Apparent electrical conductivity to characterize soil water content

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Objectives

The specific objectives of this study were (1) to assess how consistently ECa derived management zones characterize SWC at field scale and (2) to determine whether soil properties coupled with apparent soil electrical conductivity could further improve the characterization of SWC.

Introduction

Precision irrigation (PI) is a relatively new concept in agriculture, and it provides a vast potential for enhancing water use efficiency while maintaining or increasing grain yield. As part of site-specific farming, PI needs to be explored, tested, and evaluated which continues to be a research issue.

One among many challenges in implementing PI is the reliable characterization of the soil water content (SWC) across spatially variable fields.

Review of the current literature indicates that the level of efficiency of SWC characterization by ECa has not been properly studied at the field scale. We hypothesize that accounting for soil properties can further improve the relationship between SWC and ECa.

Fig. 1. Model 503 DR Hydroprobe for soil water content data collection (left). Geonics EM38-MK2 sensor for apparent electrical conductivity measurement (right).

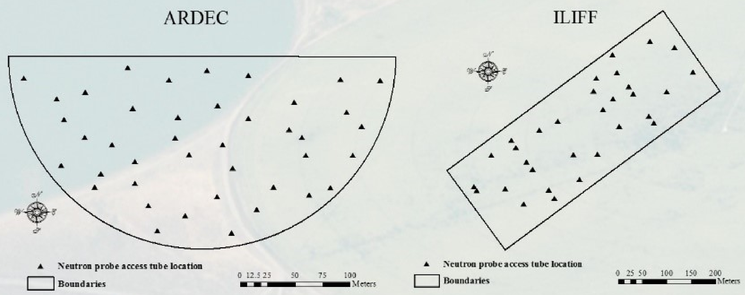

Fig 2. Map of Site I (left) and Site II (right) showing the location of neutron probe access tubes.

Materials and Methods

This study was conducted on two fields located in northeastern Colorado. In-field SWC was measured during the maize season, using neutron probes at 41 and 31 locations for Site I and II respectively (Fig. 2). Soil ECa measurements were acquired using Geonics EM38-MK2 unit (Fig. 1). The ECa derived zones from the deep and shallow ECa readings (0-1.5 m and 0-0.75 m) were evaluated with the average SWC for the soil depth down to 1.35 m and 0.75 m, respectively. In addition, cation exchange capacity, clay, organic matter and salt content were coupled with soil ECa to estimate SWC.

Management Zone Analyst (MZA) software was used to assist in the determination of the optimal number of zones for each field (Fridgen et al., 2004).

To evaluate any increase in the SWC estimation accuracy, krigged ECa values (before classification) were combined with organic matter, soluble salts, cation exchange capacity and clay content as SWC predictors.

Linear mixed models were used to explain the relationship between SWC values and ECa derived management zones.

Analysis of variance (ANOVA) was used to determine significant differences on the soil water measurements among the different ECa zones as treatments. The "dredge" function, from the "MuMIn" package for R statistical software (Barton, 2016) was used to test addition of soil properties as explanatory variables to the krigged ECa values.

Results and Discussion

ECa to assess Soil Water Content

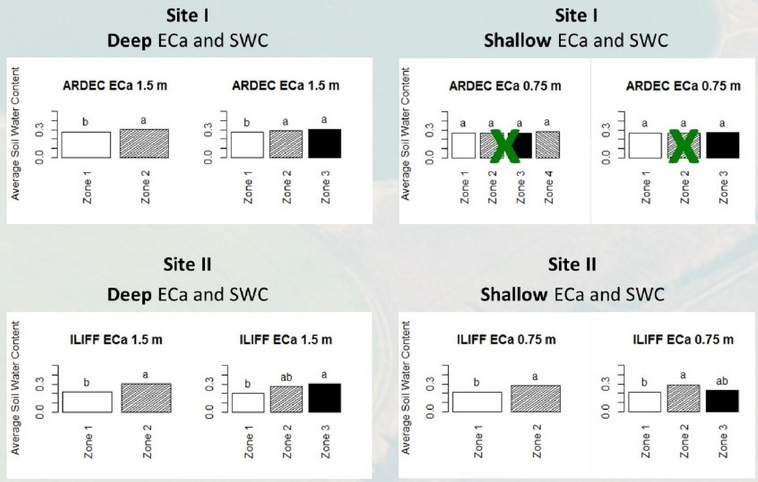

Fig. 3. Mean SWC across ECa derive management zones for Site I and II. Different letters are significantly different (p value <0.05)

ECa coupled with Soil Properties to enhance the assessment of SWC at Site I: Automated model selection

Rank	EC_a 1.5 m	CEC†	Clay	OM‡	Salts	r^2	AICc§
1	X	-	-	X	X	0.69	-82.89
2	X	-	-	-	-	0.44	-80.62

† Cation exchange capacity
‡ Organic Matter
§ corrected Akaike Information Criterion
★ SWC assessment improved including O.M. and SALT CONTENT (ANOVA test, p value = 0.02)

Results of this study showed that SWC found to be statistically different across EC_a derived zones (Fig. 3). Management Zones Analyst (MZA) software recommendations were more accurate than the fixed number of zones (3) typically proposed commercially. Organic matter and salt content significantly improved the SWC assessment when combined with the EC_a. Management zone boundaries using only ECa or using ECa plus organic matter and salinity are juxtaposed in Figure 4.

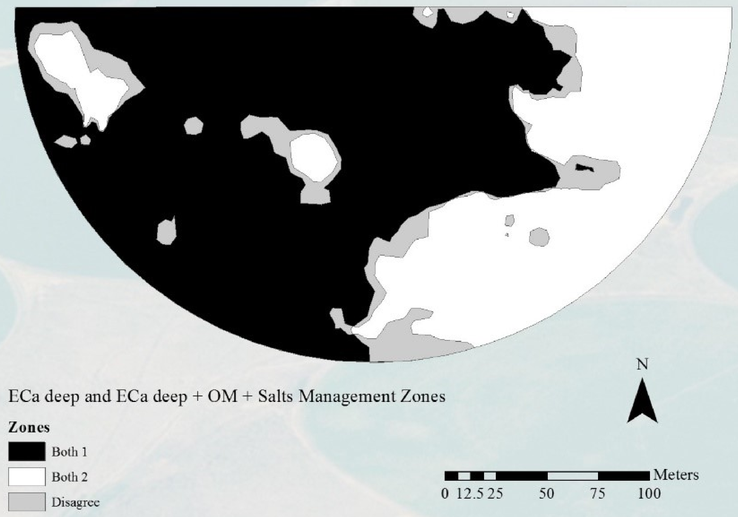

Fig. 4. Management zone map delineated using ECa measured up to 1.5 m depth in addition to organic matter and soil salinity for Site I.

Conclusion

ECa derived management zones showed to be an effective method to characterize macro-scale in-field SWC variability between zones. However, the process of deriving the management zones from the EC a should be tailor-made. To improve the accuracy on the creation of maps for precision irrigation management, ECa should be combined with the soil properties significantly influencing the ECa-SWC interaction.

Literature cited available upon request

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