Proximal sensing for monitoring the productivity of a permanent Mediterranean pasture: influence of rainfall patterns

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The main objective of this work was to evaluate technologies that have potential for monitoring aspects related to spatial and temporal variability of soil nutrients and pasture yield and for support to decision making by the farmers. Three types of sensors were evaluated: an electromagnetic induction sensor, an active optical sensor and a capacitance probe. The results are relevant for the selection of the adequate sensing system for each particular application and to open new perspectives for other works that would allow the testing, calibration and validation of the sensors in a wider range of pasture production conditions and rainfall patterns, characteristic of the Mediterranean region.

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Soil electrical resistivity at different water contents in an integrated crop-livestock-forest system in Brazil

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Application Characterizing the spatial variability of soil properties can be very useful in decision-making for crop management strategies. The electrical resistivity (ER) of the soil is a function of the soil texture and structure and sensitive to soil water content.

Introduction Soil properties may vary spatially within a plot or at a regional scale, due to intrinsic factors (clay content, water retention capacity, stoniness, source material) and extrinsic factors (structure, temperature, water content, management practices, fertilization and crop rotation). These variations in soil properties should be monitored to understand the effects of land use and land management systems. From the agricultural point of view, the main physical indicators of soil quality are texture, structure, resistance to penetration, rooting and water storage. The electrical resistivity (ER) of the soil (Ω m) is a measure of its resistance to an electric current. ER is a function of the soil texture and structure, particularly sensitive to water content. In most of the field studies, ER was used to monitor water dynamics in the soil under controlled conditions. Few studies have been conducted to monitor changes in ER as a function of soil moisture at a field scale. Therefore, water content in the soil should be considered in studies of electrical resistivity. The aim of this study was to characterize the spatial variability of soil ER in different soil moistures in integrated systems.

Material and methods This research was conducted in a study area of 9.7 ha of the crop-livestock-forest integration system (CLFIS) at Embrapa Pecuária Sudeste in São Carlos, Brazil (21 ° 57'S, 47 ° 50'W, 860 m alt) in a Red-yellow Latosol, i.e. Haplortox. The climate is tropical of altitude, with 1502 mm of annual rainfall and average minimum temperature and maximum temperature of 16.3 ° C (July) and 23 ° C (February), respectively. The CLFIS system includes different combinations of Piatã grass (*Urochloa brizantha),* corn (*Zea mays*) and *Eucalyptus urograndis* (GG100). ER measurements were obtained with the commercial sensor ARP system® (Geocarta, Paris, France) on two dates (May 4th, 2016 and Jun 1st, 2016). Soil moisture content was monitored with a Diviner 2000 probe (Sentek Environmental Technologies, Kent Town, Australia). Weather data were collected, and water balance was calculated and shown in Figure 1. The inverse distance weighting (IDW) method was used for data interpolation and generated contour maps using ArcGIS 10.1 software. From the maps obtained by IDW, values were sampled at the same geographical position in a virtual sampling grid of 500 points, regularly distributed over the set of data predicted for the study area and a correlation study was carried out.

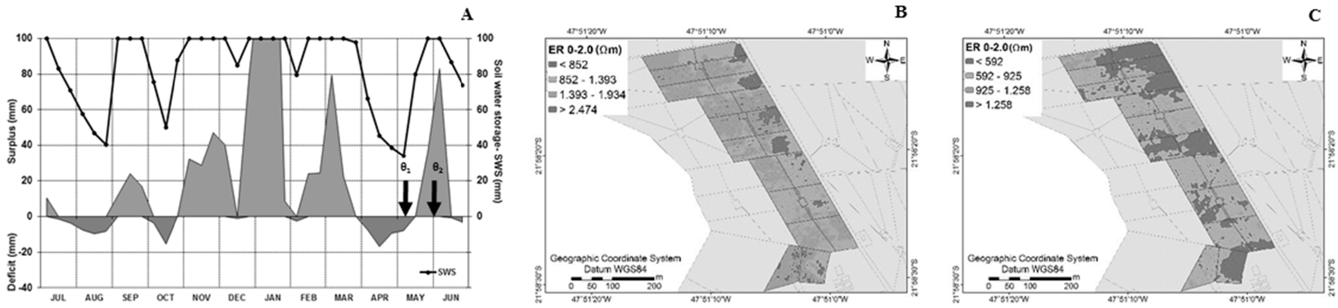

Figure 1 Soil water balance (A) and interpolated maps of soil electrical resistivity at 0-2.0 m depths with soil water at 0.208 cm^3 cm^{-3} (θ_1 - B) and 0.283 cm^3 cm^{-3} (θ_2 - C).

Results Between measurements a 216-mm rainfall event was recorded, leading to accumulation of water in the soil (Figure 1). At both dates, the recorded soil moisture (θ) contents (up to 1 m deep) were, respectively, 0.208 and 0.283 cm^3 cm^{-3}. After interpolation of the ER data for all three depths, four classes of division were established. Measurements at the 0-50 cm and 0-100 cm layers indicated little variation in soil water contents. The largest differences were observed in the measurements at the depth of 0-200 cm (Figure 1B and C), which were initially mainly in classes 2 and 3 (representing 48 and 43% of the area), and with the accumulation of water after the rain, the measured values changed predominantly to classes 1 and 2 (36 and 62 area%, respectively). This is probably due to high rates of water infiltration by the Red-yellow Latosol. The coefficient of correlation between interpolated maps of soil electrical resistivity at 0-2.0 m depths with soil water (θ) at 0.208 cm^3 cm^{-3} (May 4th) and 0.283 cm^3 cm^{-3} (June 1st) was $r = 0.65$ ($p<0.05$).

Discussion The results indicated that with ER, it was possible to establish the relationship between electrical resistivity and soil moisture content. Therefore, this spatial variability represents the variability of soil properties which can change the ER, such as porosity, structure, temperature and chemical composition of the solution. The results confirm the potential use of electrical resistivity measurements (ER) as an auxiliary tool for soil science and agronomy.

Conclusion ER allowed the delimitation of regions within the studied area, indicating differences of movement and accumulation of water in the soil horizons. There was a trend of reduction in ER values with increasing soil moisture.

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