Reducing winter P losses from dairy agroecosystems through tillage and manure application timing

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Research Motivations

• Logistical and environmental balance  Srinivasan et al. (2006)
  – ~75% of annual runoff on frozen soils  Good et al. (2012)
  – Nutrient losses from unincorporated manure on frozen soil
  – Cost-prohibitive long-term storage, emergency situations

• Updates to manure regulations

• Limited conclusive, mechanistic, or replicated field data
  – Confounding effects from weather, frozen soil complexity
  – Model routines needed for winter conditions

UW Arlington Agricultural Research Station
Objectives

• Identify management practices that reduce runoff on frozen soils
  • Conventional fall tillage vs. no-tillage
  • Manure application timing

• Quantify the biochemical and physical processes driving snowmelt, infiltration and runoff, and surface nutrient losses
6 Management Treatments

Conventional Tillage (Chisel)

No-Tillage

Unmanured Control

December: less frost, snow

January: frozen, snow-covered soil
Methods: Field Design

- UW Arlington Agricultural Research Station
- Liquid dairy manure, 37.4 kL ha\(^{-1}\) (4000 gal ac\(^{-1}\))
- Continuous corn for silage 2015-2018
- Silt loams, south-facing 5.9 % slope
Water-Energy Balance

Precipitation + Manure = Latent Heat + Infiltration + Runoff

Net Radiation + Sensible Heat + Snow Storage + Ground Heat = Infiltration + Runoff

Snow Storage + Soil Storage + Soil Water Flux

Heat Flux

Frost Depth

Air Temperature
Vapor Pressure
Wind
Surface Temperature
Net Radiation
Precipitation
Snow Depth

Soil Temperature
Soil Potential
Soil Water Content
Year 1: Tillage decreased runoff

The graph shows the run-off data from November 30 to March 21, 2016, with key events marked:
- Dec App.: December application
- Soil Froze: Soil froze
- Jan App.: January application
- Soil Thawed: Soil thawed

The graph compares run-off levels under different tillage and manure timing treatments.

- **CT-Control**
- **CT-Dec**
- **CT-Jan**
- **NT-Control**
- **NT-Dec**
- **NT-Jan**

The data indicates that tillage decreased run-off, especially noticeable in the graph's peak at the end of January.
Tillage, early application reduced TKP

![Graph showingTKP by date and tillage method]

- Conventional Tillage
- No-Tillage

Seasonal TKP [kg ha⁻¹]

- Unmanured Control
- December
- January

Manure Timing Treatment

AWRA
Mar. 9-10, 2017 | Elkhart Lake, WI
Tillage, early application reduced DRP

![Graph showing DRP levels over time for different tillage and manure timing treatments.]

- CT-Control
- CT-Dec
- CT-Jan
- NT-Control
- NT-Dec
- NT-Jan

Date in 2015-16

0 100 200 300 400 500
DRP [g ha⁻¹]

Conventional Tillage
No-Tillage

Seasonal DRP [kg ha⁻¹]

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7

Unmanured Control December January

Unmanured Control December January

Manure Timing Treatment
Frozen soil infiltration at a glance

- Tillage promoted infiltration on frozen soils
- January applications accelerated snowmelt, runoff on frozen soils

[Bar chart showing infiltration and runoff percentages for different treatments and timing of manure application.]
Hypothesized Mechanisms

Conventional tillage increases frozen soil infiltration
1. Surface depressional storage increases available time for infiltration

January applications accelerate snowmelt, runoff
2. Surface albedo decreases
3. Lowered freezing point of snowpack
Summary of Preliminary Findings

• Manure application rate reduced
  65.5 kL ha\(^{-1}\) (7000 gal ac\(^{-1}\)) to 37.4 kL ha\(^{-1}\) (4000 gal ac\(^{-1}\))

• Conventional tillage reduced runoff and P losses, January manure application accelerated P losses
  TKP losses 45x, DRP 16x higher in no-till January vs conventional till January treatments

• More data from additional freezing seasons
Thank you

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