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Effect of fall tillage following soybeans on organic matter losses in snowmelt

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Abstract

In a corn–soybean rotation, maintaining crop residue on the soil surface is a challenge following soybeans. Often farmers are encouraged not to till the soil following a soybean crop in order to maximize the amount of residue at the soil surface. In this study we evaluated the effect of this practice compared to fall moldboard plowing on snowmelt runoff and losses of total solids (TS) and organic carbon (using oxygen demand in runoff as a surrogate). A paired watershed approach was used to evaluate the effect of these management practices. Individual hydrographs were compared and contaminant losses in runoff calculated. Results show that snowmelt runoff and the associated losses of total solids, chemical oxygen demand (COD), and biochemical oxygen demand (BOD) were less with fall moldboard plowing compared to no fall tillage following soybean (0.22 cm, 1.9 kg ha^{-1}, 0.81 kg ha^{-1}, 74 g ha^{-1}, reduction in median value per melt cycle, respectively). In areas where snowmelt runoff is an important component of annual runoff, some tillage in the fall would be preferable to no-tillage in order to reduce snowmelt runoff losses.

Keywords: Corn; Soybeans; Surface runoff; Snowmelt; Oxygen demand; Carbon

1. Introduction

The use of conservation tillage to provide soil cover with crop residues is effective in reducing erosion. In the Midwest, farmers growing corn (*Zea mays* L.) and soybeans (*Glycine max* L.) in rotation are often encouraged to not till the soil in the fall following soybeans because there is little crop residue to provide soil cover and the residue decays faster than corn stover. One possible disadvantage of unanchored soybean residue and a smooth soil surface with no-tillage is that organic matter and other soluble plant residue constituents can be lost during snowmelt runoff. This has been shown to be the case for rainfall runoff (Schreiber and Neumaier, 1987; McDowell and McGregor, 1984; Maier et al., 1976).

Chemical (COD) and biochemical oxygen demand (BOD) are two of the most common measures of water quality. They both reflect the dissolved oxygen depletion by microbes as organic material is oxidized. Organic carbon can be estimated by assuming there is one mole of C oxidized per mole of O_2 consumed. The BOD and COD in field runoff can be associated with

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the solution and sediment phases. In this study BOD and COD were estimated on bulk samples. Chemical oxygen demand is an estimate of the amount of oxygen needed to oxidize the equivalent organic matter with a strong oxidant. Chemical oxygen demand is related to organic carbon in solution and solid phases. A study by Schreiber and McGregor (1979) showed the interaction between tillage, presence of crop residues, and erosion levels on losses of carbon and oxygen demanding materials in the southern United States. Crop residues were shown to be a major source of soluble carbon while sediment the likely source of solid phase carbon. Although COD better reflects potentially oxidizable organic matter, BOD better estimates levels of readily biodegradable organic carbon. In the same study BOD varied seasonally and was associated with surface residues in a no-tillage system.

There have been very few studies conducted that consider snowmelt and organic carbon losses in an agricultural setting (Hansen et al., 2000). Most of the research on snowmelt runoff has been done considering impact on alpine lakes or forested watersheds (Marsh and Pomeroy, 1999; Baron et al., 1991; Hornberger et al., 1994; Boyer and Hornberger, 1995; Hobbie and Likens, 1973). Runoff losses of labile organic carbon can result in depletion of dissolved oxygen levels in the receiving waters. This study compares fall moldboard plowing versus no fall tillage following soybeans on snowmelt runoff losses before secondary tillage in the spring using a paired watershed approach.

The carbon losses in snowmelt runoff should ultimately be viewed on an annual basis. Reicosky et al. (Reicosky et al., 1999; Reicosky and Lindstrom, 1993) have shown that physical loss of soil atmosphere carbon dioxide due to moldboard plowing can be significant although there is a wide range in reported values due to methodology (Reicosky et al., 1997). Also carbon losses associated with rainfall runoff during the growing season can be large if crop residues are not fully utilized following soybeans to control erosion. Many have shown that tillage also encourages soil carbon mineralization. This study shows that carbon loss with snowmelt runoff also needs to be considered.

The paired watershed approach (Clausen et al., 1996) is an appropriate method for assessing and comparing the effect of management systems on surface water runoff and associated contaminant losses when replication is not practical. This approach accounts for year to year climatic variability and identifies treatment effects at the watershed scale, giving more representative results than those extrapolated from small plots to larger areas. The paired watershed approach requires data collection on two watersheds (control and treatment watersheds) during two time periods (calibration and treatment periods). The statistical treatment of paired watersheds is covariance analysis, in which regression lines from both the calibration and treatment periods are compared for slope and intercept. Any difference between the two lines (slope and/or intercept) is attributed to the treatment.

2. Materials and methods

2.1. Site characterization

This research site is located on a farm north of New Prague, MN (44°40′N, 93°19′W). Two adjacent agricultural fields with natural surface drainage that allowed for a central water monitoring station were identified from detailed topographic maps. The fields are 1.7 ha (treatment watershed) and 1.1 ha (control watershed) with east facing slopes averaging 6%. The dominant soil at this site is a Clarion Loam (fine-loamy, mixed, mesic, Typic Hapludolls—FAO, Haplic Phaeozems). This soil is formed under tall prairie grasses. It has developed in undulating to rolling landscape and is well drained. Clarion soils have a high yield potential and are subject to erosion. This site was in a corn–soybean rotation with both watersheds (no-till and moldboard) under the same crop each year (1996 planted to soybean following corn and 1997 planted to corn following soybean, etc.). All tillage and planting were done perpendicular to the slope.

During the calibration period (1996–1999) both watersheds were fall chisel plowed after corn and there was no fall tillage following soybean. In the spring they were both disced twice and planted. During the treatment period (2000–2001) the no-till watershed was tilled as it was in the calibration period. During the treatment period the moldboard watershed was fall moldboard plowed followed by spring discing after