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Runoff of Trifluralin from Fields in Louisiana

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Trifluralin (2,6-dinitro-N, N-dipropy1-4- (trifluormethyl) benzenamine) was applied preemergent to soybean in plots drained or nondrained, in Louisiana. Plots 14.6 ha were arranged to give 1683 g/ha of trifluralin. The half life of trifluralin in the top 15 cm of soil was 42.6 days and 46.0 days in nondrained plot and drained plot, respectively. The concentrations of trifluralin in surface runoff water and subsurface runoff water were 0.62 ng/mL−0.02 ng/mL and 0.06 ng/mL−0.02 ng/mL, respectively. The concentration of trifluralin in runoff water was smaller than 2 ng/mL for trifluralin of U.S. Environmental Protection Agency advisory. Total loss of trifluralin in runoff water was 0.021 % of applied amount at drained plots during three month after application. Trifluralin was moved hardly in the water. Subsurface drainage reduced trifluralin losses because concentration of trifluralin in the subsurface runoff water in drained fields was low.
Key words : Trifluralin, Run off, Persistence, Subsurface drainage, Field, Louisiana.

1. INTRODUCTION

Trifluralin (2,6-dinitro-N, N-dipropy1-4- (trifluormethyl) benzenamine) was the selective herbicide for the preemergence control of annual grasses and broadleaf weeds in soybean, corn, cotton, and peanut production in Louisiana (Humbrug, 1989). Water solubility of trifluralin was 0.3 ug/mL (Humbrug, 1989). The Koc value for trifluralin was 875 (Kim et al., 1992).

When pesticides were applied to soil, physical loss of runoff, leaching and volatilization, and degradation through photochemical, microbiological and chemical processes were probably the major impact on the behavior of a pesticides (Savage, 1973). Pesticides on the soil surface were lost with surface runoff water and also subjected to downward movement into the soil profile by leaching with water.

The extent of losses with runoff water and downward leaching of pesticide in soil was generally dependent on the soil and pesticide properties, soil management, timing of leaching event and the amount of leached water (Starr and Glotfelty, 19 90).

In intensively farmed areas, such as the warm and humid climate area in the Lower Mississippi Valley, large quantities of fertilizers and pesticides were used in crop production. Baton Rouge, Louisiana, was an excellent site to conduct a groundwater pollution experiment. Results from the warm, humid climate and clay soils with high watertables could be put into practice readily throughout the Lower Mississippi Valley and perhaps extended into other areas of the Southeastern United States. Annual precipitation usually exceeds 1500 mm and may occasionally exceed 2000 mm. Subsurface drainage was used in many areas of the U.S. to increase crop yields by lowering the water table.

Subsurface drainage may also influence surface runoff, total drainage, soil loss and nutrient and pesticides loss from cropland. Information for the effects of subsurface drainage was needed on the environment in the Lower Mississippi Valley (Bengtson et al., 1988). These successes in controlling nonpoint source pollution of the environment of agricultural activities have reinforced efforts to develop these alternative production system.

Because toxicological risk was a function of exposure, reduced runoff and leaching of pesticides

would result lower concentrations in water supplies, and thereby minimized the risk of the adverse health and environmental effect (Felost et al., 19 90). The U.S Environmental Protection Agency advisory level of trifluralin for drinking water was 2. 00 ng/mL (Goodrich et al. 1991). Transport by runoff and leaching might cause contamination of surface waters and groundwater (Hall et al., 1989). Evaluation of pesticide losses by the runoff process had received considerable attention (Wauchope, 19 78).

The objective of this study was to identify persistence and runoff properties of trifluralin in the fields, to evaluate water quality of runoff with U.S EPA advisory level and to predict the effects of subsurface drainage on trifluralin losses on drained and nondrained plot.

2. MATERIALS AND METHODS

2.1. Experimental Site and Design

This study was conducted at the Louisiana Agricultural Experiment Station's Ben Hur Farms about 6 km south of Baton Rouge, Louisiana. The research farm was located on the Mississippi River alluvial flood plain with a 0.1% slope (Fig. 1). The soil was classified as a Commerce clay loam (fine silty, mixed, nonacid, thermic aeric fluvaguent) (Camp, 1976). This soil contained a saturated hydraulic conductivity of approximately 1 mm/h in the layer just below the plow depth to a depth of 0.6 m. Between 0.6 and 1.3 m depth, there was a layer of approximately 0.3 m thickness that had a saturated hydraulic conductivity of up to 80 mm/h (Rogers et al., 1985).

Plots A (3.72 ha), B (3.56 ha) and C (3.76 ha) were surface drain and had subsurface drain tubing installed one meter below the soil surface. Plots H (3.56 ha) had only surface drainage (Fig.1). Earth dikes at least 0.3 m high were constructed around each field to define its boundary and to insure that all surface runoff was measured with H-flumes. Subsurface drain outflow was collected in sumps (Fig.1).

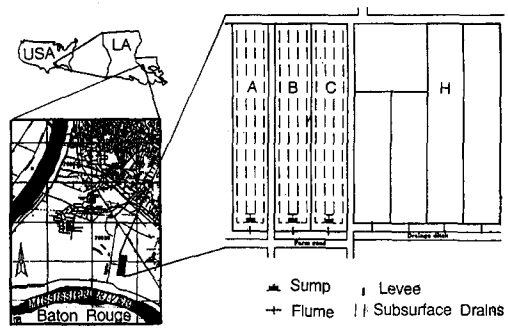

Fig. 1 Instrumentation on plot layout located at the Louisiana Agricultural Experiment Station's Ben Hur Research farm in Louisiana, USA.

2.2. Trifluralin Application

A 48.04% emulsifiable concentrate (Elanco products company) of trifluralin was applied to give 1683 g/ha at plot A, B and C on June, 4 and at plot H on June, 30 in 1991. The soybean was planted on the fields on July and was harvested on Oct. in 1991.

2.3. Sample Collection

Soil Samples were collected with 8.3 cm diameter soil auger. Soil auger was pushed vertically into the ground to obtain depth to 0~15 cm. Each sample was air dried for one week and grounded to pass a 2 mm sieve and stored at about −10℃ until analyzed.

An automatic water sampler was installed at each H-flume and sump. Surface water samples at the H-flumes were taken a 500 mL sample at a 20 minute time intervals during surface runoff events. Subsurface water samples at the sumps were taken a 250 mL sample at 3 hours time intervals during subsurface discharge. All water samples were transported immediately after collection to USDA laboratory at Batch Rouge, LA, where they were stored frozen until analyzed.

2.4. Analysis

The extraction of trifluralin in the water, which was watersediment mixture, was accomplished by mixing 250 mL water sample with 100 mL hexane on a magnetic stirrer for 2 hr. Trifluralin in the 30

g soil sample was extracted with 200 mL n-hexane : acetone (41 : 59, v/v) by soxhlet for 3 hr (Bengtson et al., 1990). The extract was partitioned into separatory funnel, washed three times with 200 mL volumes of distilled water to remove the acetone and dried over anhydrous Na_2SO_4.

Trifluralin concentration in the extracts was analyzed using a Tracor 540 GC equipped with ^{63}Ni electron capture detectors. A Megabore column (15 m long×0.53 mm i.d.) of DB210 was used. The column oven temperatures were 160℃ for trifluralin. Detector and inlet temperatures were 250℃ and 240℃, respectively. Flow rates of He (99.995% minimum purity) carrier gas and N_2 (99.995% minimum purity) make-up gas were 10 mL/min and 40 mL/min, respectively.

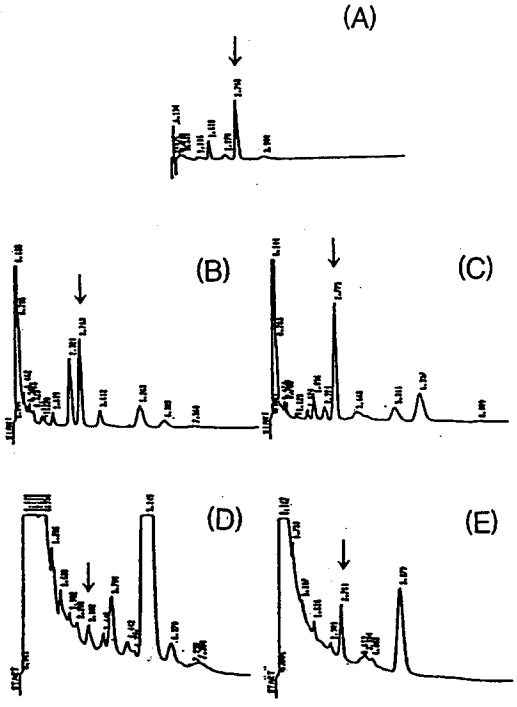

Fig. 2. Gas chromatogram of trifluralin by GC-ECD. A) 0.04 ng of standard trifluralin with 2.76 min retention time, B) trifluralin fortified 10 ng/mL in water, C) trifluralin fortified 100 ng/mL in soil, D) runoff water at drained plot on 87 days after application, and E) soil at nondrained plot on 10 days after application.

Table 1. Extraction efficiencies of trifluralin in the water and soils

Water (10 ng/mL)	Soil[1)] (100 ng/g)
82.6 ± 4.7%	72.5 ± 8.8%

1) n=9

3. RESULTS AND DISCUSSION

3.1. Analysis of Triflulin

Retention times of trifluralin was 2.76 min. The quantitative detection limites for trifluralin were 0.008 ng/mL in water and was 0.069 ng/g in soils (Fig.2-A). Chromatogram of trifluralin fortified 10 ng/mL in water and fortified 100 ng/mL in soil were shown in Fig.2-B and Fig-C, respectively. Extraction efficiencies of trifluralin was 82.6 ± 4.7% in fortified water and was 72.5.8% in fortified soil, respectively (Table 1). Fig.2-D and Fig.2-E shown the chromatogram of runoff water at drained plot on 87 days and soil at nondrained plot on 10 days after application, respectively.

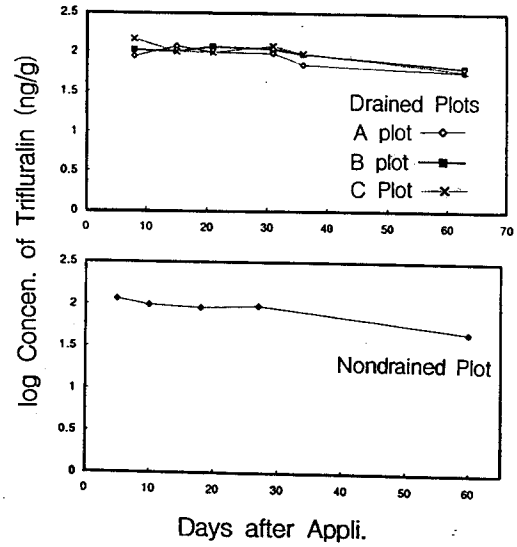

Fig. 3. Persistence of trifluralin in the soil within 0~15 cm depth at A plot, B plot and C plot in drained plots, and H plot in nondraind plot.

3.2. Persistence in Soil

Table 2. Half life of trifluralin caculated by linear regression of log concentration of trifluralin (ng/g) with time (day)

Drained plot				Nondrained
A	B	C	Mean ± SD	plot
41.7	56.5	39.9	46.0 ± 9.0	42.6

Table 3. Concentration of trifluralin in the surface runoff water at drained plot

Days after	Concen. (ng/mL)		
appli.	Plot A	Plot B	Plot C
2	NS	0.36	0.32
3	0.32	0.36	0.24
7	NS	NS	0.28
8	NS	NS	0.13
14	NS	0.50	0.30
30	0.62	0.72	0.62
32	0.34	0.05	0.32
33	0.04	0.04	0.04
35	NS	0.04	0.02
87	0.06	0.05	0.03
Mean ± SD	0.27 ± 0.23	0.26 ± 0.25	0.23 ± 0.18

1) Not Sampling

Table 4. Concentration of trifluralin in subsurface runoff water at drained plot

Days after	Concen. (ng/mL)		
appli.	Plot A	Plot B	Plot C
4	NS	0.02	NS
16	0.03	0.02	NS
28	0.03	0.03	0.03
39	0.03	0.02	0.02
51	0.04	0.06	0.04
102	0.03	0.06	0.04
Mean ± SD	0.03 ± 0.01	0.04 ± 0.01	0.03 ± 0.01

1) Not Sampling

The dissipation of trifluralin in the top 15 cm from the field soils was shown in Fig.3 and was summarized in Table 2 for half lives values. Based on the assumption that pesticides disappearance followed first-order kinetics, the half life for trifluralin was 46 ± 9 days on drained plot and was 42 days on nondrained plot. The rates of degradation of trifluralin were similar between on drained and nondrained plot. These half lives were slightly shorter than those reported by SCS (1989) which was 60 days for trifluralin.

3.3. Concentration in Runoff

Concentration of trifluralin in the surface runoff water and subsurface runoff water at drained plot was shown in Table 3 and Table 4, respectively. Concentration of trifluralin in the surface runoff water at nondrained plot was shown in Table 5. Concentration of trifluralin in drained plot B until

Table 5. Concentration of trifluralin in surface runoff water at nondrained plot

Days after appli.	Concen. (ng/mL)
5	0.28
6	0.32
7	0.25
Mean ± SD	0.28 ± 0.03

90 days after application was 0.26 ± 0.25 ng/mL in surface runoff water (n=8) and 0.04 ± 0.01 ng/mL in subsurface runoff water (n=6). The trifluralin concentrations of 0.62~0.02 ng/mL in runoff water and 0.06~0.02 ng/mL in drained water was smaller than those of the U.S. EPA advisory, which was 2.00 ng/mL.

Surface residues of pesticides in the soil were most subject to rapid volatilization and photodegradation and to leaching into the soil by rainfall. For these reasons, the decline in runoff water was much steeper than for soil concentrations (Wauchope, 1978). It was commonly accepted that the pesticides which were strongly adsorbed into soil particles and which had low water solubilities were relatively immobile in soil (Feagley and Kim, 1995; Smith and Willis, 1985). The concentrations of these pesticides in water coincided with their water solubility (Ross, 1986). Water solubilities of trifluralin was 0.3 ug/mL (Humbrug, 1989). Concentration of trifluralin in surface runoff water and subsurface runoff water was always very low (Table 3,4,5). Wauchope (1978) was reported that the concentration of trifluralin in runoff water was 0.5~2.7 ng/mL.

3.4. Loss in the Runoff

485.5 mm of rain fall from June to Aug. resulted in 143.5 mm (68.3% of total runoff) of surface runoff and 66.3 mm (31.6% of total runoff) of subsurface outflow from drained plots (Table 6). Surface runoff from the nondrained plots was 250.6 mm, which was 51.6% of the rainfall. This result indicated that subsurface drainage reduced surface runoff. Bengtson (1988) reported that subsurface drainage reduced surface runoff, soil loss and nutrient and pesticides loss.

The concentration and loss of the trifluralin in drain and nondrained plot were given in Table 7. The total trifluralin loss from drained plots was 0.021% of the amount applied during June, July

Table 6. Surface runoff and subsurface runoff drainage (mm) on the drained and nondrained plot in Louisiana in summer, 1991

Plots			Month			Total
			June	July	Aug.	
		Rainfall	223.2	137.4	124.9	485.5
		Surface	89.7	43.5	12.5	145.7 (71.0%)[1]
	A	Subsurface	25.9	31.9	1.9	59.7 (29.0%)
		Total	115.6	75.4	14.4	205.4
		Surface	88.8	43.9	1.9	134.6 (62.8%)
DR[2]	B	Subsurface	43.3	34.6	2.1	80.0 (37.2%)
		Total	132.1	78.5	4.0	214.6
		Surface	91.0	50.4	8.9	150.3 (71.7%)
	C	Subsurface	30.5	27.2	1.7	59.4 (28.3%)
		Total	121.5	77.6	10.6	209.7
		Mean of total	123.0	77.1	9.6	209.9
NDR	H	Surface	124.3	95.8	30.3	250.6

1) % of total run off water (surface+subsurface)
2) DR is drained plot and NDR is nondrained plot.

Table 7. Loss of trifluralin in surface and subsurface runoff water on the drained and nondrained plot applied 1683 g/ha

Plots			Conc. (ng/mL)	Loss (mg/ha) June	July	Aug.	Total
DR[2]	A	Surface	0.27 ± 0.23	242.2	117.4	33.7	393.3 (95.8%)[1]
		Subsurface	0.03 ± 0.01	7.1	9.5	0.5	17.1 (4.1%)
		Total		249.8	126.9	34.2	410.4
	B	Surface	0.26 ± 0.25	230.8	114.1	0.5	345.4 (91.5%)
		Subsurface	0.04 ± 0.01	17.3	13.8	0.8	31.9 (8.4%)
		Total		248.1	127.9	5.7	377.3
	C	Surface	0.23 ± 0.18	209.3	52.7	20.4	282.4 (94.1%)
		Subsurface	0.03 ± 0.01	9.1	8.1	0.5	17.7 (5.8%)
		Total		218.4	60.8	20.9	300.1
		Mean of total		238.7	105.2	20.2	362.5
		(% of applied amount)		(0.014)	(0.006)	(0.001)	(0.021)
NDR	H	Surface	0.28 ± 0.03	BA[3]	268.2	84.84	
		(% of applied amount)			(0.015)	(0.005)	

1) % of total loss (surface+subsurface)
2) DR is drained plot and NDR is nondrained plot.
3) Month before application

and Aug. The total trifluralin loss from the nondrained plot was 0.020% of the amount applied during July and Aug. These were showed no difference between drained and nondrained plots because the concentration of trifluralin was very low. Wauchope (1978) has reviewed the literature on pesticide losses in runoff waters from agricultural fields. For the majority of pesticides, total losses were 0.5 % or less of the amount applied with surface runoff. Wauchope (1978) and Bengtson et al. (1990) reported that the trifluralin losses from the fields was 0.12% of the amount applied.

The subsurface runoff water was 31.6% of total runoff water (subsurface+surface). The subsurface trifluralin loss was 6.1% of total trifluralin loss (subsurface+surface). This result indicated that subsurface drainage reduced trifluralin loss. Bengtson et al. (1990) reported that subsurface drainage reduced atrazin and metolachlor loss by 55 and 51%, respectively, and most of the atrazin and metolachlor loss were in the surface runoff waters in drained plots.

4. CONCLUSIONS

Trifluralin was strongly adsorbed into soil, and showed negligible runoff and leaching. The concentration of trifluralin in runoff from field applied 1683 g/ha of trifluralin never exceeded 2.00 ng/mL, which was the U.S. EPA advisory. The total loss of triluralin in runoff water was 0.021% of applied amount during three month after application.

Subsurface drainage reduced the trifluralin loss because concentration of trifluralin in the subsurface runoff waters in drained fields was very low. Subsurface drainage might offer a management tool for decreasing pesticide input from nonpoint agricultural sources into aquatic areas of the Lower Mississippi valley.

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Louisiana의 農場에서 Trifluralin의 流出

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미국 Louisiana주 Baton Rouge에 있는 농장 14.6 ha에 전 처리 제초제 Trifluralin (2,6-dinitro-N, N-dipropy1-4- (trifluormethyl) benzenamine)을 1683 g/ha 살포하고, 3개월간 유출량을 조사하였다. 토층 15 cm에서 Trifluralin의 반감기는 42.6~46.0일 이었다. 암거배수포장에서 Trifluralin의 농도는 surface의 유출수에서 0.62 ng/mL~0.02 ng/mL 이었으며, subsurface의 유출수에서 0.06 ng/mL~0.02 ng/mL 이었다. 이는 미국의 Trifluralin 음료수 허용기준 2 ng/mL 보다 낮은농도이다. 3개월간 유출된 Trifluralin량은 전체 살포량의 0.021%였으며, 따라서 유출수에의한 Trifluralin이동되는 양은 적었다. 한편 subsurface의 유출수에 Trifluralin농도가 낮기때문에 암거배수시설로 Trifluralin의 유출량을 줄일 수 있다.