Effect of Tillage and Nutrient Sources on Runoff and Percolation Losses of Phosphorus

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INTRODUCTION

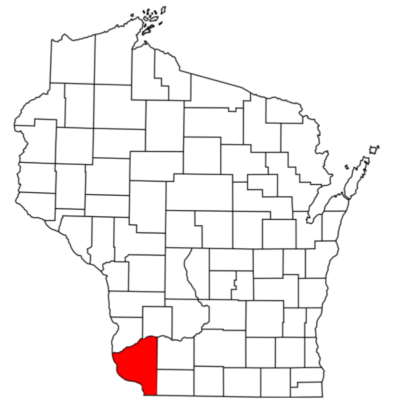
- Although phosphorus is an important plant nutrient, losses from agroecosystems can contribute to eutrophication and water quality degradation of freshwater ecosystems.
- Phosphorus is generally considered to be immobile in soil due to its high affinity for soil solids.
- Phosphorus management has largely focused on tillage control of soil erosion and runoff (e.g. Hansen et al., 2000; Daverede et al., 2003; Thoma et al., 2005)
- Leaching losses of phosphorus have been documented on sandy soils, soils where the phosphorus adsorption capacity has been exceeded, and soils containing preferential transport pathways (e.g. Brye et al., 2002; Djodjic et al., 2004; Zvomuya et al., 2005)

OBJECTIVE

- Quantify the extent of **total phosphorus losses in runoff** and **soluble phosphorus losses in percolation** in the karst region of the Upper Midwest.
- The karst region is particularly vulnerable to runoff and leaching losses of phosphorus due to runoff-prone silty soils susceptible to surface sealing, steep slope (>6%), and widespread presence of earthworm macropores.

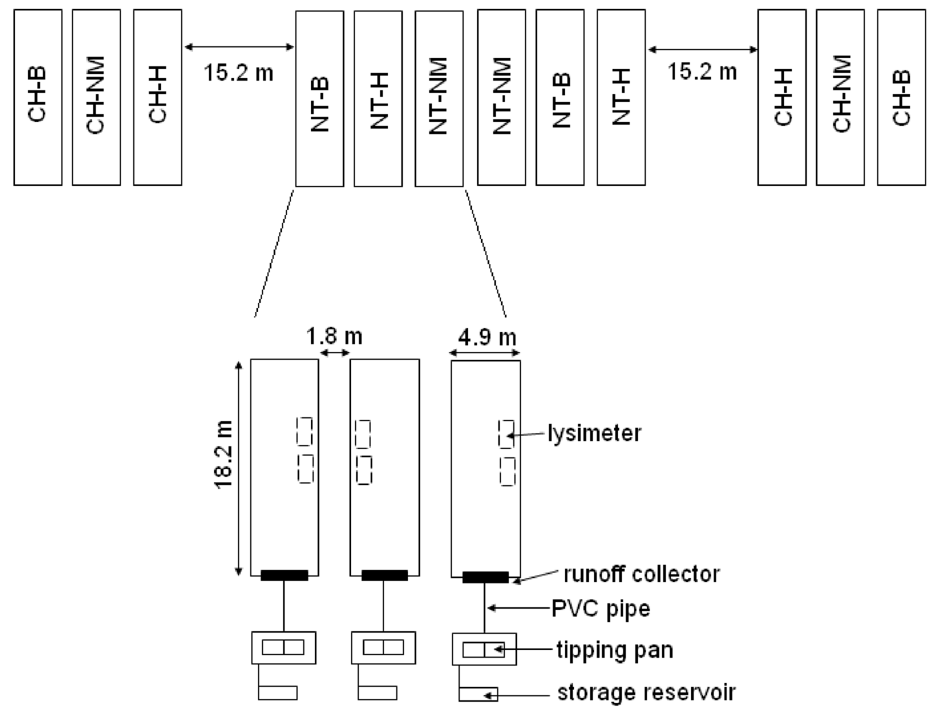
SITE LOCATION & CHARACTERISTICS

- Site Location: University of Wisconsin- Agricultural Research Station @ Lancaster, WI.
- Soil Series: Rozetta silt loam (Fine-silty, Typic Hapludalf)
- Surface Particle Size Analysis: 19% sand, 69% silt, 12% clay
- Site slope: 12%



EXPERIMENTAL DESIGN

- Two tillage treatments: chisel plow (CH) no-tillage (NT)
- Three nutrient sources: beef manure (B) hog manure (H) no-manure (NM)
- Runoff sampling: each plot isolated using galvanized sheet metal; water directed to tipping pan
- Percolation sampling: each plot contained two lysimeters (pan and wick) at 0.6m *(data averaged over both)*
- Water samples collected year-around from 2004-2006
- Runoff water sampled after each precipitation/snowmelt runoff event
- Percolation water sampled twice per month from April-October (non-frozen period)



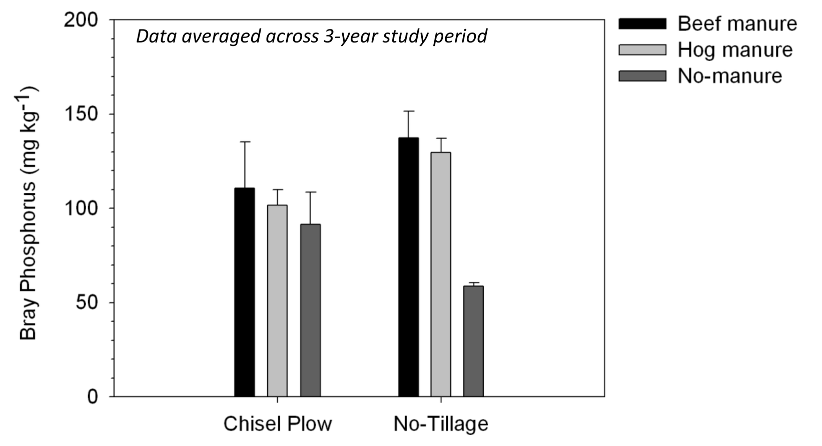
Percolation water sampling: pan lysimeter (left); wick lysimeter (right)

Runoff sampling: plot (left); runoff collector (center); tipping pan and sub-sampler (right)

NUTRIENT APPLICATION

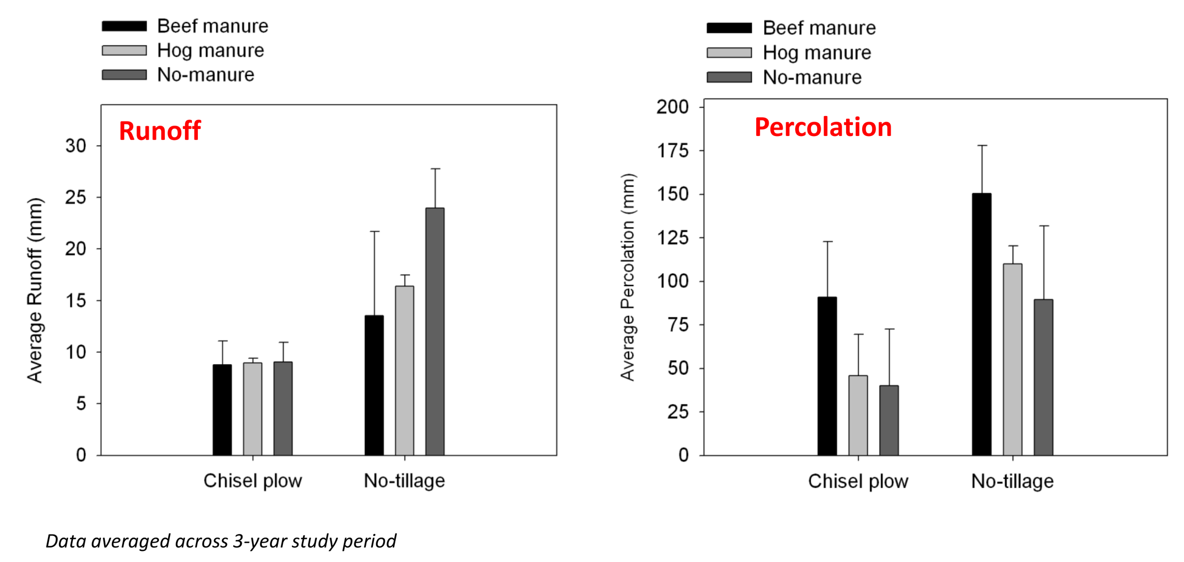
- Manure application occurred in the fall and was based on Univ. of Wisconsin nitrogen recommendations for continuous corn (180 kg N ha^{-1})
- Chisel plow: surface applied and incorporated
- No-tillage: surface applied and not incorporated
- Beef manure: 54-99 Mg ha^{-1}; **90-140 kg ha^{-1} total phosphorus**
- Hog manure: 65,500-131,000 L ha^{-1}; **56-92 kg ha^{-1} total phosphorus**
- No manure: urea application (no phosphorus)

SOIL PHOSPHORUS LEVELS



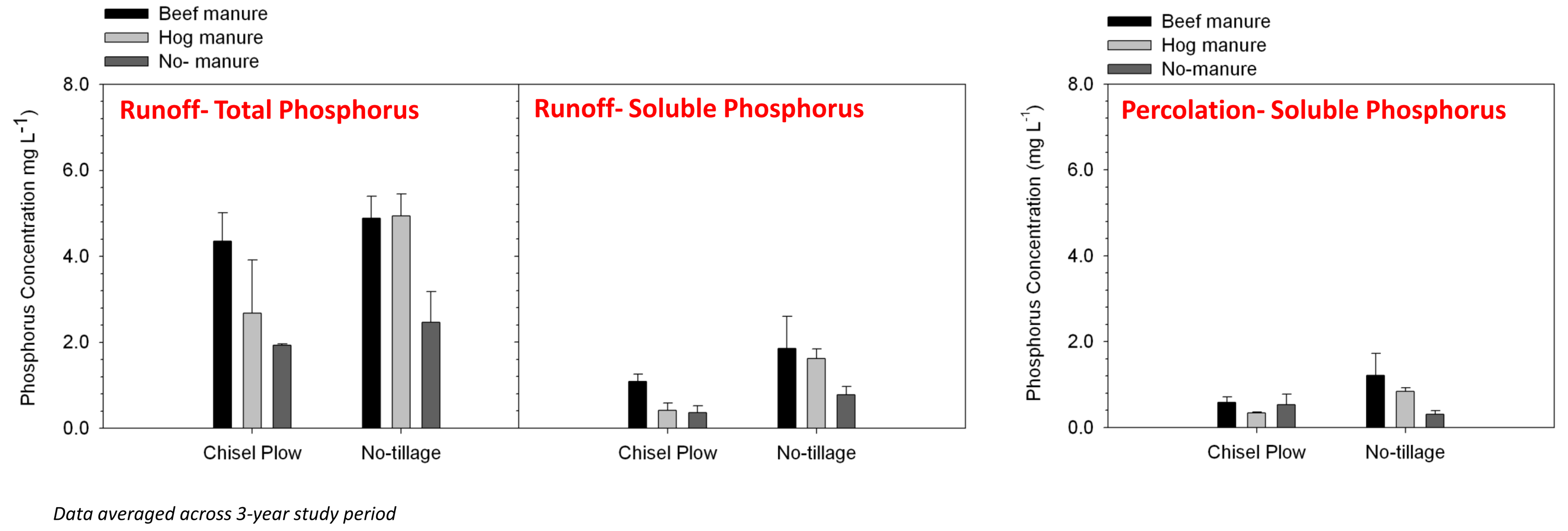
- Despite more than 6 years of no manure application prior to the start of this study, Bray soil phosphorus levels were **high** to **excessively high** for all treatments throughout the duration of the study period

WATER DYNAMICS



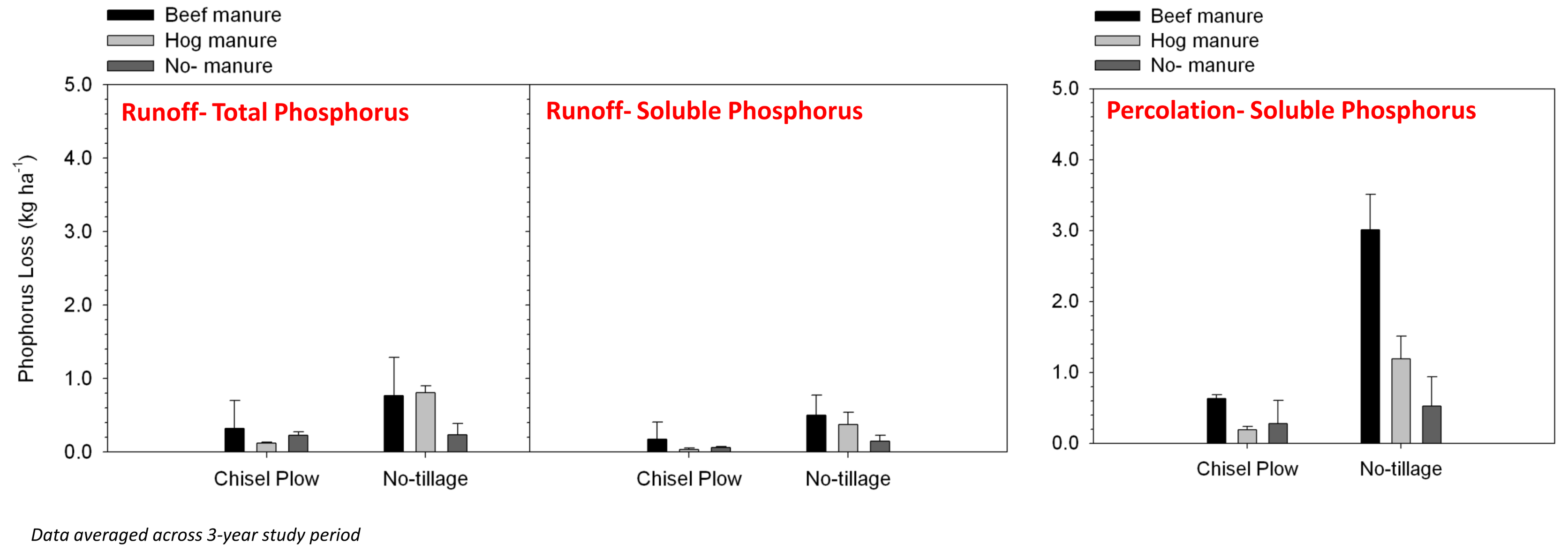
- percolation water losses >> runoff water losses
- percolation water losses approx. 10% of annual precipitation
- runoff water losses approx. 1% of annual precipitation
- runoff:
  - no tillage was greater due to smoother surface
  - chisel plow had no nutrient trend due to mixing
  - no-tillage manure application reduced runoff
- percolation:
  - no tillage was greater due to more macropores
  - nutrient dynamics inversely related to those for runoff

PHOSPHORUS CONCENTRATIONS IN RUNOFF AND PERCOLATION WATER



- runoff:
  - total P range: 0-50 mg L^{-1}
  - soluble P range: 0- 16 mg L^{-1}
  - soluble P accounted for approx. 30% of total P
- percolation:
  - soluble P range: 0-6 mg L^{-1}
  - higher concentration in no-tillage treatment (more macropores)

PHOSPHORUS LOSSES FROM RUNOFF AND PERCOLATION WATERS



- percolation P loss > runoff P loss
- no-tillage loss > chisel plow loss
- beef > hog > no manure as expected based on P application rates
- phosphorus losses due to macropore transport

REFERENCES

Brye et al. 2002. Phosphours leaching under a restored tallgrass prairie and corn agroecosystem. J. Environ. Qual. 31:769-781.
Daverede et al. 2003. Phosphorus runoff: Effect of tillage and soil phosphorus levels. J. Environ. Qual. 32:1436-1444.
Djokjic et al. 2004. Phosphorus leaching in relation to soil type and soil phosphorus content. J. Environ. Qual. 33:678-684.
Hansen et al. 2000. Snowmelt runoff, sediment, and phosphorus losses under three different tillage systems. Soil Till. Res. 57:93-100.
Thoma et al. 2005. Tillage and nutrient source effects on water quality and corn grain yield from a flat landscape. J. Environ. Qual. 34:1102-1111.
Zvomuya et al. 2005. Phosphorus leaching in sandy outwash soils following potato-processing wastewater application. J. Environ. Qual. 34:1277-1285

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