Evaluation of Soil Parameters After Long-Term Subsurface Drip Irrigation Under Minimum Tillage System

E.B. Rutter and D.A. Ruiz Diaz

Summary
The objective of this study was to evaluate soil parameters after the long-term use of sub-surface drip irrigation under no-till, with the use of high pH irrigation water. Results from this study showed that stratification of soil pH and soil test phosphorus (P) was more prominent when compared to other soil parameters. However, the stratification of pH and soil test P is likely the combined effect of surface fertilizer application and sub-surface irrigation water. The stratification of other parameters, such as soil calcium (Ca) and sodium (Na) and electrical conductivity (EC), was less clear. Soil test potassium (K) showed some level of stratification, with higher levels deeper in the soil profile; this is likely due to some K application through the irrigation water, but also the finer textured soil.

Introduction
Sub-surface drip irrigation (SDI) systems can contribute to a significant increase in water use efficiency and crop productivity. Drip tapes are placed permanently and can be located at different depths depending on installation guidelines and management. Older systems were generally placed at more than 10 inches below the surface. After multiple years, and depending on the characteristics of the irrigation water, some soil parameters, distribution of cations, and pH may be affected. The objective of this study was to evaluate soil parameters after the long-term use of SDI (>20 years) under no-till, with the use of high pH irrigation water.

Procedures
Soil samples were collected from a Crete silt loam located in a field near Moundridge (McPherson County, KS) that has been under no-till management and sub-surface drip irrigation for more than 20 years. Samples were collected in fall 2019 using a hand probe and pre-drilled wooden templates with holes spaced 3 inches apart. Three small trenches were dug to locate the length and direction of the SDI drip tape, which was buried approximately 14.5 inches below the soil surface. The sampling templates were laid on the ground, perpendicular to the drip tape, and staked into place to prevent movement during sampling. Soil cores were then collected from the 3-, 6-, and 9-inch horizontal increments on both sides of the drip tape. These soil cores were then separated in 3-inch depth increments, centered around the drip tape, and corresponded to 0-, 3-, and 6-inch depths above and below the tape (tape = 0-inch depth) to generate a grid with the profile distribution of nutrients (Hansel et al., 2017). Soil from each core

shallower than 7 inches was saved and mixed together as a composite sample to assess the surface fertility of the sampled area. This process was repeated at each template spaced approximately 30 feet apart. A sample of the irrigation water was also collected from the groundwater well on the same day soil samples were collected.

Soil pH, nutrient analysis, and salinity tests were performed on each soil sample. Soil pH was measured using a 1:1 soil-water suspension and robotic dual-probe pH meter. Phosphorus (P) concentrations were determined from Mehlich-3 extracts. Calcium, potassium, and sodium were measured using ICP-AES from both saturated paste extracts. Soil electrical conductivity was also measured from the saturated paste extracts. Water analyses include pH, EC, Ca, magnesium (Mg), K, Na, NO_3, sulfur (S), iron (Fe), manganese (Mn), copper (Cu), and zinc (Zn).

Results

The irrigation water at this location was alkaline (pH = 7.5) with measurable levels of cations (Ca, K, Mg, and Na), in addition to NO_3 and S (Figure 1). These characteristics would typically require regular maintenance of the SDI system to avoid the accumulation of carbonates over time.

Soil sampling from this study showed that pH, soil test P, and soil test K were highly stratified in these soils (Figures 2 and 3). Soil pH and soil test K generally increased with depth from the soil surface. Soil test P was also highly stratified in these soils and was approximately ten times higher near the surface than at the bottom of the profile. These results are likely due to the history of surface P fertilizer application and reduced tillage system with no soil mixing in this field, and are similar to previous studies in Kansas (Adee et al., 2016; Arruda et al., 2019; Preston et al. 2019). The increase in soil pH near the SDI drip tape was likely contributed by the high pH irrigation water, but also the surface application of fertilizers, which contributed with acidity near the surface. The higher soil K level deeper in the profile may be due to the combination of K supply through the irrigation water (Figure 1), but also the higher clay content and cation exchange capacity at this layer.

Soil salinity parameters (EC, Ca, Na) were generally low, and no clear relationship between soil depth or horizontal distance from the SDI drip tape was observed (Figures 4 and 5). Given the age of the irrigation system and the characteristics of the irrigation water, the management practices employed in this field (such as regular acid treatments of the irrigation system) appear to manage introduced cations adequately.

References

Adee, E., Hansel, F.D., Ruiz Diaz, D.A., and Janssen, K. 2016. Corn response as affected by planting distance from the center of strip-till fertilized rows. Front. Plant Sci. 7: 1232. doi: *https://doi.org/10.3389/fpls.2016.01232*.

Arruda M.J., D.A. Ruiz Diaz, F.D. Hansel, G. Hettiarachchi and P. Pavinato. 2019. Long-term fertilizer placement in a corn-soybean rotation affect soil phosphorus fractions and legacy. Geoderma. *https://doi.org/10.1016/j.geodrs.2019.e00228.*

Hansel, F.D., D.A. Ruiz Diaz, T.C. Amado, L.M. Rosso. 2017. Deep banding increases phosphorus removal by soybean grown under no-tillage production systems. Agron. J. 109:1091-1098.

Preston, C.L. D.A. Ruiz Diaz and D.B. Mengel. 2019. Corn response to long-term phosphorus fertilizer application rate and placement with strip-tillage. Agron. J. 111:1–10.

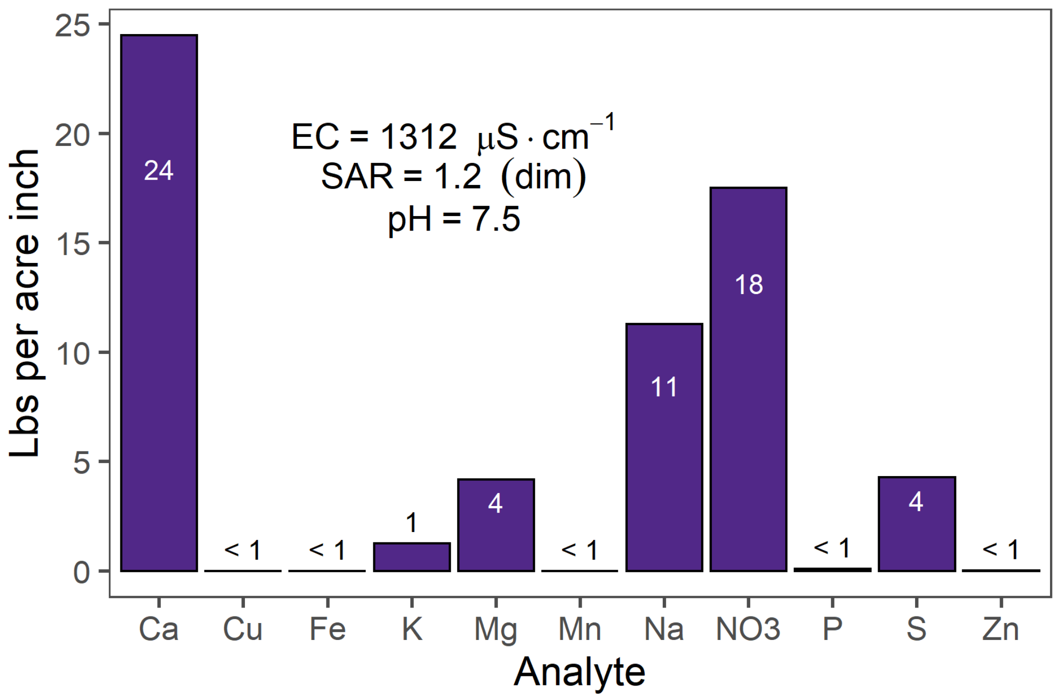

Figure 1. Nutrient analysis of the irrigation water. All nutrients are expressed in pounds of nutrient per acre inch of irrigation water applied. EC = electrical conductivity. Calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), phosphorus (P), sulfur (S), zinc (Zn). SAR = sodium adsorption ratio.

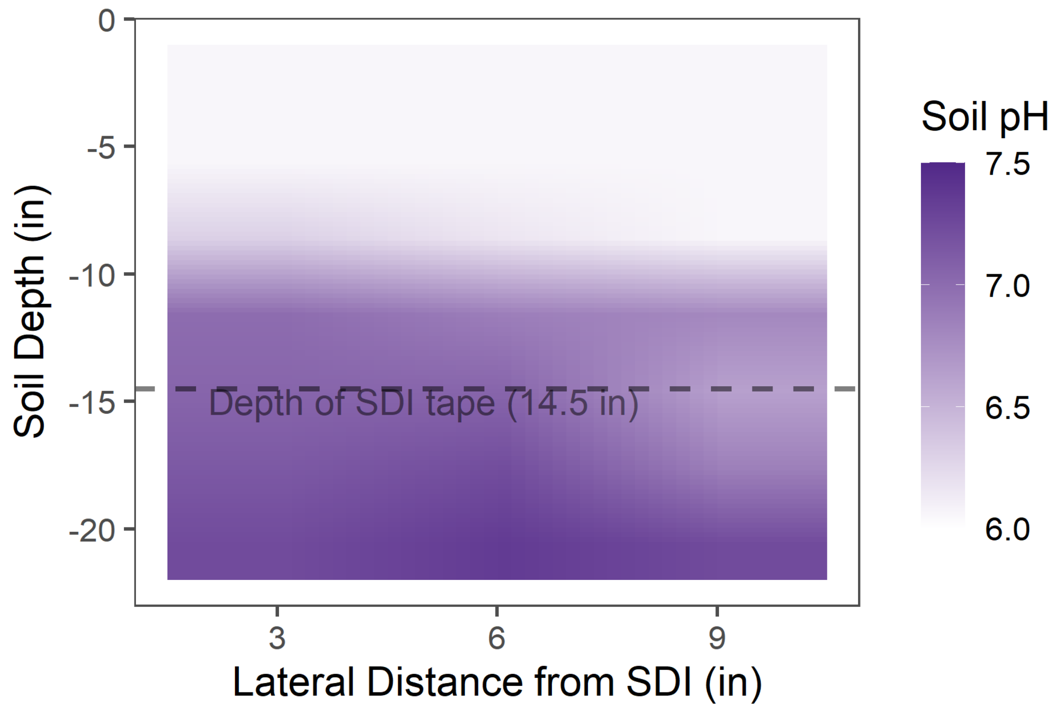

Figure 2. Soil pH as a function of soil depth and lateral distance from the sub-surface drip irrigation (SDI) drip tape. The tape was buried approximately 14 inches below the soil surface. The darker color indicates higher pH. The soil in the surface layer was approximately 6.0 pH.

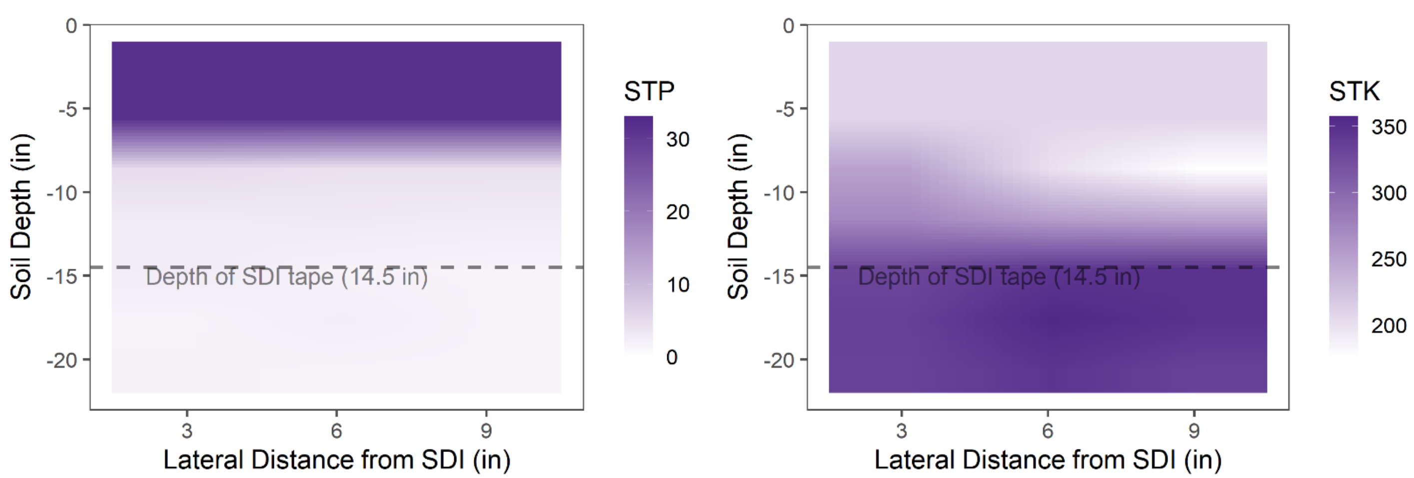

Figure 3. Soil test phosphorus (P) and potassium (K) as a function of soil depth and lateral distance from the sub-surface drip irrigation (SDI) tape. The irrigation tape was buried approximately 14 inches below the soil surface. Phosphorus is expressed as ppm and the darker color indicates higher soil test P. Soil test P (STP) in the surface layer (0–7 inches) was approximately 32 ppm. Soil test K (STK) in the surface layer was 208 ppm.

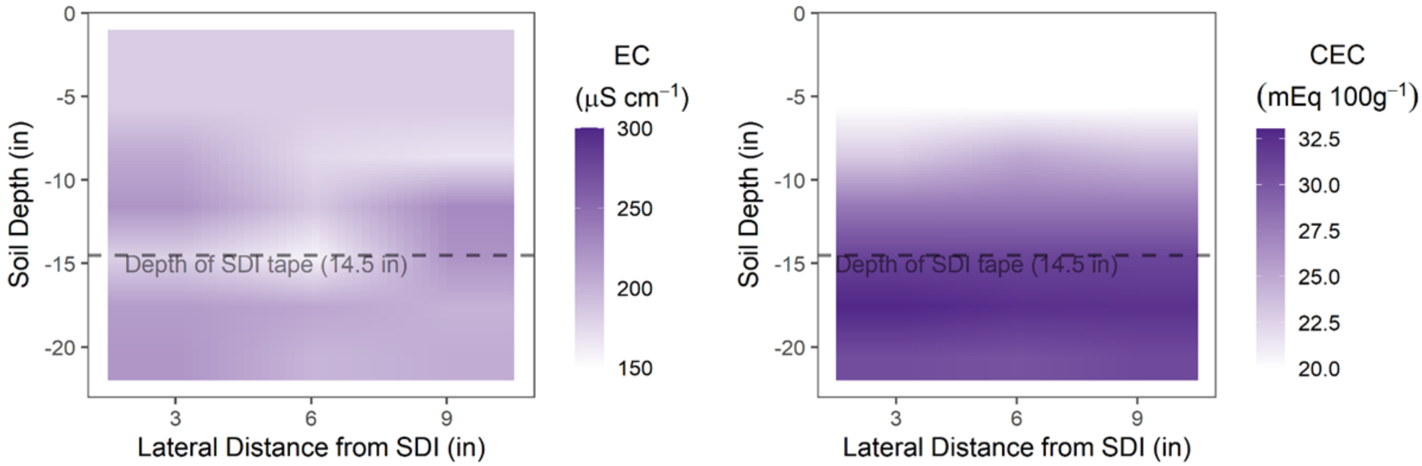

Figure 4. Soil electrical conductivity (EC) and cation exchange capacity (CEC) as a function of soil depth and lateral distance from the irrigation tape. The sub-surface drip irrigation (SDI) tape was buried approximately 14 inches below the soil surface. Electrical conductivity is expressed as µS cm^{-1} and the darker color indicates higher EC. Cation exchange capacity was estimated as a function of water required to saturate the sample.

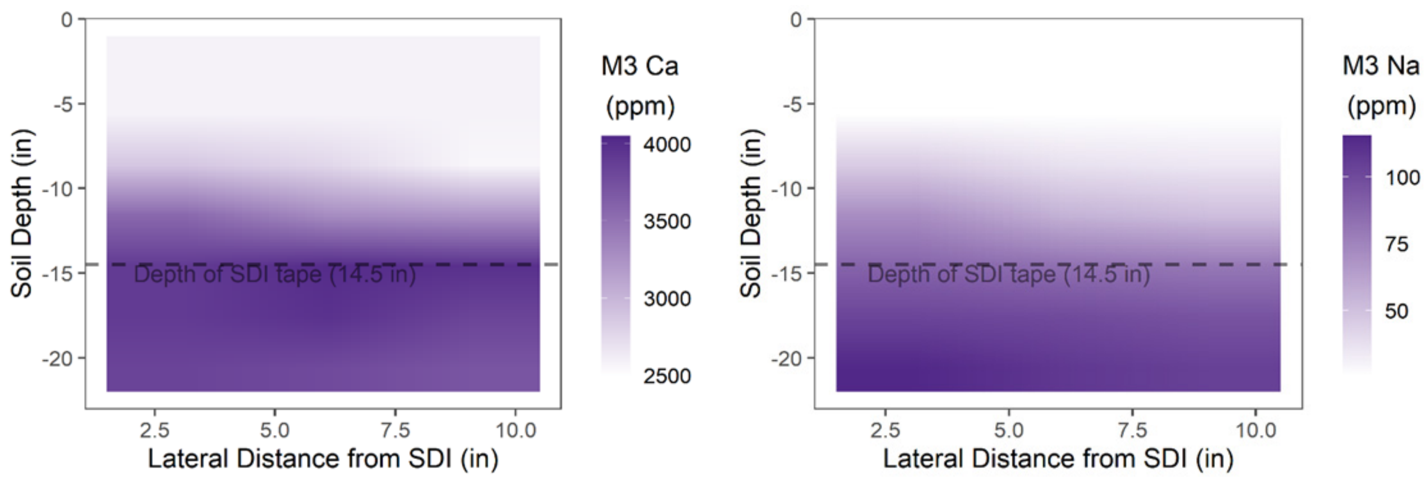

Figure 5. Soil test calcium (Ca) and sodium (Na) as a function of soil depth and lateral distance from the sub-surface drip irrigation (SDI) tape. The irrigation tape was buried approximately 14 inches below the soil surface. Calcium and Na were measured using the Mehlich-3 (M3) soil test procedures and are expressed as soil ppm.