Does tillage increase frozen soil infiltration?

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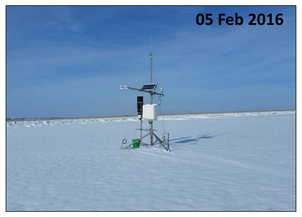
Objectives

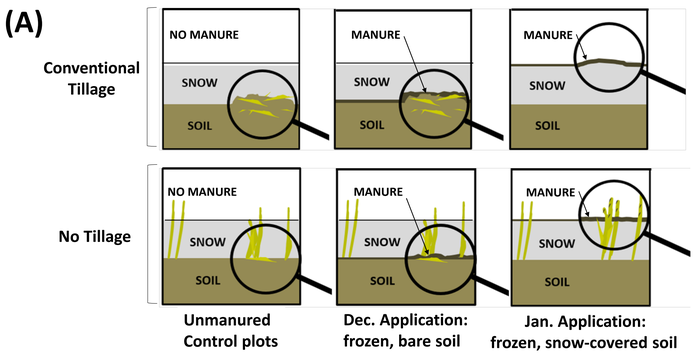
Wintertime land applications of manure are a longstanding practice in dairy agroecosystems, but may accelerate runoff generation, hence surface nutrient losses. **Our overall objectives are to:**

1) **quantify infiltration and runoff on frozen soils, and**
2) **identify key physical properties that drive differences in melt events relative to management practices.**



Methods

Location UW-Arlington Research Station, WI (43°18' N, 89°20' W)
Layout A 2x3 complete factorial design in triplicate (18 plots), that tests tillage and the timing of liquid manure applications on frozen soil



Water-Energy Balance Approach

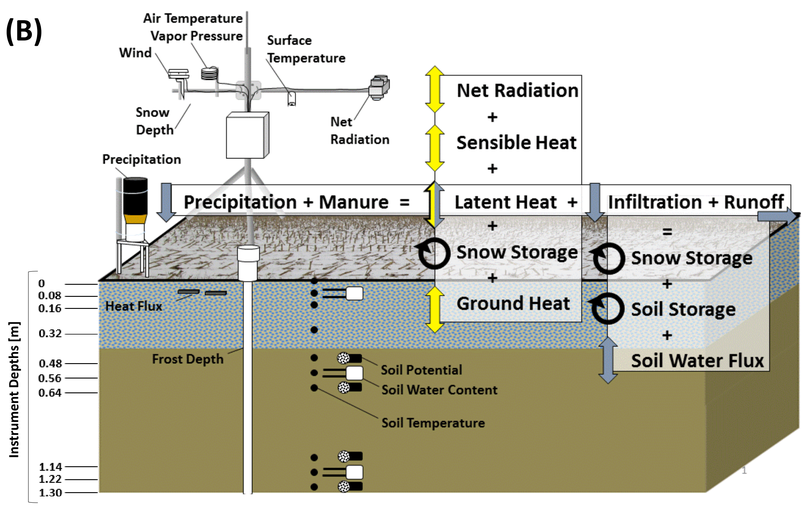


Figure 1. A) Six treatments combine conventional versus no tillage and the timing of manure applications to isolate drivers of runoff on frozen soil: surface roughness and manure-snow interactions. B) A schematic of measured field parameters to quantify the water-energy balance; the runoff collection system is pictured to the right.

Infiltration & Runoff

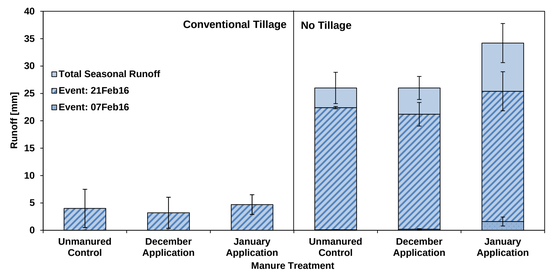


Figure 2. Total runoff (mm) with standard error (± SE) on frozen soils, relative to the key runoff events in Feb. 2016 by manure timing treatments and soils under conventional versus no tillage, respectively.

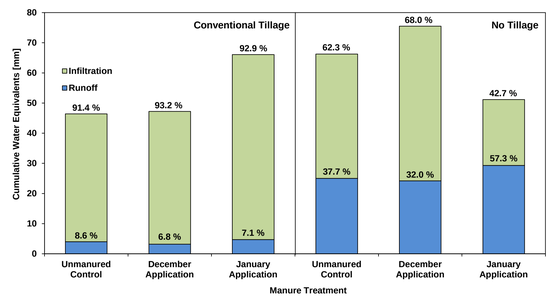


Figure 3. Cumulative water equivalents (mm) of infiltration and runoff, relative to available water, as calculated by the change in snow water equivalents minus sublimation. Percentages indicate the ratio of infiltration to runoff per treatment. Note: One event was excluded as snow drift obscured infiltration calculations.

A passive-divider runoff collection system uses V-notch weirs to collect up to 15 cm events for water analysis and load cells to record flow rate.

Hypothesized Mechanisms

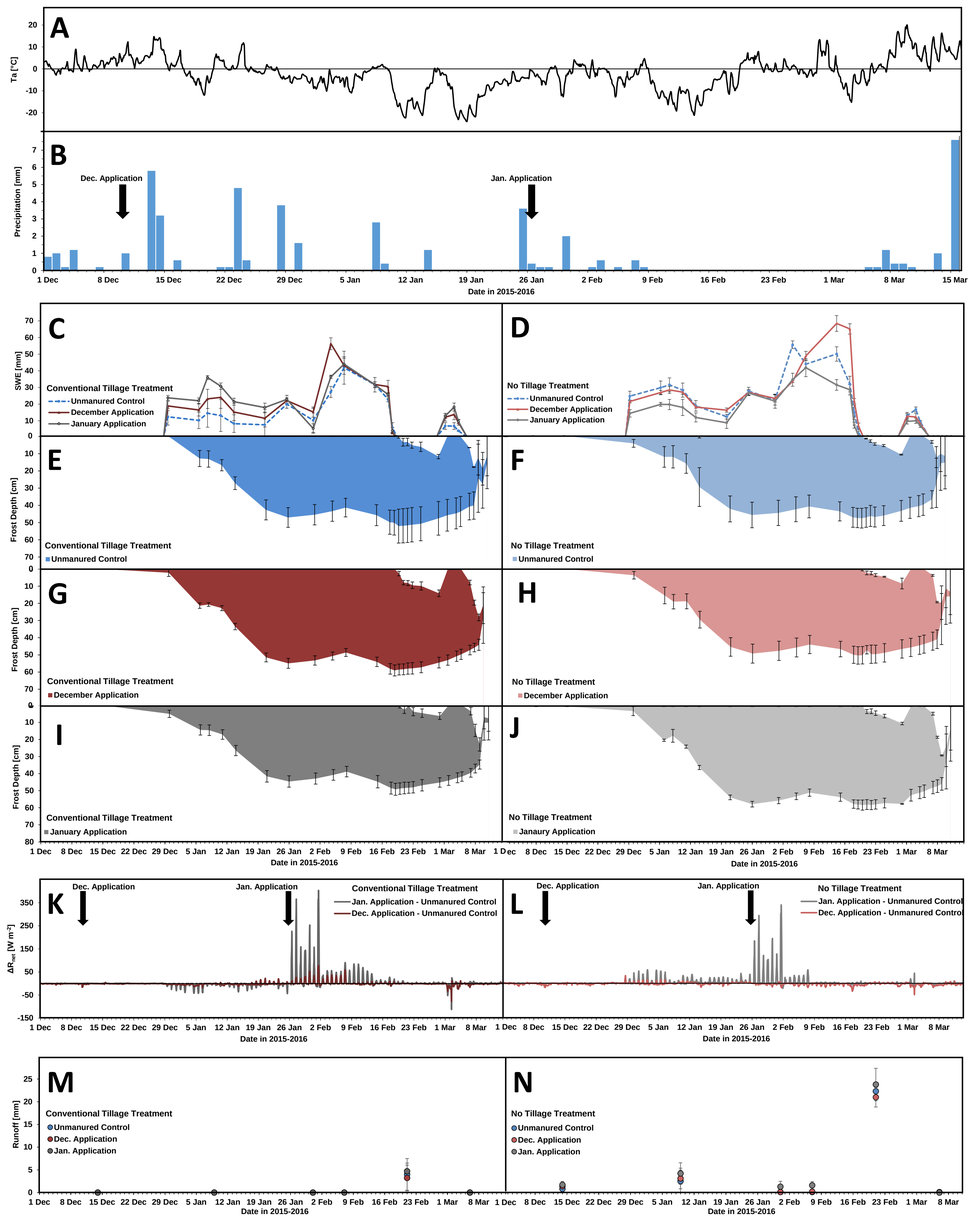


Figure 4. Atmospheric, soil, and hydrology data during the freezing season of 2015-16. A) Air temperature, Ta (°C); B) Precipitation (mm); C-D) Average Snow Water Equivalents, SWE (mm) ±SE, by manure timing treatment on soils under conventional versus no tillage, respectively; E-J) Average frost depth (cm) ±SE, by manure timing and tillage treatments; K-L) Differences in net radiation, ΔR_{net} (W m^{-2}), between manure timing treatments and unmanured controls by tillage type; M-N) Average runoff (mm) with SE by manure timing and tillage treatment.

Take-Home Message

The complexities of frozen soil processes, snowpack dynamics, and the liquid manure matrix require a mechanistic field approach to evaluate the wintertime management practices in dairy agroecosystems. Surface depressional storage from conventional tillage reduced runoff volumes by increasing the infiltration time for meltwater, relative no tillage. Mid-winter applications of manure (*i.e.* in January) decreased albedo, which promoted runoff events. Future research will investigate whether these applications also accelerate runoff by increasing the electrical conductivity of snowpack, thereby depressing its freezing point. Results will inform manure management models (SurPhos, Snap Plus) and nutrient management regulations in Wisconsin.

Acknowledgements

We thank Peter Wakeman, Andy Larson, Jim Richmond, Nick Bero, Zach Zopp, and Gabe Lujan for their field assistance and the University of Wisconsin Arlington Research Station for their collaboration.

This project is supported by the USDA-NIFA-AFRI (#3958); G.A. Harris Fellowship (Decagon Devices, Inc.); NCR-SARE Graduate Student Grant; William T. Dible Terra Int., Inc. Scholarship, Richard D. Powell Memorial Scholarship, Ruth & Carl Miller Academic Merit Awards, Champ Tanner Agricultural Physics Award, and the C.B. Tanner Memorial Travel Award (University of Wisconsin-Madison).

United States Department of Agriculture
National Institute of Food and Agriculture