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Soil nutrient variability and groundwater nitrate-N in agricultural fields☆

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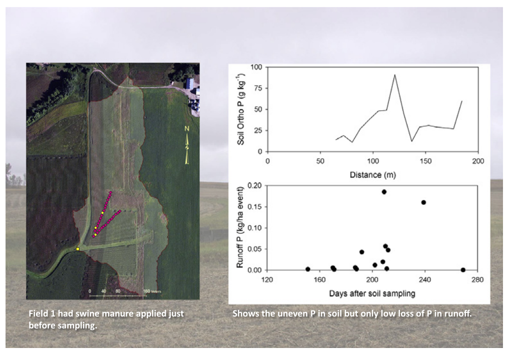
HIGHLIGHTS

- Significant slope or curvature effects only for large range
- No significant landscape effects for large nutrient range
- High groundwater nitrate-N low areas: additions balanced losses

GRAPHICAL ABSTRACT



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ABSTRACT

Landscape may result in uneven nutrient loads within a field. The objective of this study was to determine the influence of landscape on soil carbon and nutrient levels, and on levels of nitrate-N in groundwater. Soil samples were collected in three fields, two transects each, 30 sites in each field. The soil morphology was characterized for the profile, and soil organic carbon and nutrient levels were determined for 0–0.15 and 0.15–0.3 m depths. Each field had wells installed at three of the sites. One field showed a wide range of landscape variability, and significant effects of curvature on soil carbon and nutrient levels. Another field showed no significant effect of slope or curvature on soil carbon and nutrient levels because the nutrient levels were quite variable, including high spikes. The third field had less variable landscape trends but still showed a few significant effects on soil carbon and nutrient levels. Nitrate-N levels remained high in two of the nine wells (20 to 50 mg L^{-1}), suggesting that additions of nitrate-N at the concave or converging sites replaced any losses. Median nitrate-N levels at the other seven well sites were lower, ranging from 8 to 17 mg L^{-1}. Influence of landscape on soil carbon and nutrients was more detectable when the landscape factors were highly variable without excessive variability in soil nutrient properties.

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1. Introduction

Phosphorus losses from agricultural fields are primarily in runoff, whereas nitrate is lost to groundwater (Pärn et al., 2012). Landscape and management may result in uneven nutrient loads within field soils. Water tends to accumulate in low slope, concave, and converging parts of the landscape; however, high slope, convex, and diverging regions usually shed water (Moore et al., 1988). Erosion due to water and tillage may transport nutrient-laden surface soil from shoulder and backslope positions to footslope and toeslope positions (Kaspar et al., 2004; Priyashantha et al., 2007; Li et al., 2013). Sacchi et al. (2013) showed higher nitrate-N levels in groundwater at footslope sites than for other landscape positions. On the other hand, ponding

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within depressions could contribute to denitrification or leaching of nitrate (Cambardella et al., 1999). Footslope and toeslope sites often have higher levels of soil organic carbon (Ritchie et al., 2007; Li et al., 2013; Fissore et al., 2017) than shoulder or backslope positions.

The footslope, toeslope, and depressional areas with high nutrient levels in the surface soil may be located close to tiles, ditches, and grass waterways in fields. Depressions and low slope areas can trap nutrient- and carbon-rich sediment (Beach, 1994; Almendinger et al., 2014). Eroded sediments tend to be deposited close to the eroded site, and the newly deposited sediments could be a source for future erosion (VandenBygaart et al., 2012).

The hypotheses of this study were that 1) soil organic carbon and phosphorus levels are higher in low slope, concave, and converging parts of the landscape, and 2) groundwater nitrate-N concentrations at lower landscape positions will be decreased. The objective of this study were to determine if landscape factors (slope and curvature) influenced carbon and nutrient levels in surface soil or nitrate levels in groundwater.

2. Materials and methods

2.1. Site descriptions

The sites examined (Fig. 1) included Des Moines lobe sites: a field in Walnut Creek watershed (Hatfield et al., 1999) and two fields in the South Fork watershed of the Iowa River (Tomer et al., 2008). The Des Moines lobe is characterized by limited stream development, mainly at the lower outlet end of watersheds, with many closed depressions upland. Now the area is extensively tile-drained.

Field 1 (Figs. 2, and S1) in the South Fork watershed was close to the eastern edge of the Des Moines lobe and had the steepest slopes. The latitude was 42°19′28.3″N, and longitude was 93°15′20.2″W. There were fall additions of swine manure before corn (*Zea mays* L.) the following season. The injected manure was disked in (Tomer et al., 2016). The rotation was corn - corn - soybean (*Glycine* max (L.) Merr), with soybean in 2012 and 2015. This site had a flume for runoff monitoring (Tomer et al., 2016).

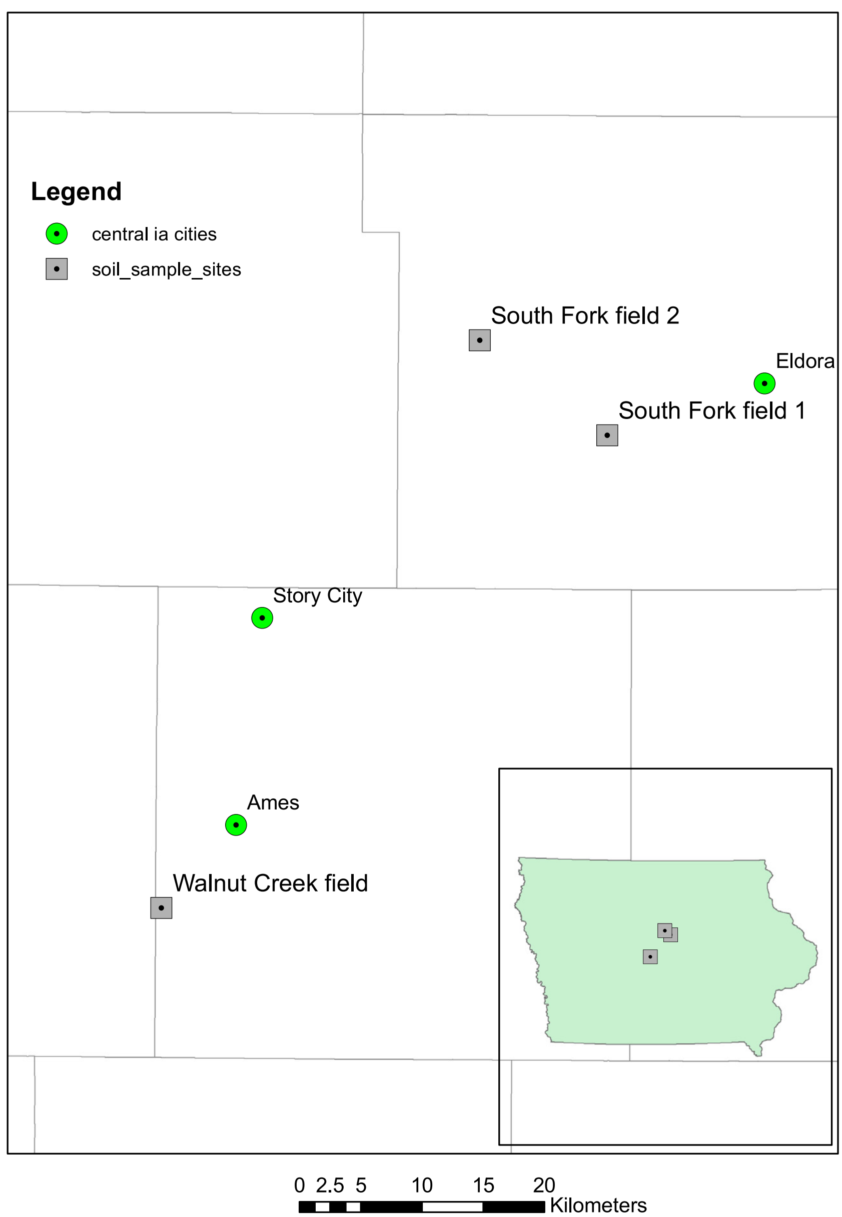

Fig. 1. Location of the three sampled fields in Iowa.