The influence of soil moisture on the spatial and temporal variability of soil electrical conductivity

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Overview

- Soil electrical conductivity (EC) is a soil quality indicator associated to attributes of interest for site-specific soil management such as soil moisture and texture.
- EC is important for tropical agricultural soils, especially because they usually have low levels of dissolved salt.
- Since EC, texture and moisture are expected to be correlated, the present study performed spatial monitoring of soil moisture in two experimental fields with different texture over two consecutive years and evaluated the influence of moisture on soil EC.

Material and Methods

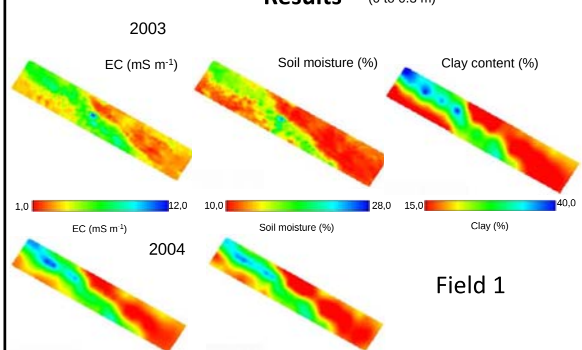
- Field 1 covers 18.9 ha, with altitude of 826 m and dystrophic red latosol (oxisol) with moderate A horizon and medium texture.
- Field 2 covers 22.2 ha, with altitude of 533 m, and predominance of alic red latosol (oxisol) with moderate A horizon and medium texture.
- Soil EC was measured with a Veris 3100® direct-contact sensor (Veris Technologies, Inc., Salina, KS, USA).
- Only the shallow soil layer (0 to 0.3 m) is presented here.
- Field 1 (subtropical) was studied in October 2003 and June 2004 and Field 2 (tropical) in October 2003 and October 2004.

Experimental field location

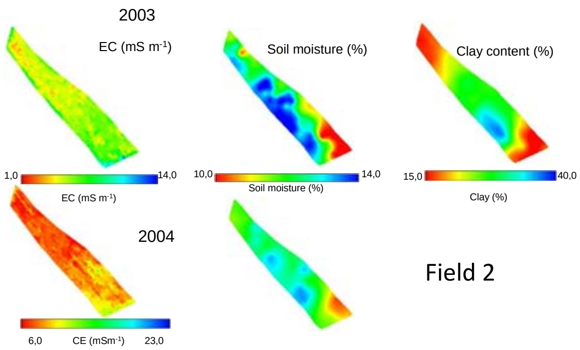
Material and methods

- While the sensor was pulled over the fields, soil samples were collected and georeferenced to determine moisture content in the 0.3 m layer.
- To determine soil texture by Bouyoucos's method, 5 sub-samples were collected at each sampling site.
- After an exploratory and discrepant data analyses the spatial dependence analyses were conducted and data were interpolated by ordinary block kriging using Vesper 1.6 at 10 m x 10 m pixels.
- EC, moisture and clay content values were interpolated to obtain coefficients of determination (r^2).

Results (0 to 0.3 m)



Results (0 to 0.3 m)



Results

Exploratory statistics for soil EC (mS m^{-1}), moisture (%) and clay (%) content

Year	Variable	Number of points[1] Initial	Number of points[1] Final	Mean	Median	Min.	Max.	SD[2]	CV[3] (%)	Asym.[4]	Kurt.[5]
Field 1											
03	EC	5004	5003	4.1	3.6	1.0	12.9	1.8	43.5	0.86	0.28
	Moisture	83	83	16.2	14.8	10.3	27.6	4.6	28.6	0.78	-0.37
04	EC	8472	8472	3.0	2.4	0.6	13.1	1.7	57.4	1.08	0.92
	Moisture	84	84	15.6	14.2	9.2	26.6	4.8	30.5	0.68	-0.60
	Clay	42	42	21.5	18.9	11.5	42.3	9.1	42.5	0.90	-0.45
Field 2											
03	EC	10402	10388	6.2	6.1	2.9	16.6	1.3	21.5	0.70	1.70
	Moisture	63	63	12.4	12.3	9.5	14.5	1.3	10.8	-0.46	-0,65
04	EC	8734	8529	8.3	8.2	3.9	12.7	1.7	20.2	0.16	-0,12
	Moisture	33	32	12.2	12.1	10.1	13.6	0.9	7.3	-0.27	-0,32
	Clay	92	92	23.1	23.0	16.1	36.2	3.7	15.9	0.80	1.48

[1] Before and after removing the outlier data identified by exploratory analyses, [2] Standard deviation; [3] Coefficient of variation; [4] Asymmetry; [5] Kurtosis

The attributes studied had similar mean and median values, although medians were in general lower and some asymmetrical distributions were observed
Field 2 had lower attribute variation than Field 1.

Results

Semivariogram models and parameters fitted to the soil attributes studied

Year	Attribute	Model	C_0	Sill (C_1)	R (m)[3]	DR (%)[4]	SDD[5]	RSS[6]
Field 1								
03	EC	Sph.[1]	0.1352	2.9402	135.9	4.60	Strong	8.69E-03
	Moisture	Sph.[1]	0.0001	0.0633	168.7	0.16	Strong	6.71E-05
04	EC	Sph.[1]	0.1358	2.6778	140.8	5.07	Strong	3.00E-02
	Moisture	Sph.[1]	0.0090	19.3800	148.9	0.05	Strong	30.76
	Clay	Sph.[1]	0.0002	0.1509	153.0	0.13	Strong	1.17E-03
Field 2								
03	EC	Exp[2]	0.8284	1.3195	24.5	62.79	Mod.[7]	6.83E-04
	Moisture	Sph.[1]	0.0001	0.0122	185.4	0.83	Strong	9.16E-05
04	EC	Exp.[2]	0.6555	1.4109	21.2	46.47	Mod.[7]	6.79E-03
	Moisture	Sph.[1]	0.0003	0.0062	361.1	4.76	Strong	2.20E-06
	Clay	Sph.[1]	0.0122	0.0240	307.3	50.41	Mod.[7]	3.19E-05

[1] Spherical; [2] Exponential; [3] Range (m); [4] Dependence ratio; [5] Spatial dependence degree ($C_0/(C_0+C_1)$); [6] Residual sum of squares; [7] moderate.

In Field 1, spatial dependence explains 95.4% of total EC variation in 2003 and 94.9% in 2004, with random error caused by a nugget effect of 4.6% and 5.1%, respectively. In Field 2, random errors in EC were 62.8% in 2003 and 46.5% in 2004.

Results

Regression analyses between EC and soil moisture and clay levels

	Field	Year	Moisture level r^2	Moisture level F	Clay level r^2	Clay level F
EC	1	2003	0.77	*	0.73	*
		2004	0.74	*	0.72	*
	2	2003	0.04	*	0.00	*
		2004	0.09	*	0.00	ns

* F test, significant at $p<0.01$; ns = F test, non-significant ($p>0.01$)

r^2 between soil EC and clay content in Field 1 was similar to those reported in earlier studies (0.50 - Johnson et al., 2001; 0.76 - Corwin et al., 2003).

An important result was reading repetition over the two years. The fact that EC reading varied as a function of soil moisture at reading time suggests that it is a good soil quality indicator that is magnified by moisture level, which in turn depends on soil texture.

In Field 2, there was weak or even absent correlation between EC, soil moisture and clay content, likely because it had lower clay and moisture ranges than Field 1, with lower spatial variability of the attributes.

Conclusions

- Soil moisture content exhibits a high degree of spatial dependence.
- A correlation between soil moisture and EC was found only in experimental Field 1, which had a higher soil moisture range.
- An important result is data repetition over the years, suggesting that EC is a qualitative indicator in areas with high spatial variability in soil texture.
- In Field 2, where soil moisture range was lower, EC was not associated to moisture level.

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