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MEASUREMENT OF SOIL ELECTRICAL PROPERTIES FOR THE CHARACTERIZATION OF THE CONDITIONS OF FOOD CHAIN ELEMENT TRANSPORT IN SOILS. PART II. CLASSIFICATION OF MANAGEMENT UNITS

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Introduction

At present, when unsustainable agricultural utilization and contamination of soil might endanger crop production, the transport of elements in food chain is among the most recent topics in environmental research. Sustainable plant production, providing adequate basic supply for the population depends on appropriate utilization of soil physical, chemical and biological conditions. All such utilization is based on proper assessment of soil properties.

The instrumental opportunities for characterizing the spatial variability of individual soil properties were described by Ristolainen et al. (2006). It is also very important, however, to distinguish different ranges of soil properties, which can be summed up by some categories, such as soil type or management unit, depending on conditions and information demand.

Our objectives were to distinguish different soil management units and vegetation classes, using indirect instrumental techniques.

Results and discussion

The applied methods and the research area were described by Ristolainen et al. (2006). In this study the same instruments were used to distinguish different soil management units, based on differences in soil properties measured in three transects (Figure 1. of Ristolainen et al., 2006).

From the soil parameters studied, most evident was the effect of soil salinity and water content to field measured bulk soil electrical conductivity (EC_a) values (Table 1 and Figure 1). Mineral soil particles are resistive in dry conditions and electrical conductivity in soil is mainly electrolytic, i.e. through ions in soil water fraction

(Friedman, 2005). Therefore, significant correlations between EC_a and soil particle size classes were found due to larger water retention typical for soils with fine texture and high clay content (Table 1). The effect of soil humus content was controversial: a positive correlation was found in Transects 1 and 3, but for the whole dataset the weight of Transect 2 turned the relationship from positive into negative. Transect 2 was located in area with high salt content causing high EC_a values in areas with almost no vegetation and low humus content.

Table 1. Correlation between soil parameters sampled at the depth of 0-0.20 m and soil electrical conductivity (n=45). Values in Bold are statistically significant ($p<0.01$)

Soil parameter	M_ec
Clay (<0.002 mm)	**0.73**
Silt (0.002-0.05 mm)	0.30
Sand (>0.05 mm)	**-0.52**
Humus (g g-1)	**-0.74**
Water (g g-1)	-0.21
pH	**0.86**
EC (mS)	**0.98**

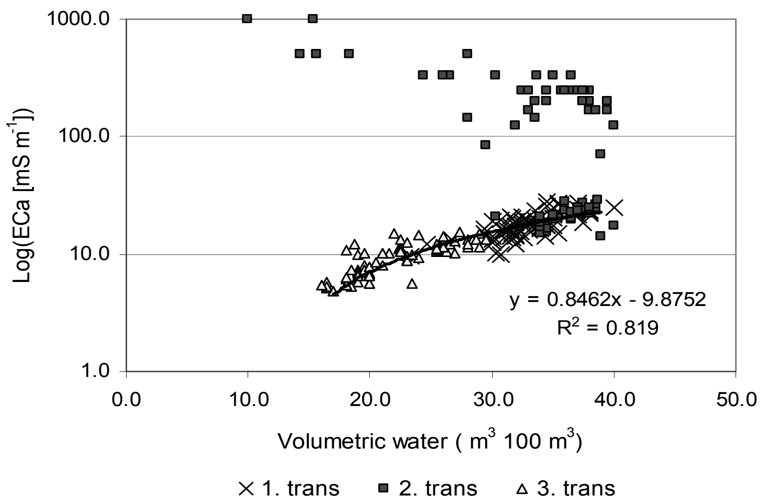

Figure 1. The relationship between soil electrical conductivity (mS m^{-1}, response from 0-0.25 m) and soil volumetric water content (m^3 $100m^{-3}$ taken at the depth of 0.10 m) along three transects. Regression line represents relationship between θ and EC_a in points where the effect of salt wasn't dominant ($EC_a>100$ mS m^{-1}).

One-way ANOVA of instrumental measurements was used to show, which soil cultivation system and vegetation classes could be differentiated with EC_a measurements in the three transects.

Transect 1. Agricultural field, pasture-maize-winter wheat (sown)

Table 2 shows that EC_a values were statistically different in several categories inside Transect 1.

Table 2. Significant differences (+ there is difference, - no difference) as shown by Tamhane's T2 for classes of Transect 1 by EC_a 0-0.45 (left) and soil moisture content (right, taken at the depth of 0.10) at the significance of 0.05

EC_a 0-0.45 m	Pasture	Wheat	Maize	Soil Moisture (0.10 m)	Pasture	Wheat	Maize

Cases (n)	13	12	38
Pasture	/	+	-
Wheat		/	+

Cases (n)	13	12	38
Pasture	/	-	-
Wheat		/	+

The difference between the EC_a values can be attributed to the recent application of nitrogen fertilizer on the sown wheat plot, as proven by differences in lab measured soil EC values. On the other hand soil moisture content values in Table 2 showed differences only between wheat and maize fields, since wheat field has not used the moisture becoming available during summer.

Transect 2. Salt-affected grassland

Table 3 showed that average EC_a values were statistically significant between most vegetation categories of the salt-affected grassland. Vegetation categories are listed in the order of increasing tolerance to salinity. The lab measured EC value did not show as many significant categories, since the number of observations in each category was lower. Soil moisture content could be used to distinguish only the most salt-affected category from the others. In this case the high soil salinity affected the readings measured with capacitive probe and the values are not reflecting the soil moisture as expected.

Table 3. Significant differences (+ there is difference, - no difference) between the vegetation classes in salt affected grassland as shown by Tamhane's T2 by EC_a 0-0.45 (top) and soil moisture content (bottom, taken at the depth of 0.10) at the significance of 0.05

EC_a 0-0.45 m	**Cala**	**Ach-F**	**Art-F**	**Puc**	**Cam**
Cases (n)	4	27	20	14	6
Calamagrostis	\	-	+	+	+
Ach-Festucetum		\	+	+	+
Art-Festucetum			\	-	+
Puccinellietum				\	+

Soil Moisture (0.10 m)	**Cala**	**Ach-F**	**Art-F**	**Puc**	**Cam**
Cases (n)	4	27	20	14	6
Calamagrostis	\	-	-	-	+
Ach-Festucetum		\	-	-	+
Art-Festucetum			\	-	+
Puccinellietum				\	+

Note:Cala=Calamagrostis stand, Ach-F=Achilleo-Festucetum pseudovinae stand, Art-F=Artemisio- Festucetum pseudovinae stand, Puc=Puccinellietum limosae stand, Camp=Camphorosmetum annuae stand

Transect 3. Forest-wheat, sandy soil

The two main categories of wheat (46 cases) and forest (23 cases) inside Transect 3 had statistically significant differences in means of EC_a and soil moisture content in case of both, field and laboratory measured values (no data are shown, see Fig 1 of Ristolainen et al., 2006).

ANOVA showed less difference in Transect 1 than in Transect 2 or 3 due to the looser correlation between the soil properties and weaker evidence of gradients in soil properties found in Transect 1. In Transect 2 the increasing gradient of soil salinity from the highest lying point towards the lowest lying one defined the instrumental readings. In Transect 3 most measured soil properties showed statistically significant correlation, since the transition from the highest plot towards the lowest one coincided with the increase in fine fraction and moisture content, resulting in higher electrical conductivity and soil water contents.

Conclusions

From the soil parameters studied in three transects with different land use, most evident was the effect of salinity. Thus, EC_a measurements could be used to distinguish different vegetation classes according to their tolerance to salt. Field measurements suggest, that at locations, where EC_a values exceed 100 mS m^{-1} (ca 1 mS soil paste ec) only species tolerant to salt survive, while below that level areas might be suitable for cropping. In non-saline soils, soil water content, dependant on soil texture had the greatest effect on field measured EC_a values. Generally higher EC_a values should be expected on clayey soils. Also different cultivation practices differentiated in EC_a because of differences in water uptake and fertilizer levels. Our results are readily available for those situations when the conditions for food chain element transport, such as soils with high or low hydraulic conductivity must be characterized and classified.

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