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Landscape planning and designing for nature management optimizing in agriculture

Author: V.I. Kiryushin,

Russian Timiryazev State Agricultural University, Timiryazevskaya str.49, Moscow, 127550 Russia

Adoption of the Declaration on sustainable development in Pto (1992) and the European convention on landscapes in 2004 promoted the active development of landscape planning.

Taking into attention the world and domestic experience and our researches we develop the following toolkit of landscape planning: the assessment of ecological and social-economic functions of landscapes, their stability to loadings, the analysis of environmental conflicts, the forecast of man-made influence on the adjacent landscapes, planning the co-adaptive natural-economic systems taking into account the environmental regulations and planning of natural-reserved and protective zones, etc.

The following ecological functions are considered as the basic ones: bio-ecological (bio-topical and biocoenotic, bioproductive, bio-energetic, biogeochemical, concentration, oxidation-reduction, destruction, sanitary); atmospheric (gas, heat-exchange, hydro-atmospheric), lithospheric (relief-forming, litologic); hydrological and hydro-geological.

On the basis of identification and assessment of landscapes ecological functions the social and economic functions are determined as ones directed on satisfaction of one or another needs of a society. They include: functions of resources supply, including abiotic (heat, water, fuel, energy), biological natural (wood, peat, fish etc.), biological cultivated (crop production, animal industries, forestry); support functions for the enterprises of the industry, power et cetera, and also water-economic, transport, recreational, information and culture-forming functions.

The modern project of intra-farm land management is considered as the project of agricultural landscape optimization, covering its various categories, including field agrolandscapes, water landscapes, recreational and other landscapes.

The agrolandscapes design is considered as the bases of land management project which is carried out with reference to their various agroecological categories: summit, erosive, salted, solonetzic, lithogenic, cryogenic, etc. Design includes: land-use organization, crop selection, crop rotations, systems of soil tillage, fertilizing, plant protection, territory organization - including crop strips, no-till, mulching, landscape-differentiated fertilizing systems. Design is carried out on the basis of soil-landscape mapping, GIS with land agroecological assessment and existed experience of adaptive-landscape farming systems.
Multi-electrode 3D resistivity survey on soil structure in conservation agriculture

Authors: I. Piccoli, N. Dal Ferro, B. Lazzaro, L. Furlan, S. Macolino, A. Berti, F. Morari

1DAFNAE Dept., University of Padova, Viale Dell’Università 16, 35020 Legnaro (PD), Italy
2Sezione Agroambiente, Servizio Politiche Agroambientali, Regione Veneto, Via Torino 110, Mestre (VE), Italy
3Veneto Agricoltura, Viale dell’Università 14, 35020 Legnaro (PD), Italy
ilaria.piccoli@studenti.unipd.it

Introduction
No tillage (NT) influences different physical-chemical soil properties, which in turn affect roots growth and crop yield. Despite the benefits observed after the adoption of NT, subsurface soil layers suffer from compaction, especially during the conversion period from conventional tillage (CT) to NT. This is generally highlighted by the increase in bulk density (BD) within the soil profile as observed by Dal Ferro et al. (2014) in a sandy loam soil during a 2-yrs transitional period. In particular, the authors noticed that the root system of maize (Zea mays L.) experienced a reduction of root length density and root mean diameter.

In order to investigate the effects of NT on soil structure and root distribution, traditional soil physical methods are time-consuming and expensive. Modern geophysical techniques like electrical resistivity tomography (ERT) are a cost-effective and rapid method to sense the 3D spatial variability of soil properties. ERT is a non-destructive method that provides subsurface information at different scales without requiring invasive soil surveys. Moreover ERT can visualize spatial distribution of root systems (Amato et al. 2008) when soil resistivity response is not masked by other properties such as soil water content, soil water solution salinity and stone fraction (Loperte et al. 2006).

In this study, the soil structure and root distribution in conservation and conventional systems were studied using multi-electrode ERT 3D surveys. The potentials of ERT for a rapid assessment of soil physical properties were also evaluated in comparison to the traditional physical methods.

Materials and Methods
Field experiment was established in 2010 in order to compare conservation agriculture versus conventional systems. The field-size experiment was set up in four experimental farms (henceforth called F1, F2, F3 and F4) located on the low plain of north-eastern Italy and characterized by sub-humid climate with a mean rainfall of 850 mm yr⁻¹. Soil texture ranged from sandy in F1 to silty-clay loam in the others. A 4-yrs rotation (wheat, Triticum aestivum L.; rapeseed, Brassica napus L.; maize, Zea mays L. and soybean, Glycine max (L.) Merr.) was managed according to conservation agriculture’s principles, namely direct sowing on
untilled soil, residue retention and use of cover crops. For comparison the 4-yrs rotation was also managed according to conventional tillage, with a 35-cm depth ploughing in autumn and seedbed preparation in spring.

To evaluate the effects of tillage practices on soil structure and root development, ERT 3D surveys were performed in August 2014 in 3 positions within each field cropped with maize (8 fields in total). Tomograms were acquired using three cables, each connected with 24 electrodes, positioned parallel at 0.4 m from each other. The volume investigated was 2.9 m$^3$ (4.6 m × 0.8 m × 0.78 m). Acquisition parameters were: dipole-dipole configuration, 0.20 m inter-electrode spacing and 500 ms time of injection using a Syscal-Pro Junior switch-72 (Iris Instrument, Orléans, France) resistivity-meter. 3D data inversion was performed with ERTLab software (Multi-Phase Technologies and Geostudi Astier). Along the central cable, the soil profile (up to 90 cm depth) was investigated for: a) bulk density in 3 points using a hydraulic sampler (core method), b) penetration resistance in 9 points using a digital cone-penetrometer (Eijkelkamp), c) root measurements (root length density, diameter and mass) in 2 points by image analysis (WinRhizo, Regent Instrument).

Results and discussion
Soil moisture within the profile, due to high summer rainfall (+80% above the average), reached levels that partially smoothed the contrast between treatments. Mouldboard ploughing in sandy soil of F1 originated a plough sole around 35 cm depth as highlighted by BD, which increased from 1.50 g cm$^{-3}$ at 0-20 cm to 1.73 g cm$^{-3}$ at 20-40 cm. Accordingly, PR increased from 0.5 MPa to 2 MPa at 10 cm depth up to 3.0 MPa at 40 cm. Results showed that ERT was able to sense the peculiar hardpan (Fig. 1) since resistivity doubled from 65 $\Omega$m to 120 $\Omega$m between 20 and 40 cm. In spite of the high BD and PR values, this layer was more resistive than the others because of high sand content and low soil moisture. The plough sole was not depicted in the NT profile where, conversely, resistivity increased with depth from 30 $\Omega$m at the surface to 169 $\Omega$m at 78 cm depth. Higher surface conductivity was influenced by the higher water content, which decreased within the soil profile (from 27% to 13%).

Multi-electrode resistivity survey was less effective in the finer soils of F2, F3 and F4. Indeed ERT profiles were more homogeneous in spite of contrasting BD and PR distributions. BD highlighted a compaction in NT with values increasing from 1.3-1.4 g cm$^{-3}$ in the top layer to 1.6-1.7 g cm$^{-3}$ at 20-40 cm and decreasing downwards. PR measurements were not always consistent with BD because it seems that the water content masked the effect of BD on PR. Accordingly, resistivity measurements also decreased from the top (about 127 $\Omega$m) to the deepest layer (about 5 $\Omega$m) in both CT and NT.

Generally root length density and root mean diameter were affected by the management systems. However the peculiar subsurface hardpan (ca. 20-40 cm) under conventional tillage in F1 did not increase the differences observed between CT and NT on root growth parameters down to 90 cm depth.
Figure 1 - 2D section (a) and 3D volume (b) of F1 site under CT management. Resistivity is expressed in Ωm. Plough sole is visible between 20 and 40 cm with resistivity higher than 120 Ωm (orange-red colour).

Conclusion
Summer 2014 was one of the rainiest in the last century and soil water content within the profile consequently reached values that partially smoothed the contrast between treatments. Only in sandy soil ERT 3D highlighted tillage effects on soil structure (e.g. plough sole) confirming its potential as a rapid survey method. Conversely, ERT 3D was less effective in finer texture soils since resistivity response to soil structure was partially masked by the moist conditions. These preliminary results indicate that a better understanding of ERT response to tillage systems, disentangling the role of the single components on soil electrical conductivity (e.g. root water uptake), requires the integration of 3D resistivity survey with traditional soil analysis.

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