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

Semi-annual Report #4
Covering the time period of
July 1, 2009 to December 31, 2009

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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 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. Further details outlining the establishment of the plot and collection of the water samples were described in Semi-Annual Report #1.

The experimental procedures used in the conduct of the study from July-December are shown in Table 1. Collection procedures for the water samples in November were similar to those described in Report #3. Leaf chlorophyll readings, a surrogate measurement relating to the N status of the plant, were taken on 30 plants per plot with a SPAD meter. Prior to harvest 1.5’ was trimmed from each end of four rows per plot. These four rows were then combined with a research-plot combine equipped with an electronic scale and a grain moisture meter. An 8-inch section of stalk between 6” and 14” above the soil surface was not taken in 2009 due to the extremely wet field conditions after physiologic maturity (PM) and the sensitivity of the test results to the timing between PM and sample collection and rainfall. Soil samples were taken in 1-foot increments from two cores per selected plot to a depth of four feet. The samples were dried, ground, and analyzed for nitrate-N to determine residual N left in the soil after harvest. Corn stalks were chopped before chisel plowing the entire site. Potassium was broadcast on all plots after chiseling. Prior to the soil freezing, the culverts used for collecting the acetochlor samples were covered with tarps after securely fastening the culvert tops down. This was done to prevent any overwinter wind blown soil from contaminating the instrumentation and collection equipment.

Results and Discussion

<u>Precipitation and Tile Discharge</u>

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 2 indicate soil water levels never reached field moist capacity (11.05”) at any time during the year. In fact, the soil moisture level on September 16 (2.86”) was the lowest of any September measurement on record. At that time, 83% of the available water was below 3 feet.

Available soil water was greatest in early November following 7.05” of rain in October (Table 3). Below normal monthly precipitation was recorded each month from March through September with growing season (May-September) precipitation (11.00”) being the second lowest in our 95-yr weather records.

Tile flow data for the entire season are shown in Table 4. Drainage started on April 29 and continued very sporadically through June 20, as evidenced by tile flow occurring from only 2.7 and 2.9 plots each day from 4/29-5/21 and 6/10-6/20, respectively. Flow started sporadically again on 10/24 and continued through 11/19 with an average of only three tile lines flowing each of the 27 days. There was no day during the tile flow season when all plots were draining.

Tile discharge for each of the plots and acetochlor treatments averaged 0.72” for the April-November drainage season and 0.50” from the acetochlor post-application period (5/22-11/19) (Table 5). As is customary in small drainage plots, flow variability among plots was substantial. Although tile flow was measured from all nine plots at one time or another during the season, 4 of the 9 plots registered <0.10” of drainage. Drainage from two plots was >1.7”. When averaged across the three replications, drainage for the post-acetochlor application period averaged 1.04” for the zero-acetochlor treatment, 0.42” for the 1.5 pint/A rate, and 0.05” for the 2.5 pint/A rate. Since the acetochlor treatments were assigned to the drainage plots based on tile flow in previous years using restricted randomization, we have no explanation for this horrendous variability, except that the flow was so low and sporadic. Tile flow was consistently highest in rep 1 due to the restricted randomization.

Acetochlor Concentration

Concentration of acetochlor in the composite, FW water samples for each of the plots for the 2009 drainage season is shown in Table 6. Two samples out of 14 showed detectable concentrations of acetochlor. Of the four samples taken on 6/12, one from the 2.5 pint/A rate showed 0.09 ppb acetochlor; non-detectable levels of acetochlor were found in the rest. Only 1 of 10 samples taken in November (more than 5 months after acetochlor application) showed detectable acetochlor --- 0.04 ppb from a zero-acetochlor treatment. Unfortunately, drainage was minimal for this plot (1506) earlier in the season and samples were not taken. Thus, we have no idea if acetochlor was present in the soil water earlier in the season due to an unknown source or if this detection was simply a false-positive. Samples taken on 4/29 during the rinsing of the drainage collection equipment showed 0.10 ppb acetochlor in the first rinse water and a non-detectable level in the third rinse water.

Two grab samples of tile water taken on 6/12 indicated detectable levels of acetochlor-ESA from both the 1.5 and 2.5 pint/A treatments (Table 7). However, acetochlor-OXA was not detectable in the 1.5 pint/A treatment. Base neutral analyses indicated no detectable EAW acetochlor in the 1.5 pint/A treatment, but 0.15 ppb in the 2.5 pint/A treatment. Without additional grab samples, it is difficult to determine confidently the implications of these data.

Flow-weighted concentrations of acetochlor in the drainage water after the acetochlor treatments were applied were not calculated due to the very low tile flow rates and the few samples taken.

Acetochlor loss

Acetochlor losses in the post-application flow period were not calculated due to the low tile flow (<0.5" from the plots receiving acetochlor) and the few samples taken.

Corn Production

The previous crop, N rate used, tile discharge for 2009, corn yield, grain moisture content, and grain N concentration for each of the acetochlor drainage plots are shown in Table 8. Total tile drainage in 2009 for rep 1 ranged from 0.39" to 2.93" and averaged 1.69", for rep 2 ranged from 0.03" to 0.58" and averaged 0.23", and for rep 3 ranged from 0.03" to 0.78" and averaged 0.28". All corn plots followed soybean in 2008. Grain yields averaged across the three replications ranged from 111 bu/A on the zero-N control plots to 173 and 178 bu/A on the 120-lb preplant and 60 + 40-lb split N treatments, respectively. Grain moisture at harvest was about 3.2 points lower for the 120 and 100-lb N rates (25.5%) compared with the zero-N rate (28.7%). Grain N concentration ranged from 0.95% (5.9% protein) for the zero-N treatment to 1.06% (6.6% protein) on the 120-lb preplant treatment to 1.26% (7.9% protein) on the 60 + 40-lb split treatment. Considering the moisture stress throughout the 2009 season, these corn yields were considered to be quite good.

Residual soil nitrate-N remaining after harvest was quite low (Table 9). While most of the residual nitrate was found in the top 12", nitrate-N concentrations did not exceed 4 ppm for the zero-N rate and 5 ppm for the 120-lb rate. Total nitrate-N ranged from 34 lb/A in the zero-N treatment to 42 lb/A in the 120-lb treatment. These low values suggest rather low nitrate-N concentrations will be found in the spring 2010 drainage water.

Table 1. Experimental procedures used in the acetochlor drainage study at Waseca from July 1-Dec. 31, 2009.

Procedure	Date
Take SPAD meter readings (leaf chlorophyll status)	July 31
Take stover yield from all corn plots	Sept. 30
End trim 1.5' from end of each corn row	Oct. 20
Combine harvest corn plots	Nov. 5
Combine harvest soybean plots	Nov. 7
Combine harvest remaining corn & soybeans	Nov. 12
Take 0-4' soil samples from selected plots	Nov. 12
Chop corn stalks and disk all plots	Nov. 13
Broadcast apply 120 lb K_2O/A as 0-0-60	Nov. 20
Chisel plot the experimental site	Nov. 16
Soil froze	Dec. 5

Table 2. 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
July 15	6.10
July 31	4.10
August 17	4.38
September 2	3.78
September 16	2.86
October 2	Too wet, no samples taken
October 16	7.80
November 2	10.94

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

Table 3. Precipitation amounts in 10-day periods for April-November, 2009 at acetochlor drainage site at Waseca.

Month	Period	Precipitation	Long-term Normal
		inches	inches
January	1-31	0.71	1.39
February	1-28	1.22	0.95
March	1-31	1.81	2.49
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
July	1-10	0.31	
	11-20	0.03	
	21-31	1.19	
	Total	1.53	4.47
August	1-10	1.22	
	11-20	1.37	
	21-31	0.74	
	Total	3.33	4.58
September	1-10	0.00	
	11-20	0.78	
	21-30	0.70	
	Total	1.48	3.19
October	1-10	3.62	
	11-20	0.51	
	21-31	2.92	
	Total	7.05	2.50
November	1-10	0.16	
	11-20	0.10	
	21-30	0.65	
	Total	0.91	2.32
December	1-31	2.96	1.40
Jan-Dec	Total	27.01	34.70
Apr-Nov (Flow period)	Total	19.97	28.47

Table 4. 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[2/] draining/day	Tile Flow
		plot-days	plots/day	days all plots flowing
<4/29	--	No flow	--	--
4/29-5/21	23	62	2.7	0
5/22-6/9	19	No flow	--	--
6/10-20	11	32	2.9	0
6/21-10/23	125	No flow	--	--
10/24-11/19	27	80	3.0	0
>11/20	--	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.
[2/] Potential maximum of 9.0.

Table 5. Monthly tile flow from April 1-November 30, 2009 from the acetochlor treated plots at Waseca.

Acetochlor		Rep 1	Rep 2	Rep 3		
		- - - - - - plots - - - - - -				
		1503	2109	3510		
		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	
			October			
1	0	0.55	0.11	0.27	0.31	0.13
2	1.5	0.02	0.00	0.00	0.01	0.01
3	2.5	0.00	0.00	0.00	0.00	0.00
					0.11	
			November			
1	0	1.06	0.44	0.31	0.60	0.23
2	1.5	1.01	0.09	0.00	0.37	0.32
3	2.5	0.02	0.00	0.00	0.01	0.01
					0.33	
			April-November			
1	0	2.93	0.58	0.78	1.40	0.76
2	1.5	1.74	0.09	0.04	0.62	0.56
3	2.5	0.39	0.03	0.03	0.15	0.11
			May 22 – Nov. 19			
1	0	1.88	0.56	0.69	1.04	
2	1.5	1.14	0.09	0.02	0.42	
3	2.5	0.13	0.00	0.02	0.05	

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

Table 6. Acetochlor concentrations in tile drainage samples collected at Waseca in 2009.

	Flow weighted samples								
Trt:	1	1	1	2	2	2	3	3	3
Plot:	1503	2109	3510	1103	2307	3513	1506	2309	3512
	- - - - - - - - - - Acetochlor concentration (ppb) - - - - - - - - - -								
June 12	ND		ND	ND			0.09		
Nov. 2	ND	0.04	ND	ND	ND				
Nov. 16	ND	ND		ND	ND		ND		

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

Table 7. Acetochlor concentrations in tile water grab samples collected at Waseca on June 12, 2009.

	Acetochlor Trt.		CHL Degradates Acetochlor		EAW
Plot	No.	Rate	ESA	OXA	Base Neutral
		pt/A	- - - ppb - - -		ppb
1103	2	1.5	0.10	ND[1/]	ND
1506	3	2.5	0.09	0.17	0.15

[1/] ND = not detected at MRL = 0.07 ppb

Table 8. Tile discharge and corn production parameters for the plots receiving acetochlor in 2009.

Acetochlor		Plot	Prev.	2009	2009 Tile	Corn	Grain	Grain N
Trt. No	Rate	No.	Crop	N rate	discharge	yield	moisture	concentration
	pt./A			lb N/A	acre-inches	bu/A	%	%
1	0	1503	Soyb	0	2.93	94.2	30.7	0.93
		2109	"	0	0.58	128.4	27.4	0.94
		3510	"	0	0.78	111.3	28.1	0.98
				Average	1.43	111.3	28.7	0.95
2	1.5	1103	"	120	1.74	163.4	27.3	0.95
		2307	"	120	0.09	182.4	24.2	1.08
		3513	"	120	0.04	174.1	25.4	1.16
				Average	0.62	173.3	25.6	1.06
3	2.5	1506	"	60+40	0.39	176.0	25.7	1.15
		2309	"	60+40	0.03	193.7	23.8	1.21
		3512	"	60+40	0.03	162.7	26.8	1.42
				Average	0.15	177.5	25.4	1.26

Table 9. Soil nitrate-N concentration and amount in the 0-4' soil profile after harvest in 2009.

	N Rate (lb/A)	
Depth	0	120
feet	- - - - - - - - - - ppm - - - - - - - - - -	
0-1	3.5	4.9
1-2	1.9	2.4
2-3	1.6	1.6
3-4	1.5	1.5
0-4' Total (lb/A)	34.3	41.7