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 and 2010 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

Ten 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 in 2010. Nine plots were the same as used in 2009 with the acetochlor treatments being the same in both years for each plot. Because of below-normal precipitation in 2008 and 2009, resulting in limited drainage each year, an extra plot with a high-flow history was added as an “insurance” plot in 2010. This plot was planted to soybean in 2009 and had not received acetochlor in either 2008 or 2009. The other nine plots were planted to second-year corn. The ten 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 2008 and 2009, nitrogen rate used in 2010, and the tile discharge amount in 2009 for each plot are also shown in Table 2. 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 6-9.

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 10 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.

Beginning in March, 39 water samples were collected on four dates (Table 1) prior to acetochlor application and sent to Monsanto for parent acetochlor analysis. Each flow-weighted (FW) sample was collected in 250 ml fluoridated plastic bottles, stored in ice-containing coolers and a refrigerator at 4ºC, and sent via overnight delivery to

Monsanto. Because of the heavy tile flow prior to acetochlor application and the virtual absence of acetochlor in the samples, the sumps, pumps, meters, and plumbing tubes were not cleaned and rinsed prior to acetochlor application to the plots in 2010.

Following acetochlor application on May 16, 81 post-application water samples were taken and submitted to Monsanto for parent acetochlor analysis using the protocol described above. In addition, two grab samples were taken from two plots (1103, treatment #2 and 1506, treatment #3) on seven dates (5/16, 5/20, 5/27, 6/1, 6/4, 6/18, and 6/21) following acetochlor application. These samples were kept in 1 liter amber glass bottles prior to delivery to Bill Van Ryswyk for analysis by MDA. Half for the 28 samples were analyzed for parent acetochlor and half of degradates.

Corn was planted on April 30, but tile flow was minimal between planting and acetochlor application on May 16. Thus, water samples from only five plots were collected on the 16th prior to application. Tarps were then placed over the collection culverts before applying the acetochlor with a tractor-mounted plot sprayer using a 20' boom between 0730 and 0830 hours. The tarps were left on the culverts until June 3.

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 content was close to or above field moist capacity (11.05") for most of the April through June period. These data agree quite well with the precipitation data (Table 4) and tile flow data (Table 5) for this time period. Daily rainfall events >1.00 inches occurred on May 26 (1.08"), June 11 (1.24"), June 18 (3.93"), and June 27 (1.11").

Tile flow in 2010 began on March 11 (Table 5). Most of the flow was due to a thick snow-pack that contained as much as 4" of water. March was unseasonably and consistently warm. Snow melt occurred daily from March 8 throughout the month. Rainfall totaling 0.93" on March 10-12 added to the snowmelt. Without any extremely warm temps or large precipitation events, very little surface runoff occurred and virtually all of the precipitation infiltrated into the soil profile. Consequently, all of the 10 acetochlor plots were flowing on 12 of the 21 days in March that tile drainage occurred. For the 21-day period, 8.3 plots/day yielded tile drainage. Drainage was much lower and sporadic in April and May. Drainage was particularly abundant during the last half of June following the 3.93" rainfall event on June 18. All 10 of the acetochlor plots had measurable drainage on 10 of the 15 days during this period. During the 45-day post-application period, measurable drainage occurred on 303 plot-days for an average of 6.7 plots draining per day. This intensive drainage period provided an excellent scenario to meet the objectives of this study - - - to determine if reduced application rates will result in reduced concentrations and losses of acetochlor in tile water.

Tile discharge during the pre-application period for each of the plots and acetochlor treatments is shown in Table 6. Averaged across the nine primary plots, tile discharge averaged 6.0 acre-inches for March, <0.1 inch in April, and <0.1 inch in May 1-16 for a pre-application average of 6.2 acre-inches. Tile flow variability was greatest during March, especially for the 2.5 pt./acre acetochlor rate (treatment #3).

During the post-application period (May 17-June 30), tile flow for the nine primary plots averaged 0.4 acre-inches for May 17 - 30, 0.7 inches for June 1-15, and 4.2 inches for June 16-30 for a grand average of 5.3 acre-inches for the 45-day period (Table 7). Variability of drain flow among the three acetochlor treatments was very low and the overall uniformity was particularly pleasing.

Acetochlor Concentration

Acetochlor concentrations in the tile water during pre-acetochlor application period only equaled or exceeded the minimum detection limits (MDL) of 0.03 μg/L (ppb) in four of 39 samples (Table 8). The highest concentration (0.07 ppb) was in plot 1103 – a 1.5 pt/acre treatment applied in 2009. The other three "detects" each had an acetochlor concentration of 0.03 ppb. One was for the 2.5-pt rate applied last year; one was for the "extra" plot which had no acetochlor history; and one was in a duplicate sample where acetochlor was not detected in the original sample. Acetochlor concentrations for each treatment in each collection date averaged <0.03 ppb in all cases. Based on the randomness of the detects among treatments and plots and the very low concentrations of acetochlor found, these detects are considered to be "false positives". These data also indicate the collection systems were void of acetochlor contamination.

Concentrations of acetochlor in the 11 post-application water samples (9 primary samples and 2 duplicate samples) for May 20 and 24 were below the detection limits of 0.03 ppb in 10 samples. One sample on May 20 from a 2.5 pt/acre rate contained 1.29 ppb acetochlor. Analytical results from the remaining 70 post-application samples have not yet been received from Monsanto. Similarly, acetochlor concentration results have not been obtained from the 28 samples sent to MDA. After receiving the analytical results from these samples, we will be able to assess the validity of the 1.29 ppb concentration found for plot 2309 on May 20 – a 2.5-pt/A acetochlor treatment.

Acetochlor loss

Acetochlor losses for this period were not calculated because many of the analyses had not been received from the laboratory at the time of preparing the report and water samples were still being taken in early July.

Table 1. Experimental procedures used in the acetochlor drainage study at Waseca in 2010.

Procedure	Date
Chisel plow entire site	Nov. 16, 2009
Broadcast applied 0+0+120 to entire plot area	Nov. 20, 2009
Took 11 flow-weighted composite water samples for acetochlor analyses	Mar. 13, 2010
Took 11 flow-weighted composite water samples for acetochlor analyses	Mar. 17
Took 11 flow-weighted composite water samples for acetochlor analyses	Mar. 24
Broadcast applied gypsum (94 lb/A) at 15 lb S/A	Mar. 31
Broadcast applied 0+180+0 to entire plot area	Apr. 1
Disk plots in E-W direction	Apr. 22
Take 0-2' PPNT soil samples	Apr. 30
Broadcast-apply preplant N treatments as urea	Apr. 30
Field cultivate all plots (E-W)	Apr. 30
Plant DKC 48-37 at 35,000 seeds/A, this is a triple-stack hybrid so no CRW insecticide was used	Apr. 30
Plant Pioneer 92Y20 soybeans at 8 beans per foot in 30" rows	May 4
Took 6 flow-weighted, composite water samples for acetochlor analyses prior to acetochlor application.	May 16
Applied acetochlor treatments to plots with a plot sprayer after covering each collection culvert with a tarp. Tarps were not removed until June 3.	May 22 (8:00-9:00 AM)
Took 6 flow-weighted, composite water samples for acetochlor analyses.	May 20
Took 5 flow-weighted, composite water samples for acetochlor analyses.	May 24
Took 5 flow-weighted, composite water samples for acetochlor analyses.	May 27
Apply Roundup WeatherMax (24 oz/A) + AMS to all corn and soybean plots.	May 28
Take plant population counts in all corn plots	June 1
Took 6 flow-weighted, composite water samples for acetochlor analyses.	June 1
Thin corn plots to uniform stand.	June 2
Apply sidedress N as UAN injected mid-way between rows of specific treatments	June 3
Took 7 flow-weighted, composite water samples for acetochlor analyses.	June 4
Took 4 flow-weighted, composite water samples for acetochlor analyses.	June 8
Took 0-6" soil samples from selected plots.	June 10

Took 0-12” PSNT soil samples from selected corn plots.	June 16
Took 11 flow-weighted, composite water samples for acetochlor analyses.	June 21
Took 10 flow-weighted, composite water samples for acetochlor analyses.	June 25
Took 11 flow-weighted, composite water samples for acetochlor analyses.	June 28
Collect NDVI biomass from each corn plot using GreenSeeker and Crop Circle instruments	June 25-28 (V7 & V8) and July 1 (V10)

Table 2. Crop history of each plot used in the acetochlor drainage study in 2010.

Plot No.	Trt.[1/] No.	Collection Culvert	Crop 2008	Crop 2009	N Rate 2010	Tile Discharge 2009
		#			lb N/A	acre-inches
1503 (12)[2/]	1	3	Soybean	Corn	0	2.93
2109 (18)	1	4	Soybean	Corn	0	0.58
3510 (29)	1	6	Soybean	Corn	0	0.78
1103 (1)	2	1	Soybean	Corn	120	1.74
2307 (10)	2	2	Soybean	Corn	120	0.09
3513 (32)	2	6	Soybean	Corn	120	0.04
2507 (16)	2 extra	3	Corn	Soybean	0	2.08
1506 (15)	3	3	Soybean	Corn	100	0.39
2309 (23)	3	5	Soybean	Corn	100	0.03
3512 (31)	3	6	Soybean	Corn	100	0.03

[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 2010.

Date	Avail. soil water[1/]
	inches in 0-5’
April 16	10.46
May 3	9.73
May 17	10.11
June 1	11.02
June 16	10.27
July 1	11.11

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

Table 4. Precipitation amounts in 10-day periods for March-June, 2010 at the acetochlor drainage site at Waseca.

Month	Period		Precipitation		Long-term Normal
			inches		inches
March	1-10		0.63		
	11-20		0.71		
	21-31		0.11		
		Total		1.45	2.49
April	1-10		0.32		
	11-20		0.44		
	21-30		0.84		
		Total		1.60	3.23
May	1-10		0.75		
	11-20		1.25		
	21-31		1.27		
		Total		3.27	3.96
June	1-10		1.57		
	11-20		5.75		
	21-30		2.32		
		Total		9.64	4.22

Table 5. Tile flow periods and the number of drainage plots flowing from the 10 plots in the acetochlor drainage study in 2010.

Period	No. Days	Drainage[1/]	Avg. No. of Plots draining/day	Tile Flow Recorded
		plot-days	plots/day	days all plot flowing
< 3/11	--	No flow	---	---
3/11-3/31	21	175	8.3	12
4/1-4/30	30	52	1.7	0
5/1-5/16	16	16	1.0	0
pre-application flow total				
3/11-5/16	**67**	**243**	**3.6**	**12**
5/17-5/31	15	83	5.5	0
6/1-6/15	15	82	5.5	0
6/16-6/30	15	138	9.2	10
post-application flow total				
5/17-6/30	**45**	**303**	**6.7**	**10**

[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 during the pre-application period (March 11-May 16, 2010) from the acetochlor treated plots at Waseca.

		Rep					
		1	2	2 Ex	3		
		- - - - - - plots - - - - - -					
		1503	2109		3510		
Acetochlor		1103	2307	2507	3513		
Trt. No.	Rate	1506	2309		3512	Avg.	SE[1/]
	pt./acre	- - - - - - - - - - - - - - Tile flow (acre – inch) - - - - - - - - - - - - - -					
		March					
1	0	4.4	1.8		3.6	3.3	0.8
2	1.5	4.2	6.8	10.9	4.5	5.2	0.8
3	2.5	9.9	13.1		5.7	9.6	2.1
	Avg.					6.0	
		April					
1	0	0.3	0.0		0.0	0.1	0.1
2	1.5	0.1	0.0	0.6	0.0	<0.1	0.0
3	2.5	0.1	0.0		0.0	<0.1	0.0
	Avg.					<0.1	
		May 1-16					
1	0	0.3	0.0		0.1	0.1	0.1
2	1.5	0.2	0.0	0.3	0.0	<0.1	0.1
3	2.5	0.1	0.0		0.0	<0.1	0.0
	Avg.					<0.1	
		March – May 16 Total					
1	0	4.9	1.8		3.7	3.5	0.9
2	1.5	4.5	6.8	11.8	4.5	5.3	0.8
3	2.5	10.2	13.1		5.7	9.7	2.1
	Avg.					6.2	

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

Table 7. Monthly tile flow during the post-application period (May 17-June 30, 2010) from the acetochlor treated plots at Waseca.

		Rep					
		1	2	2 Ex	3		
		- - - - - - plots - - - - - -					
		1503	2109		3510		
Acetochlor		1103	2307	2507	3513		
Trt. No.	Rate	1506	2309		3512	Avg.	SE[1/]
	pt./acre	- - - - - - - - - - - - - - - Tile flow (acre – inch) - - - - - - - - - - - - - - -					
		May 17-31					
1	0	1.0	0.1		0.3	0.5	0.3
2	1.5	0.8	0.0	1.3	0.0	0.3	0.3
3	2.5	0.6	0.0		0.1	0.3	0.2
	Avg.					0.4	
		June 1-15					
1	0	1.4	0.6		0.6	0.9	0.3
2	1.5	1.1	0.4	1.5	0.4	0.6	0.2
3	2.5	1.1	0.1		0.6	0.6	0.3
	Avg.					0.7	
		June 16-30					
1	0	4.2	4.7		2.4	3.8	0.7
2	1.5	5.3	4.7	4.9	2.9	4.3	0.7
3	2.5	5.7	4.4		3.4	4.5	0.6
	Avg.					4.2	
		May 17 – June 30 Total					
1	0	6.8	5.4		3.4	5.2	1.0
2	1.5	7.3	5.1	8.0	3.3	5.2	1.2
3	2.5	7.5	4.5		4.1	5.4	1.1
	Avg.					5.3	

Table 8. Acetochlor concentrations in the FW tile drainage samples collected on the following dates at Waseca during the pre-application period in 2010.

		Rep				
		1	2	2 Ex	3	
		- - - - - - plots - - - - - -				
		1503	2109		3510	
Acetochlor		1103	2307	2507	3513	
Trt. No.	Rate	1506	2309		3512	Avg.
	pt./acre	- - - - - - - - - - Acetochlor concentration (μg/L) - - - - - - - - - -				
		March 13				
1	0	ND	ND		ND	<0.03
2	1.5	0.07	ND	ND	ND	<0.05
3	2.5	ND	ND[2/]		ND	<0.03
		March 17				
1	0	ND	ND		ND	<0.03
2	1.5	ND	ND	0.03	ND[3/]	<0.03
3	2.5	ND	ND		ND	<0.03
		March 24				
1	0	ND[3/]	ND		ND	<0.03
2	1.5	ND	ND	ND	0.03	<0.03
3	2.5	0.3	ND		ND	<0.03
		May 16				
1	0	ND[3/]	--		ND	<0.03
2	1.5	ND	--	ND	--	<0.03
3	2.5	ND	--		--	<0.03

[1/] ND = <0.03 ppb (0.03 μg/L)
[2/] Duplicate sample = 0.03 μg/L
[3/] Duplicate sample also = ND

Table 9. Acetochlor concentrations in the FW tile drainage samples collected on the following dates at Waseca during the post-application period in 2010.

Acetochlor		Rep 1	Rep 2	Rep 2 Ex	Rep 3	
		- - - - - - plots - - - - - -				
		1503	2109		3510	
		1103	2307	2507	3513	
Trt. No.	Rate	1506	2309		3512	Avg.
	pt./acre	- - - - - - - - - - Acetochlor concentration (μg/L) - - - - - - - - - -				
			May 20			
1	0	ND[2/]	--		--	<0.03
2	1.5	ND	--	ND	--	<0.03
3	2.5	ND	1.29		--	<0.66
			May 24			
1	0	ND	--		--	<0.03
2	1.5	ND	--	ND[2/]	--	<0.03
3	2.5	ND	--		--	<0.03
			May 27			
1	0		Results unavailable[3/]			
2	1.5					
3	2.5					
			June 1 [3/]			
1	0					
2	1.5					
3	2.5					
			June 4 [3/]			
1	0					
2	1.5					
3	2.5					
			June 8 [3/]			
1	0					
2	1.5					
3	2.5					

		June 21
1	0	[3/]
2	1.5	
3	2.5	
		June 25
1	0	[3/]
2	1.5	
3	2.5	
		June 28
1	0	[3/]
2	1.5	
3	2.5	
		July 2
1	0	[3/]
2	1.5	
3	2.5	
		July 6
1	0	[3/]
2	1.5	
3	2.5	

[1/] ND = <0.03 ppb (0.03 μg/L)
[2/] Duplicate sample also = ND
[3/] Results unavailable at time of report