	BDL
T_5	0.3730	0.2040	0.1578	0.1260	0.0752	0.0628	0.0240	0.0090	BDL	BDL	BDL
T_6	0.7910	0.5370	0.2640	0.2250	0.1422	0.0847	0.0201	0.0088	0.0052	BDL	BDL

BDL - Below Detectable Level (0.005 µg/g)

T_1- Pretilachlor 0.75 kg/ha+ hand weeding, T_2- Pretilachlor 1.5 kg/ha+ hand weeding,

T_3 - Green leaf manure + T_1, T_4 - Green leaf manure + T_2, T_5 - Gypsum + T_1, T_6 - Gypsum + T_2.

Table 3. Degradation and persistence of pretilachlor (µg/g) in rice plant

Treatments	Residues (µg/g)										
	0 (1 hr)	1	3	5	7	10	15	30	45	60	At harvest
T_1	1.2200	0.7600	0.5650	0.4740	0.2700	0.0760	0.0650	BDL	BDL	BDL	BDL
T_2	1.5780	1.5600	1.1137	0.9100	0.5650	0.5510	0.4730	0.0530	0.0170	0.0034	BDL
T_3	1.0150	0.7800	0.4517	0.3950	0.1794	0.1335	0.0820	0.0430	0.0049	BDL	BDL
T_4	1.5300	1.0720	0.9520	0.5540	0.4180	0.4090	0.2170	0.0320	0.0069	BDL	BDL
T_5	1.0010	0.5550	0.5710	0.2860	0.2780	0.1134	0.1130	0.0374	BDL	BDL	BDL
T_6	1.3750	1.4900	0.8800	0.7819	0.6080	0.3670	0.2740	0.0550	BDL	BDL	BDL

BDL - Below Detectable Level (0.005 µg/g)

T_1- Pretilachlor 0.75 kg/ha+ hand weeding, T_2- Pretilachlor 1.5 kg/ha+ hand weeding,

T_3 - Green leaf manure + T_1, T_4 - Green leaf manure + T_2, T_5 - Gypsum + T_1, T_6 - Gypsum + T_2.

The results on dissipation and persistence of pretilachlor in rice plant indicated that there was a maximum concentration of pretilachlor observed at 0 DAA (1 hour after application of herbicide). Pretilachlor at 0.75 kg/ha was degraded to BDL at 30 DAA, whereas pretilachlor at 1.5 kg/ha was degraded to BDL at 60 DAA. The treatment GLM + pretilachlor at 0.75 and 1.5 kg/ha were degraded to BDL at 60 DAA, whereas gypsum + pretilachlor at 0.75 and 1.5 kg/ha degraded to BDL at 30 DAA (Table 3). The maximum accumulation of pretilachlor was 1.57 µg/g with application of pretilachlor at 1.5 kg/ha. But Scarponi *et al*. (2005) who reported maximum accumulation of pretilachlor was 7.2 µg/g. The disappearance of pretilachlor is due to their conjugation with reduced glutathione through the action of glutathioneS-transferase enzyme (GST) which transforms the parent molecule in to a non-toxic derivative (Scarponi *et al*. 2005). The half-life of pretilachlor ranged from 3.4 to 8.5 days. These finding are in line with inference made by Scarponi *et al*. (2003) who had reported half life of pretilachlor was 6 days.

Table 4. Degradation and persistence of pretilachlor (µg/ml) in flood water

Treatments	Residues (µg/ml)									
	0 (1 hr)	1	3	5	7	10	15	30	45	60
T_1	0.3620	0.3580	0.1660	0.0730	0.0148	BDL	BDL	BDL	BDL	BDL
T_2	1.0080	0.6255	0.2430	0.0239	0.0090	BDL	BDL	BDL	BDL	BDL
T_3	0.5950	0.2670	0.0771	0.0288	0.0096	BDL	BDL	BDL	BDL	BDL
T_4	0.9090	0.4060	0.3447	0.0299	0.0139	BDL	BDL	BDL	BDL	BDL
T_5	0.5640	0.2650	0.0897	0.0350	0.0101	BDL	BDL	BDL	BDL	BDL
T_6	1.0260	0.6060	0.3199	0.0276	0.0046	BDL	BDL	BDL	BDL	BDL

BDL - Below Detectable Level (0.005 µg/g)

T_1- Pretilachlor 0.75 kg/ha+ hand weeding, T_2- Pretilachlor 1.5 kg/ha+ hand weeding,

T_3 - Green leaf manure + T_1, T_4 - Green leaf manure + T_2, T_5 - Gypsum + T_1, T_6 - Gypsum + T_2.

Maximum levels of pretilachlor in flood water was detected in all the treatments at 1 hour after the application and thereafter pretilachlor in all the treatments degraded to minimum detectable limit within 7 days after application. The residues of pretilachlor were at BDL at 10 DAA (Table 4). It is evident from the results that the pretilachlor in floodwater irrespective of the concentrations or treatments were degraded to BDL at 10 DAA. The half life of pretilachlor in flood water ranged from 0.97 to 1.69 days. These findings are in line with previous works that pretilachlor in surface water degraded quickly with half life of 2 days (Moon and Kim 2000). Almost the similar findings are also opined by Fajardo *et al*. (2000). He concluded that the half life of pretilachlor in flood water ranged from 3.0 to 3.6 days. The computed modified regression coefficients revealed that in all the treatments the degradation of pretilachlor followed first order kinetics in flood water. The above findings were in close conformity with the findings of several other workers (Rai *et al.* 1999*,* Fajardo *et al*. 2000, Sultana *et al*. 2005)

Herbicides are applied to the soil in hopes of obtaining season-long weed control. It is desirable for the chemicals to control weeds during the season of application, but they should not remain long enough to affect subsequent crop growth. In the present study concluded that pretilachlor at lower dose in soil dissipated below detectable level (BDL) within 30 days after application when applied along with green leaf manure, whereas it persisted up to 45 days in soil in other treatments. The residues are detected in plant up to 30 days after application at lower dose and 60 days after application in case of higher dose. Irrespective of the treatments, residues are persisted only up to 7 days in flood water.

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