

Tillage Effects on Surface Runoff Water Quality from Artificially Drained Cropland

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ABSTRACT

Sediment, phosphorus and nitrogen were monitored in surface runoff and tile flow from approximately 4-ha watersheds subjected to a conservation tillage treatment (chisel plow) and a conventional tillage treatment (moldboard plow). The study site was located southeast of Saginaw Bay in mid-Michigan on a clay loam soil with less than 1% slope. Surface runoff constituted 35% and 42% of the total drainage volume for the conservation and conventional treatments, respectively, but generated 60-80% of the sediment, phosphorus and total Kjeldahl nitrogen losses. Conservation tillage markedly reduced sediment and nutrient losses during snowmelt events and early season rainstorms. Sediment concentrations in surface runoff were generally low in comparison to other agricultural field studies. Soluble P constituted one-half of the total P transported for both treatments.

INTRODUCTION

Conservation tillage has been widely promoted to reduce offsite transport of agricultural chemicals from croplands in the Great Lakes Basin (Lake and Morrison, 1977; PLUARG, 1978). The USDA-SCS (1987) defines conservation tillage as

"any tillage and planting system in which at least 30 percent of the soil surface is covered by plant residue after planting to reduce soil erosion by water."

While conservation tillage has been shown to reduce total waterborne discharges of sediment and nutrients from croplands (i.e., edge-of-field losses) on erosion-prone sites, it has not proved as effective for reducing losses of

soluble nutrients (Johnson et al., 1979; Baker and Laflen, 1981). Reduced fertilizer incorporation (Timmons et al., 1973; Baker and Laflen, 1982) and leaching of soluble nutrients from the surface residues (Timmons et al., 1970; Holt et al., 1973) have been forwarded as possible explanations. Most water quality studies have compared conservation tillage with minimal incorporation of surface applied fertilizer to conventional tillage with fertilizer incorporation.

Much of the cropland bordering the Saginaw Bay of Lake Huron is characterized by flat slopes and cohesive, tile-drained soils. The annual storm erosivity, as measured by the rainfall erosion index (R), is 1275 (MJ·mm)/(ha·h) which is among the lowest that occurs east of the Mississippi River (Wischmeier and Smith, 1978). Erosion and sediment-bound nutrient transport is expected to be lower than in many other regions where conservation tillage has been tested. The study reported here was conducted to provide information on the influence of conservation tillage on edge-of-field losses of sediment, phosphorus, and nitrogen on tile drained sites. Selected runoff events were monitored over a three-year period on two watersheds; one subjected to conventional tillage (fall moldboard plow) and the other to conservation tillage (fall chisel plow).

To control phosphorus (P) losses from erosion-resistant sites may require practices that reduce losses of both sediment-bound and soluble P. High proportions of soluble P can result when the quantity of sediment in surface runoff is insufficient to sorb P from solution (McDowell and McGregor, 1980; Harms et al., 1974; Smith et al., 1974). Logan and Adams (1981) concluded that the proportion of soluble P in surface runoff increases rapidly as sediment loads decrease.

Management practices that promote infiltration into tile drainage systems can significantly reduce phosphorus losses, since subsurface soils can sorb P as it percolates to drainage tile (Baker et al., 1975; Lake and Morrison, 1977). Conservation tillage has been found to increase infiltration and reduce the volume of surface runoff on soil with good internal drainage (Logan and Adams, 1981). On sites with tile drainage systems, conservation tillage may reduce sediment transport of P and reduce soluble P loss by increasing infiltration to tile. Increased infiltration may, however, increase nitrogen losses. Nitrate-nitrogen (N) is not adsorbed by the soil and has been found in high concentrations in subsurface drainage water.

The specific objectives of this study were: (1) to compare surface runoff and sediment transport for conservation and conventional tillage treatments, and (2) to quantify the mode of nutrient transport (soluble vs. sediment-bound) for the two tillage treatments.

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METHODS

Tile flow and surface runoff from two contiguous fields (surface areas of 4.66 ha and 3.89 ha) were monitored continuously from March 1, 1981, to July 7, 1983, and during selected periods from July 1983 to June 17, 1984. Primary tillage was performed during the fall on each field. The primary tillage tool on the conservation treatment was a chisel plow which left 20 to 60% residue cover on the field throughout the winter, depending on the crop grown. For the conventional treatment, primary tillage was performed with a moldboard plow. Table 1 gives the crop rotation, residue cover and field operations performed during the study. Residue cover was measured both gravimetrically and with the line point method (USDA-SCS, 1981). Except for the primary tillage method, agronomic activities and inputs were identical on both tillage treatments, a common practice in the study region.* All phosphate was band incorporated. Table 2 gives fertilizer application rates. All fertilizer was applied at planting time.

The average slope was 0.8% on both fields. Slight surface depressions developed over time at the lower end of each field due to tillage operations with large equipment. Surface ponding on fields prior to runoff discharge is normal in the study area. The soil was

*Muhtar, H. 1982. An economic comparison of conventional and conservation tillage systems in the S.E. Saginaw Bay coastal drainage basin. Unpublished Ph.D. dissertation, Michigan State University, E. Lansing, MI.

classified Londo loam, an aeric glossaqualf, fine-loamy mixed mesic soil (39% clay, 22% silt, 39% sand). The organic matter content of the surface soil for both treatments was approximately 4.5%. The soil was somewhat poorly drained in its natural state and the site was tilled in a gridiron pattern at approximately 18-m intervals.

Surface runoff on each field was isolated by a natural divide on the upper end of the field and with low earthen

TABLE 2. Fertilizer application amounts and schedule for both treatments

Application amount, kg/ha			
Crop Year	N	P	Crop
1981	38* 168	77	Corn
1982	31†	62	Dry Beans
1983	118‡	39	Sugar Beets
1984	30§ 168	60	Corn

* 384 kg/ha of 10-20-20 fertilizer plus 168 kgN/ha as anhydrous ammonia.

† 308 kg/ha of 10-20-20

‡ 562 kg/ha of 21-7-14

§ 300 kg/ha of 10-20-20 plus 168 kgN/ha as anhydrous ammonia.

TABLE 1. Agronomic activity and residue status

Period	Conventional Treatment			Conservation Treatment		
	Tillage	Crop	Residue Mass/Area (%)	Tillage	Crop	Residue‡ Mass/Area (%)
Fall, 1980	Moldboard	Harvest Corn	283 kg/ha (10%)	Chisel*	Harvest Corn	2000 kg/ha (58%)
Spring, 1981	Field Cultivate	Plant Corn on 5/6/81	NM† (3%)	Field Cultivate	Plant Corn on 5/6/81	1056 kg/ha (35%)
Fall, 1981	Moldboard	Harvest	NM (10%)	Chisel	Harvest Corn	2107 kg/ha (56%)
Spring, 1982	Field Cultivate	Plant Beans on 5/31/82	NM (10%)	Field Cultivate	Plant Beans on 5/31/82	2004 kg/ha (51%)
Fall, 1982	Moldboard	Harvest Beans on 10/6/82	NM (19%)	Chisel	Harvest Beans on 10/6/82 Plant Oats (broadcast/drag)	NM (19%)
Spring, 1983	Field Cultivate	Plant Beets on 4/27/83	548 kg/ha (NM)	Field Cultivate	Plant Beets on 5/14/83	1978 kg/ha (NM)
Fall, 1983	Moldboard	Harvest Beets on 10/20/83	NM	Chisel	Harvest Beets on 10/20/83 Plant Rye 10/31/83	NM
Spring, 1984	Field Cultivate	Plant corn on 5/19/84	NM		Rye killed on 5/17/84 Plant corn on 5/19/86	NM (27%)

*Chisel plow used was a Glencoe "Soil Saver" with twisted shanks.

†NM = Not Measured

‡Residue cover after field operations

