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Pedodiversity of three experimental stations in Estonia

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ABSTRACT

The soil cover composition and properties of three experimental stations of Estonia - Jõgeva (JEA), Kuusiku (KEA) and Olustvere (OEA) - were analysed in detail (by soil type subdivisions - species and varieties) in relation to soil forming ecology and land management practices. The arable soil covers' pedodiversity and taxonomical conversion of Estonian Soil Classification into the World Reference Base for Soil Resources system were analysed on the basis of seven arable land parcels. The soil cover of JEA was relatively homogenous by soil species. The soil cover of KEA was much more heterogeneous, with five contrasting soil species in terms of soil genesis and with four stages in soil moisture regimes. OEA's soil cover consisted predominantly from *Glossic Retisols* with topsoils' texture - sandy loam. The texture of JEA is predominantly loamy and has, therefore, optimal agronomical properties. The texture of OEA is of a lower quality, by approximately one stage. The texture of KEA varies considerably (from sand to loam). Clay-rich textures are absent in all three EAs. In terms of soil species and properties, JEA is a representative of Central Estonian, OEA of South Estonian and KEA of North Estonian pedo-ecological conditions. All three field experimental areas are representative of the arable soils of the eastern part of the North European plain. The detailed research on soil cover is a good base for further researches on soils' humus and agrochemical status, productivity and suitability for crops, and for the evaluation of soils' environmental protection ability.

1. Introduction

Soil functions are inter-related with the properties of soil species and/or varieties, regional climatic conditions, land use agro-technology and soil management regime (Pierzynski et al., 2000). Depending on local pedo-ecological conditions (topography, diversity of soil parent materials or geodiversity, and meteorological conditions) the patterns of soil and plant cover are very diverse (Ibáñez et al., 1998; Guo et al., 2003). Natural ecosystems are formed due to the synergistic mutual interactions between soil and plant systems, and site-specific ecological conditions. Agricultural land use and the formation of agro-ecosystems depend foremost on the suitability of soils for the cultivation of feed and food crops. Usually, the most fertile soils of a region, which present minimal constraints for agricultural land use, are selected for arable use (Kokk and Rooma, 1974, 1978). We argue that a pedocentric approach should be useful in understanding not only the fabric and function of natural ecosystems, but agro-ecosystems as well.

Compared with conventional fields, the requirements for the field experimental areas' (EA) soil cover are more fastidious. EA soil cover should correspond to local pedo-ecological conditions and represent the dominant soil types of the region (Rannik and Kõlli, 2013). In addition, the fields should be as homogeneous as possible. For detailed interpretation and application of experimental research results the knowledge on properties of the soil cover of EAs, on ecological interactions of soil covers and on characteristics of soil functions are essential.

Unfortunately, the information on EAs' soils is frequently insufficiently available. Generally the available information includes the names of soil species and/or varieties, plough layer pH, humus and total nitrogen content, soil texture, and content of plant available potassium and phosphorus. In lesser cases, the soil morphological researches with descriptions of soil diagnostic horizons, subsoil textures and parent materials are available.

Data on soil texture, as a stable soil property, should include the particle-size distribution of both fine-earth and coarse-earth fractions, in both the topsoil and subsoil. Some greatly influencing soil functions and productivity properties (as topsoil humus and plant available nutrient contents, acidity) are very dynamic and may substantially be changed by tillage and land management intensity. Additionally, the soil moisture conditions may be regulated by drainage and irrigation. The stable properties of the landscape, which include land topography and the nature and properties of superficial (1–2 m depth) regolith are of great importance as well.

Arable field experiments usually aim to develop tillage and fertilization techniques to optimize the soil environment that would provide crops with the conditions needed for their successful growth and development. The detailed research of the selected EAs' soils enables to elucidate mutual inter-relationships' between soil and plant systems. These

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relations may be used as a theoretical basis for the integrated interpretation of soils as a dynamic, determining and integral component of ecosystems.

In the present work (1) the soil cover composition, (2) the pedo-ecological conditions of soil formation, (3) the morphology of dominant soil species, and (4) the soil cover representation of the national (Estonia) and regional (eastern sections of the North European Plain) conditions are analysed on the basis of the experimental fields' soil covers. For the better understanding of different soils' interrelationships and evaluation of pedo-ecological equivalence of EAs' soils by international reader, the research data received by Estonian Soil Classification (ESC) are converted into the World Reference Base for Soil Resources (WRB; Reintam, 2002; IUSS WG WRB, 2014).

2. Materials and methods

2.1. Location and pedo-ecological characterization of experimental areas

For the analysis of soil cover composition, large scale (1:10,000) digital soil maps (with related soil contour data) of three EA — Jõgeva Plant Breading Institute (JEA), Kuusiku Experimental Centre (KEA) and Olustvere Experimental Station (OEA) — were used (Land Board, 2001; Fig. 1). For the extraction of soil data from large scale digital soil maps the program MapInfo Professional 9.5 was used. The analysis and field research in three EAs were performed within seven arable land parcels. JEA and KEA had three land parcels, but OEA one. For the demonstration of EA soil distribution patterns, black-and-white soil map excerpts for four land parcels are presented in Figs. 2, 3, 4 and 5.

In terms of local government administration, JEA is located in Jõgeva County, KEA in Rapla County and OEA in Viljandi County. According to the agro-soil districts (ASD) schema, elaborated for the characterization of regional soil cover composition (Kokk and Rooma, 1974), JEA belongs to Adavere, KEA to Mahtra-Haimre and OEA to Viljandi ASD. Considering the collected data on soil cover composition within specific ASDs, it is possible to evaluate the correspondence of EA soil covers to those of ASD. Some general pedo-ecological characteristics of ASDs and associated EAs are given in Table 1.

On the basis of landforms, topography and location, JEA belongs to the Vooremaa accumulative upland region. The landscape consists of glacial deposits from the last glacial period, especially drumlin fields.

Fig. 1. Location of experimental areas on the map of Estonian Counties.

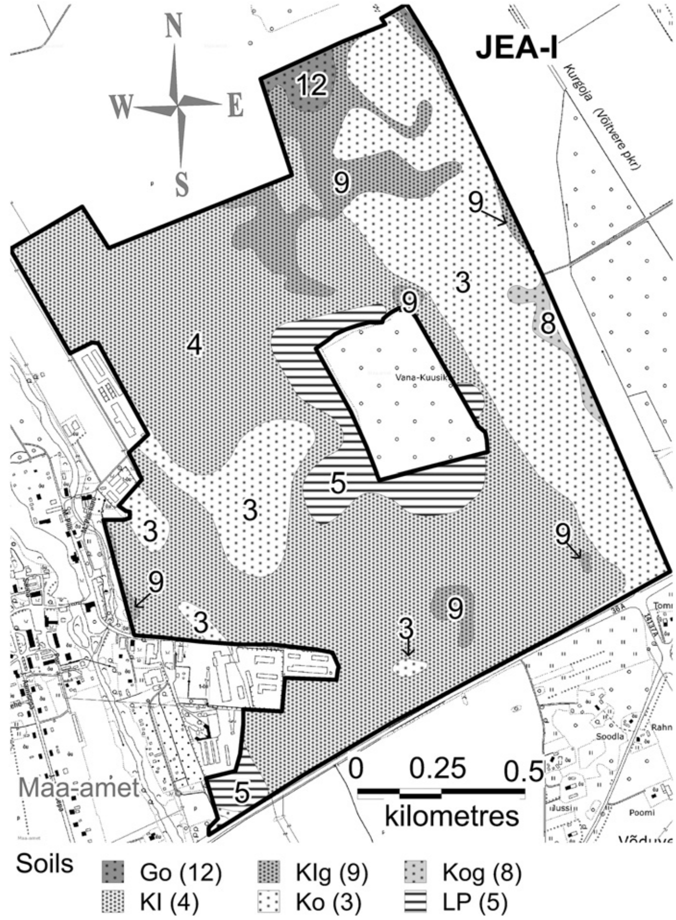

Fig. 2. Soil map (original 1:10,000) of land parcel I of the Jõgeva Plant Breading Institute (JEA-I).

Situated on the northern part of this region, JEA is characteristic of localities with gently undulating calcareous till plains, with some mounds and oblong hills. KEA is located on the southern part of the Harju Plateau. It is characteristic of heterogeneous mixed plains composed of glacial till, limestone and former glacial lakes. OEA is situated on the northern part of the Sakala Upland, which is an undulating abraded upland till plateau, divided by pre-Quaternary valleys. OEA is a representative of gently undulating abraded and outwashed non- and slightly calcareous till plains, with some mounds (Arold, 2005). The Quaternary cover and landforms are directly related to soil parent materials. For JEA it is yellow-brown slightly stony (pebbly) loamy till. KEA parent materials are white-grey pebble till and fine sand sediments originating from glacial lakes. Within OEA, parent materials are reddish-brown loamy tills.

All moist and wet soils of all three EAs were artificially drained during the period 1966–1987, in accordance with the demands of field crops. Their status in 1996–2001 ranged from satisfactory to good (Agricultural Board, 2004). In terms of precipitation and thermal resources, the most favourable conditions are found in OEA (Table 2).

2.2. Soil cover characterization according to Estonian Soil Classification

For comparative analysis, the soil species codes used in ESC and given on large scale soil maps were converted into the WRB system soil names (Land Board, 2001; IUSS WG WRB, 2014; Table 3). Differently from WRB instructions (2014), for separating qualifiers from each other in WRB soil codes, a single slash (/) was used instead of comma (,). The genetic horizon designations used in soil profile formulae (by ESC) are: A - humic, El - eluvial, Ea - albeluvial, Egl - glossic, B - illuvial,