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EVALUATION OF PLOUGH LAYER THICKNESS IN GREY FOREST SOILS USING SPECTROPHOTOMETRIC AND MAGNETIC MEASUREMENTS

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ABSTRACT

This paper considers the possibility of objective and reliable location of the plough layer's lower boundary by determining color characteristics and magnetic susceptibility of the samples. It is shown that magnetic susceptibility profile can provide more reliable assessment of the plough layer thickness than color curves in CIELAB. The formal analysis using magnetic measurements eliminates subjective mistakes. Magnetic measurements can be a useful tool for the tillage induced erosion estimation while monitoring soil characteristics for the purposes of precision agriculture.

Keywords: arable gray forest soil, magnetic susceptibility, CIELAB chromaticity coordinates, lower boundary of the plough layer, tillage induced erosion.

1. INTRODUCTION

Spatial heterogeneity of composition and properties is one of the fundamental features of the soil and can be caused by both natural and anthropogenic factors. For agricultural soils, it was found that the soil properties can vary significantly even within the borders of a small agricultural field [1]. The main causes of spatial variability in this case are considered to be erosion processes in the classical sense of the term. However, the last two decades show a growing recognition of tillage erosion [2, 3, 4, 5, 6]. This type of erosion is defined as a displacement of the cultivated layer during tillage. For instance, tractor mounted ploughs can easily move the humous material from microelevations to microdepressions. In its turn, the spatial heterogeneity of the plough layer thickness (which is due to the tillage induced erosion) has a direct impact on the agricultural fields' productivity. Therefore, it should be taken into account while monitoring soil characteristics and organizing plot experiments for agricultural purposes and crop farming.

The common practice suggests that the plough layer thickness is determined on the basis of morphological descriptions which are subjective and rely heavily on the individual researcher's experience. Of special importance are analytical and relatively simple methods which can be used to locate the lower boundary of the layer disturbed by tilling.

Before tilling, the vast majority of southern taiga and northern forest-steppe soils in eastern part of European Russia showed mature eluvial/illuvial differentiated profile with a complete set of specific genetic horizons. The characteristic feature of gray forest soils is eluvial/illuvial R_2O_3 distribution profile, in particular, accumulation of non-silicate Fe minerals in the illuvial layer. In its turn, Fe minerals are responsible for a wide variety of soil colors and shades. The plough layer of gray forest soils is formed during a systematic tilling by mixing organogenic horizons with underlying mineral layers. This is reflected in a sharp change in Fe mineral content on the boundary with the undisturbed part of the layer. Therefore, CIELAB chromatic components (hue, saturation) should probably be used to locate the lower boundary of the plough layer.

In the last decades, magnetic properties of various environmental objects, including soils, has drawn increasing scientific attention [7, 8, 9]. Magnetic properties of soils depend primarily on the iron content, its phase composition and dispersion [10]. It was found that magnetic properties can naturally vary with depth, forming a magnetic profile that shows close relationship to the type and intensity of the soil-forming processes [7]. It was shown that magnetic susceptibility profiles may be of both eluvial/illuvial and accumulative nature [7, 11, 12]. It was also noted that periodic tillage operations have the greatest impact on soil magnetism due to 'equalization' of the magnetic parameters [7]. Therefore, the magnetic susceptibility of gray forest soils should change at the boundary of ploughed and subsurface layers.

This paper considers the possibility of objective and reliable location of the plough layer's lower boundary by determining color characteristics and magnetic susceptibility of the samples.

2. MATERIALS AND METHODS

Experiments were conducted on arable gray forest loamy soil derived from a Quaternary deluvial loam (according to the USSR classification). According to WRB soil classification, the soil was classified as Cutanic Luvisols (Anthric). The 1-ha plot is located in Laishevskii district of Central Volga region (55°37′46.42″ N, 49°21′16.38″ E). It is a flat agricultural field, which was used for multiple-factor experiment (the year before sampling) and divided into 36 individual plots with areas of 161 m^2 and dimensions 23×7 m (Figure-1). After the experiment, the field was plowed and sown with winter