The International Society of Precision Agriculture presents the
15th International Conference on
Precision Agriculture
26–29 JUNE 2022
Minneapolis Marriott City Center | Minneapolis, Minnesota USA

Investigating the spatial relationship of apparent electrical conductivity with turfgrass and soil characteristics in sand-capped golf course fairways

Chase Straw, Briana Wyatt, A. Peyton Smith, Dallas Williams, Kate Watkins, Sarah Hong, Cesar Garza, Ty Jansky, and Weston Floyd

Texas A&M University, Department of Soil and Crop Sciences, College Station, TX 77843, United States

A paper from the Proceedings of the
15th International Conference on Precision Agriculture
June 26-29, 2022
Minneapolis, Minnesota, United States

Abstract

Turfgrass quality decreases when grown on fine textured soils that are irrigated with poor quality water. As a result, sand-capping (i.e., a sand layer above existing native soil) is now considered during golf course fairway renovation and construction. Mapping spatial variability of soil apparent electrical conductivity (EC_a) has recently been suggested to have applications for precision turfgrass management in native soil fairways, but sand-capped fairways have received less attention. The objective of this study was to use electromagnetic induction (EMI) to investigate the spatial relationship of EC_a with turfgrass and soil characteristics in sand-capped fairways from two golf courses in TX that were either bermudagrass or zoysiagrass. Apparent electrical conductivity, soil moisture (% volumetric water content), penetration resistance, normalized difference vegetation index (NDVI), and depth of organic layer data were collected on two fairways at each course in April 2021. Interpolation of turfgrass and soil characteristics was done in ArcMap using ordinary kriging and correlation coefficients were calculated to assess the strength and direction of relationships (α=0.05). Correlation coefficients of EMI EC_a on all fairways were positive with soil moisture (r=0.13 to 0.63), and the relationships were statistically significant on three of the four fairways. The NDVI and EMI EC_a relationships were positive and significant on zoysiagrass fairways (r=0.33 and 0.42), but not significant and had mixed directional trends on bermudagrass fairways (r=-0.10 and 0.20). Depth of organic layer and penetration resistance correlation coefficients with EMI EC_a were all positive (r=0.08 to 0.30) and negative (r=-0.24 to -0.49), respectively, yet the relationships were statistically significant on only one fairway. Results indicate that the spatial variability of EC_a in sand-capped fairways may be influenced by several turfgrass and soil characteristics; nevertheless, inconsistent strength and direction of relationships in fairways within and between golf courses warrants further research.

Keywords
apparent electrical conductivity, golf courses, soil moisture, turfgrass, variability

Introduction

Turfgrass quality decreases when grown on fine textured soils that are irrigated with saline water. As a result, sand-capping (i.e., a sand layer above existing native soil) is now considered during golf course fairway renovation and construction to enhance surface drainage and assist in flushing salts. Mapping spatial variability of soil apparent electrical conductivity (EC_a) has been utilized in precision agriculture for decades to help manage soil salinity of large areas (Corwin and Lesch, 2003). This strategy has also been considered in precision turfgrass management of golf course fairways for site-specific leaching and soil amendment applications, as well as to identify locations for in-ground EC_a monitoring sensors (Carrow et al., 2010). While overall research investigating the spatial variability of EC_a in fairways is limited, native soil systems have received all consideration, so knowledge regarding the factors that most strongly influence it in sand-capped systems is needed. The objective of this study was to use electromagnetic induction (EMI) to investigate the spatial relationship of EC_a with several turfgrass and soil characteristics in sand-capped fairways from two golf courses in TX.

Materials and Methods

Data were collected 12 April 2021 at The Club at Carlton Woods in The Woodlands, TX, which consists of two 18-hole golf courses. Both courses had a target fairway sand-capping depth of 20.3 cm during construction; however, one was built in 2001 with 'Tifway 419' bermudagrass and the other in 2005 with 'Zeon' zoysiagrass. Two fairways at each course were considered in the study. Georeferenced EC_a (mS m^{-1}) data were measured from the fairways at a 0.5 m depth using a tow-behind DUALEM-1S (Dualem Inc., Ontario, Canada) that had an equipped external GNSS receiver (Jupiter Systems Inc., Hayward, CA, United States). Georeferenced soil moisture (% volumetric water content) and penetration resistance (MPa) data were collected at a 10.2 cm depth using a tow-behind Toro Precision Sense 6000 (PS6000; The Toro Company, Bloomington, MN, United States) that had an equipped external GNSS receiver (NovAtel Inc., Alberta, Canada). Additionally, the PS6000 measured normalized difference vegetation index (NDVI) with two GreenSeeker Model 500 (Trimble Inc., Sunnyvale, CA, United States) active sensors mounted to its back. An 8.5 m^2 sampling grid was also generated for each fairway in ArcMap version 10.6.1 and imported into a Trimble Geo 7X handheld GNSS receiver (Trimble Inc., Sunnyvale, CA, United States) connected to a Trimble Tornado antenna on a 2 m surveying pole. The sampling grid was used to identify locations for measuring soil moisture and EC_a at a 12.2 cm depth with a handheld FieldScout TDR 350 (Spectrum Technologies Inc., Aurora, IL, United States) and elevation with the handheld GNSS receiver (mean sea level; m), as well as obtaining a single soil core for measuring the depth of organic layer with a digital caliper.

Interpolation of turfgrass and soil characteristics was done in ArcMap using ordinary kriging to produce raster maps that were classified into three classes with Jenks natural breaks. Values from the raster maps using the DUALEM-1S and PS6000 data were extracted to the sampling grid locations in each fairway. The 'modified.ttest' function in the SpatialPack package of RStudio was used to determine correlation coefficients for assessing the strength and direction of relationships between all measured characteristics. Relationships were considered significant at α=0.05.

Results

Correlation coefficients with EMI EC_a in all fairways were positive for PS6000 (r=0.13 to 0.63) and handheld (r=0.20 to 0.62) soil moisture, and the relationships were statistically significant in three of the four fairways for each (Fig 1). There were significant, positive relationships between EMI EC_a and handheld EC_a in all fairways (r=0.33 to 0.61). The NDVI and EMI EC_a relationships were positive and significant in zoysiagrass fairways (r=0.33 and 0.42), although not significant and had mixed directional trends in bermudagrass fairways (r=-0.10 and 0.20) (Fig 1). Penetration resistance and depth of organic layer correlation coefficients with EMI EC_a were all negative (r=-

0.24 to -0.49) and positive (r=0.08 to 0.30), respectively, yet each relationship was statistically significant in only one fairway (Fig 1). Elevation had a negative relationship with EC_a in three fairways, but only one of these relationships was significant.

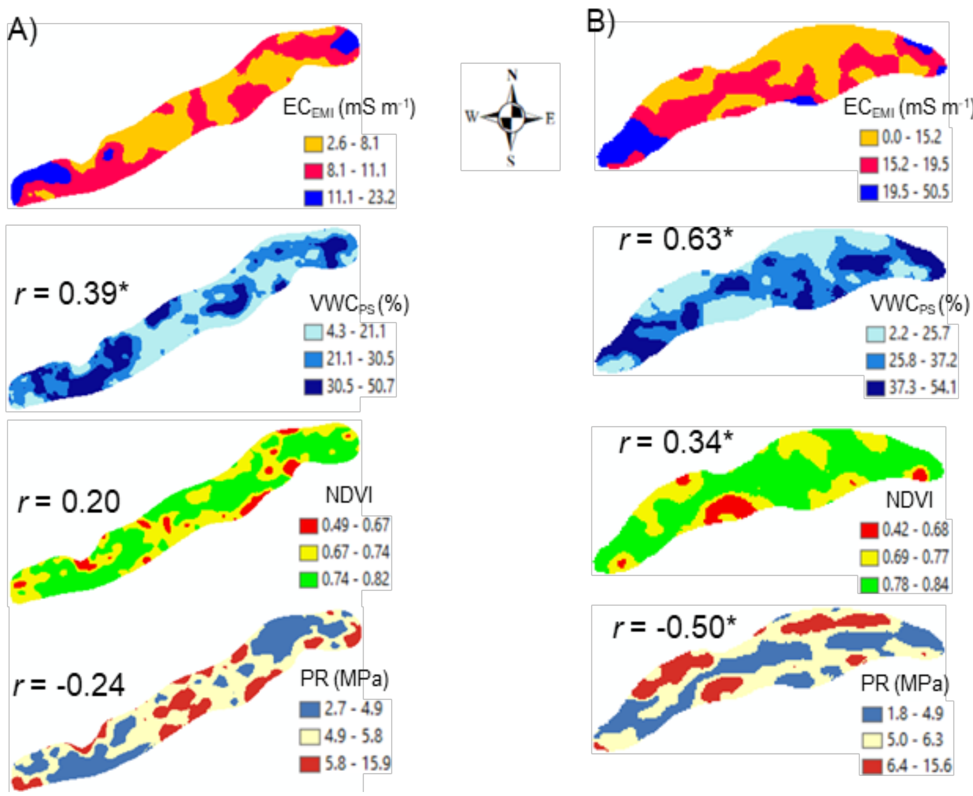

Fig 1. Spatial maps of apparent electrical conductivity from the DUALEM-1S (EC_{EMI}), soil moisture from the Precision Sense 6000 (VWC_{PS}), normalized difference vegetation index (NDVI), and penetration resistance (PR) from one fairway at the A) bermudagrass and B) zoysiagrass course. Correlation coefficients are the relationship to EC_{EMI} (* = significant at α=0.05).

Conclusion

Results indicate that the spatial variability of EC_a in sand-capped fairways may be influenced by several turfgrass and soil characteristics; nevertheless, inconsistent strength and direction of relationships in fairways within and between golf courses warrants further research.

Acknowledgements

The authors would like to thank Tim Huber, golf course superintendent at The Club at Carlton Woods, for use of the golf courses. Thanks are also extended to Gary Hinton (GreyHawk Multi-Scope), Zeke Hurd (Pegasus Environmental), and Adam McCaffery, Bailey Simmons, Canute Janish, and Jose Diaz (Texas A&M University) for their assistance with data collection.

References

Carrow, R. N., Krum, J. M., Flitcroft, I., & Cline, V. (2010). Precision turfgrass management: Challenges and field applications for mapping turfgrass soil and stress. Precision agriculture, 11(2), 115-134.

Corwin, D. L., & Lesch, S. M. (2003). Application of soil electrical conductivity to precision agriculture: theory, principles, and guidelines. Agronomy journal, 95(3), 455-471.

Grubbs, R. A., Straw, C. M., Bowling, W. J., Radcliffe, D. E., Taylor, Z., & Henry, G. M. (2019). Predicting spatial structure of soil physical and chemical properties of golf course fairways using an apparent electrical conductivity sensor. Precision Agriculture, 20(3), 496-519.