EVALUATION OF REDUCED APPLICATION RATES OF ACETOCHLOR TO REDUCE CONCENTRATION IN TILE DRAINAGE WATER

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Introduction

Acetochlor, a commonly used herbicide applied to the soil surface for grass control in corn, has been found in some southern Minnesota rivers. Leaching of acetochlor to tile lines in poorly drained soils has been proposed as a mechanism transporting acetochlor from the soil surface to the rivers. Thus, a study was initiated in the spring of 2008 and continued in 2009 at the University of Minnesota Southern Research and Outreach Center at Waseca to determine if reduced application rates of acetochlor will result in reduced concentrations and losses of acetochlor and its metabolites in tile drainage water from a corn-corn-soybean rotation.

Experimental Procedures

Nine small plots in a 36-plot tile drainage research facility located on a Canisteo-Webster clay loam soil complex were used to conduct the acetochlor phase of the study. The nine plots were superimposed on a larger study examining nitrogen rate and timing practices in a corn-corn-soybean rotation study.

The experimental procedures used in the conduct of the study are shown in Table 1. The plot number for each plot in the acetochlor phase of the experiment is shown in Table 2. The acetochlor treatment number, collection culvert number, previous crops for 2007 and 2008, nitrogen rate used in 2009, and the tile discharge amount in 2008 for each plot are also shown in Table 2. All nine plots were planted to corn following soybeans. The tile discharge rates for previous years were used to group the plots into three replications; one with plots having a high flow history, one with plots having a medium flow history, and one with plots having a lower flow history. Thus, each treatment was evaluated on all three flow histories as can be seen in Tables 7 and 8.

Each plot measures 20’ wide by 30’ long, has a plastic perforated tile placed 3.5’ deep and 5’ from one end, and is isolated to a depth of 6’ by a 12-mil plastic sheet placed in a backfilled trench around each plot. Drainage from each of the 9 plots flows into a dedicated separate sump that a sump pump emptied when the water level exceeded a preset level. Flow from each pump went through a flow meter; flow volume was recorded daily with a data logger. Cumulative drainage for any specific period of time was calculated by summarizing the discharge volume from each plot and dividing by the plot area. Due to minimal rainfall and very limited tile flow this spring, only four flow-weighted (FW) water samples from four plots were collected in glass bottles on June 12. They were kept refrigerated at 4ºC before sending via overnight delivery to the Monsanto laboratory on June 22 for acetochlor analysis. Four grab samples were also collected from the same four plots and given to Bill Van Ryswyk.

Specific procedures in Table 1 relative to the acetochlor study indicate that each of the sumps, pumps, meters, and plumbing tubes for collection of the “flow-weighted” tile water samples was cleaned and triple rinsed on April 29. Water samples were collected from each tile water collection system after the first and third rinses, stored at 4ºC overnight in a refrigerator, and sent via overnight delivery to Monsanto on April 30 for

acetochlor analyses. A sample of the rinse water used was also sent for acetochlor analyses. The collection culverts were then covered with tarps, which were anchored down, to prevent any acetochlor contamination from the surrounding fields prior to, during, and following acetochlor application to the plots.

Some tile lines began to dribble on April 29, and they sporadically dribbled until May 24. During this time, we waited for additional rain to increase the flow rates to where we could collect flow-weighted tile water samples prior to acetochlor application. The purpose was to determine if any residual acetochlor from 2008 existed in the collection system. Because an ample amount of rain did not occur to increase flow rates and because corn was planted on May 4, we did not get the opportunity to collect the flow-weighted samples before it was necessary to apply acetochlor to the plots. The treatments were applied with a tractor-mounted plot sprayer using a 20' boom on May 22 between 8 AM and 9 AM. The tarps were left on the culverts for more than two weeks. Rainfall stimulated slight tile drainage beginning on June 10. On June 12, drainage was occurring at a rate sufficient to obtain samples for acetochlor analyses from 4 of the 9 plots. They were sent to Monsanto the next day. Over the next few days drainage declined. No drainage has occurred since June 20.

Results and Discussion

Precipitation and Tile Discharge

Available soil water in the 0-5' soil profile was determined twice each month on a continuous corn site adjacent to the study. The data shown in Table 3 indicate soil water levels less than field moist capacity (11.05"). These data are supported and agree with the precipitation data found in Table 4 and the tile flow data found in Table 5. Greatest rainfall occurred during the April 25-27 (1.29"), May 5-9 (1.30"), and June 6-9 (1.34") periods. Largest rainfall events occurred on April 27 (0.98"), May 5 (0.56"), and June 7 (0.62").

Tile flow did not occur in 2009 prior to April 29 (Table 5). From April 29 through May 24, 8 of the 9 drainage plots dribbled small amounts of water. Over the 26-day period, daily drainage, ranging from 3 gal/day (0.008 acre-inch) to 28 gal/day (0.07 acre-inch), occurred for 62 plot-days (the total number of plots that had some drainage over this 26-day period) for an average of 2.4 plots that were draining each day. There was no day in which all 9 plots were draining. Thus, because of this low and sporadic flow, it was impossible to collect flow-weighted water samples prior to acetochlor application. Tile drainage did not begin again until June 10. During the 11-day period between then and June 20, drainage occurred from 5 of 9 plots for an averaged of 2.9 plots draining per day. Flow-weighted and grab samples of tile water were taken from four plots on June 12, which happened to be the day of greatest drainage post-acetochlor application. Daily drainage totaled only 7, 7, 10, and 15 gal/day from these plots on that day. Tile drainage was not occurring from the remaining five plots.

Tile discharge for each of the plots and acetochlor treatments are shown in Table 6. Averaged across all nine plots, tile discharge averaged 0.22 acre-inches for May and 0.07 acre-inches for June. As is customary in small drainage plots, flow variability among plots was substantial in this low-flow year. Tile flow was greatest in rep 1, much lower in rep 3, and least in rep 2. Averaged across replications, flow was greatest for the zero-acetochlor control treatment (0.50 acre-inches) and least for the 2.5 pint/A acetochlor treatment (0.14 acre inches) over the April-June period.

Even though the results from the experiment in this spring period were disappointing, it was encouraging to see the instrumented collection system work well; at least within the limited flow conditions of 2009.

Acetochlor Concentration

Acetochlor concentrations in the rinse water on April 29, prior to acetochlor application, are shown in Table 7. Seven of the 9 drainage plots showed detectable levels of acetochlor in the first rinse and 4 of 9 plots in the third rinse. Three of the “detects” in the third rinse were very low (0.04 ug/L) and one was still of concern (0.11 ug/L). Thus, the rinsing procedure was considered quite successful.

Concentration of acetochlor in the four F.W. water samples is shown in Table 8. Three of the four samples had non-detectable levels of acetochlor. However, water from plot 1506 (2.5 pt. acetochlor/A) had an acetochlor concentration of 0.09 ug/L. Water samples taken during the rinsing/cleaning stage on April 29 from this plot showed 0.10 ug acetochlor/L in the first rinsate and a non-detectable level (<0.03 ug/L in the third rinse. Thus, it is difficult to determine whether the 0.09 ug/L amount on June 12 was due to the acetochlor treatment on May 22 of if it was simply a small amount of residual acetochlor from any possible previous contamination. With only 0.37” of tile drainage water in May and June and only 0.04 acre inches of drainage between acetochlor application (5/22) and sampling (6/12), it seems very unlikely that the 0.09 ug/L detect could have originated from the 2009 application.

Acetochlor loss

Acetochlor losses in 2009 were not calculated because of the few number of samples and the very low and sporadic tile flow.

Table 1. Experimental procedures used in the acetochlor drainage study at Waseca in 2009.

Procedure	Date
Moldboard plow entire site	Nov. 16, 2008
Field cultivate all plots	April 22, 2009
Clean each well sump and pump with soap and water; triple rinse wells with clean water. Take samples from first rinse and last rinse, also take sample of the cleaning water (19 total samples)	April 29
Take 0-2' PPNT soil samples	May 1
Broadcast-apply preplant N treatments as urea	May 2
Field cultivate all plots (E-W)	May 2
Plant DKC 52-59 at 35,000 seeds/A, this is a triple-stack hybrid so no CRW insecticide was used	May 4
Plant Pioneer 92Y20 soybeans at 8 beans per foot in 30" rows	May 4
Applied acetochlor treatments to plots with a plot sprayer after covering each collection culvert with a tarp. Tarps were not removed until June 11	May 22 (8:00-9:00 AM)
Apply Roundup WeatherMax (24 oz/A) + AMS to all corn and soybean plots	June 1 and 26
Apply sidedress N as UAN injected mid-way between rows of specific treatments	June 5
Take plant population counts in all corn plots	June 11
Collect tile water samples.	June 12
Thin corn plots to uniform stand.	June 12
Take 0-6" soil samples from selected plots and 0-12" PSNT soil samples from selected corn plots	June 19
Collect NDVI biomass from each corn plot using GreenSeeker and Crop Circle instruments	June 26 and 30

Table 2. Crop history of each plot used in the acetochlor drainage study in 2009.

Plot No.	Trt.[1/] No.	Collection Culvert	Crop		N Rate	Tile Discharge
			2007	2008	2009	2008
		#			lb N/A	acre-inches
1503 (12)[2/]	1	3	Corn	Soybean	0	7.53
2109 (18)	1	4	Corn	Soybean	0	1.09
3510 (29)	1	6	Corn	Soybean	0	3.49
1103 (1)	2	1	Corn	Soybean	120	5.72
2307 (10)	2	2	Corn	Soybean	120	1.51
3513 (32)	2	6	Corn	Soybean	120	1.26
1506 (15)	3	3	Corn	Soybean	100	5.96
2309 (23)	3	5	Corn	Soybean	100	1.23
3512 (31)	3	6	Corn	Soybean	100	2.30

[1/] Trt. No. 1 = no acetolchlor, No. 2 = 1.5 pt. acetochlor/A, and No. 3 = 2.5 pt. acetochlor/A.
[2/] Tile number

Table 3. Available soil water in the 0-5' profile of a Webster clay loam, continuous corn site located adjacent to the acetochlor drainage site in 2009.

Date	Avail. soil water[1/]
	inches in 0-5'
April 16	8.74
May 1	9.05
May 15	9.38
June 1	9.31
June 15	8.85
July 2	8.38

[1/] Available water at 100% field moist capacity is 11.05".

Table 4. Precipitation amounts in 10-day periods for April-June, 2009 at acetochlor drainage site at Waseca.

Month	Period	Precipitation	Long-term Normal
		inches	inches
April	1-10	0.29	
	11-20	0.41	
	21-30	1.69	
	Total	2.39	3.23
May	1-10	1.30	
	11-20	0.37	
	21-31	0.23	
	Total	1.90	3.96
June	1-10	1.50	
	11-20	0.58	
	21-30	0.68	
	Total	2.76	4.22

Table 5. Tile flow periods and the number of drainage plots flowing in the acetochlor drainage study in 2009.

Period	No. Days	Drainage[1/]	Avg. No. of Plots draining/day	Tile Flow Recorded
		plot-days	plots/day	days all plots flowing
<4/29	--	No flow	--	--
4/29-5/24	26	62	2.4	0
5/25-6/9	16	No flow	--	--
6/10-20	11	32	2.9	0
>6/20	--	No flow	--	--

[1/] Includes all acetochlor plots where >3 gal/plot/day of flow was recorded. This equals 220 gal/A/d or 0.008 acre-inch/day.

Table 6. Monthly tile flow from April 1-June 30, 2009 from the acetochlor treated plots at Waseca.

		Rep				
		1	2	3		
		- - - - - - plots - - - - - -				
		1503	2109	3510		
Acetochlor		1103	2307	3513		
Trt. No.	Rate	1506	2309	3512	Avg.	SE[1/]
	pt./acre	- - - - - - - - - - - - - - - - Tile flow (acre – inch) - - - - - - - - - - - - - - - -				
			April			
1	0	0.07	0.00	0.00	0.02	0.02
2	1.5	0.00	0.00	0.00	0.00	0.00
3	2.5	0.00	0.01	0.00	0.00	0.00
					0.01	
			May			
1	0	0.98	0.01	0.08	0.35	0.31
2	1.5	0.60	0.00	0.02	0.20	0.20
3	2.5	0.26	0.02	0.01	0.10	0.08
					0.22	
			June			
1	0	0.27	0.01	0.11	0.13	0.08
2	1.5	0.11	0.00	0.02	0.04	0.03
3	2.5	0.11	0.00	0.02	0.04	0.03
					0.07	

[1/] SE = standard error of the mean.

Table 7. Acetochlor concentrations in sump and pump rinse water on April 29, 2009 at Waseca.

Plot No.	Tile No.	Sample ID		Rinse No.	Acetochlor concentration
					ug/L
1103	1	ACE TILE	09-01	First	0.14
2307	10	" "	09-02	"	ND[1/]
1503	12	" "	09-03	"	0.16
1506	15	" "	09-04	"	0.10
2109	18	" "	09-05	"	ND
2309	23	" "	09-06	"	0.24
3510	29	" "	09-07	"	0.07
3512	31	" "	09-08	"	0.16
3513	32	" "	09-09	"	0.14
1103	1	" "	09-10	Third	ND
2307	10	" "	09-11	"	ND
1503	12	" "	09-12	"	ND
1506	15	" "	09-13	"	ND
2109	18	" "	09-14	"	0.04
2309	23	" "	09-15	"	ND
3510	29	" "	09-16	"	0.04
3512	31	" "	09-17	"	0.04
3513	32	" "	09-18	"	0.11
--	--	" "	09-19	Rinse water source	ND

[1/] ND = <0.03 ppb (0.03 ug/L)

Table 8. Acetochlor concentrations in the F.W. tile drainage samples collected at Waseca in 2009.

		Composite samples			
Sample	Plot:	1503	1103	1506	3510
collection	Trt:	1	2	3	1
date	Tile:	12	1	15	29
		- - - - - - - Acetochlor concentration (ppb) - - - - - - -			
Jun 12		ND[1/]	ND	0.09	ND

[1/] ND = not detected at the MRL of 0.03 ug/L (ppb).