Impacts of strip-tillage on herbicide loss from a Coastal Plain Soil

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Abstract

Because conservation tillage practices like strip-till commonly increase infiltration, they have the potential to increase agrichemical leaching and contribute to unforeseen impacts on water quality in landscapes where rates of lateral subsurface drainage (LSF) are high. The later is the case in much of the Coastal Plain. To answer this and other questions related to hydrologic and water quality responses to conservation-tillage during cotton and peanut production in the region, we began a long-term field study in 1999. Losses of two herbicides fluometuron and pendimethalin are reported as a function of tillage for the first 8-years of the study. When combined losses (surface and LSF) were evaluated ST was shown to consistently reduce off-site discharge of both compounds. However, ST did contribute to increased fluometuron LSF loss. Results showed that this transport pathway should be included when comparing potential water quality impacts of ST and other tillage systems.

Introduction and Methods

Over the past ten years we have produced cotton and peanut in rotation under strip- (ST) and conventional-tillage (CT) management and examined losses of water, nutrients and selected pesticides in surface runoff and subsurface drainage (LSF) at a study site in Tift County Georgia. In this report we focus on surface runoff and LSF losses of the herbicides fluometuron and pendimethalin. Commercially available formulations Cotoran 4L (fluometuron) and Prowl 3.3 EC (pendimethalin) were used and applied at label recommended rates. Prowl was applied preemergence to all crops except to peanut in 2004. Cotoran was tank-mixed with Prowl during applications to cotton. The 2001 cotton crop also received a post-directed Cotoran application. Crops, dates of planting, and harvest and herbicide applications are summarized in Table 1.

Table 1. Crops, planting and harvest dates and fluometuron and pendimethalin applications during 1999-2006.†

					herbicide applications (lb acre^{-1})	
year	crop	plant	harvest	date	fluometuron	pendimethalin
1999	cotton	6-May	16-Sept	6-May	1.0	0.4
2000	cotton	1-May	11-Sept	1-May	1.0	0.8
2001	cotton	7-May	5-Oct	7-May	1.0	0.8
				18-June	1.25	not applied
2002	peanut	10-May	10-Sept	10-May	not applied	1.0
2003	cotton	12-May	22-Oct	12-May	1.0	0.8
2004	peanut	10-May	15-Sept	10-May	not applied	not applied
2005	cotton	23-May	1-Nov	23-May	1.0	0.8
2006	peanut	16-May	27-Sept	16-may	not applied	1.0

† harvest date for cotton was date of machine picking and for peanut date of digging.

Research plots and tillage practices were established in 1999 at the University of Georgia Gibbs Farm. The soil is in the Tifton series with 3 to 4% slope. Fig.1 shows key features of the experimental setup.

The three ½ acre plots on the south side of the study area have been maintained continuously in ST and the three on the north in CT. During construction, plots were bermed to direct runoff to H-flumes installed at downslope corners. The flumes were used to measure runoff volume during each event and to collect water samples for nutrient and pesticide monitoring. LSF volumes were measured and water samples collected for analysis from H-flumes installed on outlets of 6-in tile drains installed at the downslope edges of each tillage block. An inceptor drain was installed at the upslope edge of the plots to direct upgradient LSF flow away from the study area. All herbicide residue analyses made in our laboratory used solid-phase extraction combined with high performance liquid chromatography-mass spectrometry (HPLC-MS) techniques.

Results and Discussion

Runoff, LSF, sediment, and the amount of each herbicide lost are summarized in Table 2.

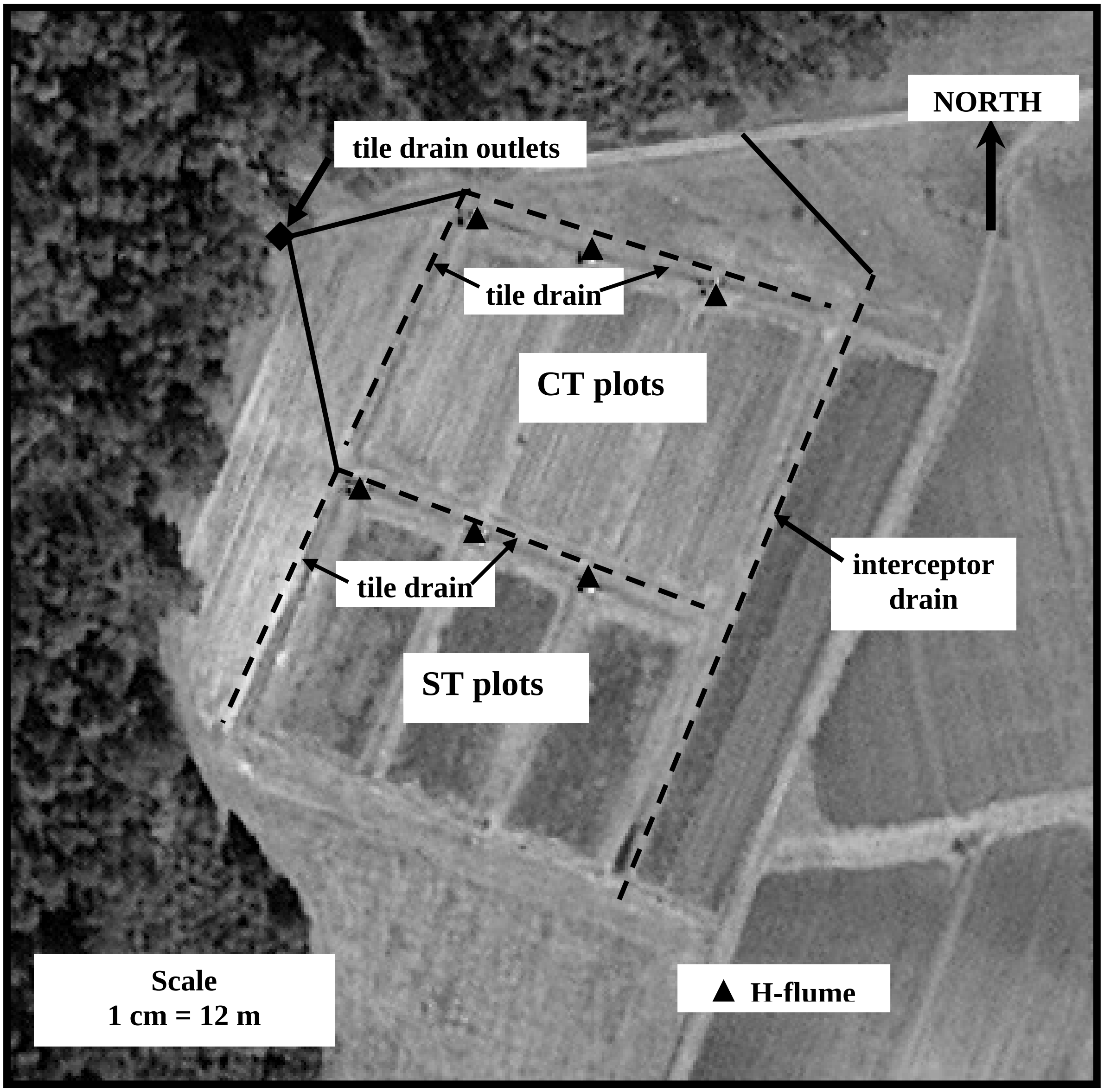
Table: 8-year summary (1999-2006) of runoff, LSF, sediment, fluometuron and pendimethalin losses.†

parameter	ST	CT
surface runoff (% rainfall + irrigation)	14	22
LSF (% rainfall + irrigation)	18	10
sediment (tons $acre^{-1}$)	1.3	6.4
runoff fluometuron (% of applied)	0.2	0.8
LSF fluometuron (% of applied)	0.2	0.1
runoff pendimethalin (% of applied)	0.03	0.5
LSF pendimethalin (% of applied)	<0.01	<0.01

† fluometuron reported as sum of parent compound and its degradate desmethylfluometuron (DMF).

Results showed that ST when compared to CT decreased surface runoff volume by about 40% and that LSF volume from the ST-system was increased proportionally. On balance the amount of rainfall and irrigation lost from both systems was nearly equal (26-28 % of the total). The increased LSF from the ST-system doubled fluometuron loss. This compound and its degradate (DMF) are prone to leaching due to relatively high water solubility and low binding potential to soil. In the case of runoff, there was 4-fold greater fluometuron loss from the CT versus the ST-system primarily due to the CT-system's increased runoff volume. Pendimethalin was not detected in any of the LSF samples with estimated losses <0.01% of applied for both tillage systems. In contrast, runoff losses were much greater (about 16-fold) with the CT versus ST system. Pendimethalin's behavior is explained by its low leaching potential and tendency for transport with eroded sediment. As indicated the CT-system sediment loss was nearly 5-fold greater than the ST-system.

Figure 1. Study site features.



In summary, monitoring over 8-years showed that the net amount of water lost from both the ST- and CT-systems was about equal (about 25% of rainfall plus irrigation) with the ST-system exhibiting greater LSF and CT greater surface runoff. From a water quality perspective, the ST-system was clearly superior to the CT-system when combined (runoff and LSF) losses of the two herbicides were evaluated (Table 3). Finally results showed that LSF loss of herbicides like fluometuron which are prone to leaching may be increased in LSF, thus when tillage systems are evaluated this transport pathway should be taken into account.

Table 3. Combined (runoff and LSF) losses (% of applied) of fluometuron and pendimethalin.

Compound	ST	CT
fluometuron	0.4	0.8
pendimethalin	0.03	0.5