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APPLICATION OF GIS IN MANAGING THE AGGREGATE COMPOSITION OF THE SOIL WITH A NEW ACTIVE WORKING BODY FOR SURFACE TREATMENT

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Abstract

The fertility of the soil depends on its conditions, which are quantitatively expressed through its properties of porosity, density and humidity. The change in these properties is due to its structural construction and the environmental impacts. A part of the soil is damaged by heavy metals, improper fertilization and threatened by erosion. In this research proposal, innovative working bodies will be investigated for soil treatment, with the aim of managing the aggregate composition and predicting fragmentation, to protect it from erosion. The aim of the study is to application of GIS investigate innovative working bodies with active drive, to achieve a higher quality of surface tillage taking into account the existing external and controllable factors. Statistical processing of the results and optimization lead to the various operating modes of a machine to achieve the main idea and the resulting soil fragmentation regression equations are entered into a GIS environment. The Surface soil treatment is managed by GIS tools for variety visualization and presented statistically the most suitable information. The implementation of working bodies in practice will enrich the soil fragmentation data base, which leads to a greater choice of tillage bodies for soil erosion control.

Key words*: GIS, soil treatment, soil fragmentation.*

INTRODUCTION

On a global scale, agriculture has the proven potential to increase food supplies faster than the growth of the population (Davidson, 1992).
Tillage is the oldest operation in agriculture, so tillage machines have the longest development path and the greatest variety of types and types. Their main task is to bring the soil to the level of suitability for carrying out the following work processes, such as sowing, planting, fertilizing and others.
The main goals of tillage machines are saved of soil conditions, which are quantitatively expressed through its properties of porosity, density and humidity to increase crop yields and soil fertility. Therefore, the necessary tillage is determined above all by agrotechnical expedient general measures. Most importantly for the soil, if it is fertile and sufficiently enriched with nutrients, there will be a rich harvest and yield, which is the goal of every farmer (Dobrevska et al., 2015).
According to (Ksenevich, 1985; Mandrajiev, 1982) the density of the soil is essential and important, with this indicator the porosity can be determined and, accordingly, the amount of soil mass per unit volume can be determined. The conclusion is that at high density the porosity is lower.
With the advancement and improvement of the methodology, at the different stages of growing crops, it is appropriate to use and apply computerized and mechanized techniques for the evaluation and analysis of various factors that have a strong influence on the development of the cultivated plants and the evaluation of the land. Such a modern method is the use of the Geographical Information System (GIS). This approach offers structured processing of various types of data, both textual and graphical.
The combination of diverse information presupposes the analysis and arrangement of important information.
The natural conditions in Bulgaria favour the cultivation of various types of agricultural crops through a variety of soil and climatic conditions. Several authors indicate the need to develop strategies for the production and realization of agricultural production (Stoeva, 2013; Hristova & Ilieva, 2013; Toskov, 2014; Nikolova, 2013, Dobrevska et al., 2015). According to them, the developed measures should have a complex

nature, tied into a common system for effective management of agricultural holdings.

With the advancement of technology and the development of agricultural industries, more and more methods are used to analyze the purpose and usability of the land. These technologies and methods present the available information in the form of maps combining the various data (Carver, 1991; Eastman, 1997). All action related to spatial data as collecting new information, organize in groups, creating connection between them, logical links, correct and sufficient presentation and sharing can be realized by Geographical Information Systems, named GIS (Stefanova et al., 2014).

Based on the Geographical Information Systems, the methods for evaluating the multitude of factors are presented as a process combining within itself the transformation of spatial information into a process for finding solutions with optimal results.

MATERIALS AND METHODS

The surface tillage machine with which the studies were carried out combines the kinematics of a tiller with a horizontal axis of rotation and the horizontal displacement of the soil by a disc working body (Dallev, 2012). Surface active cultivation machinery soil led to a suitable condition for conducting subsequent operations sowing or planting. The experiments were carried out according to the methodology of the planned passive two-factor experiment (Mitkov, 2011).

The forward speed in the process of machine operation is changed to V1 = 1.89 km/h; V2 = 5.48 km/h; V3 = 7.97 km/h and the humidity is measured. Machine which carries out the surveys (Dallev, 2013) is equipped with a cut disc.

Studies of the aggregate composition of the different type of soil according to the speed and the moisture content are done by using a regression model. After a data-processing are derived regression equations describing fragmentation of the three fractions of soil: up to 1mm; from 1 to 25 mm and over 25 mm.

The next formulas calculated the soil fragments and grouped in 3 levels.

For aggregate composition < 1 mm is the next formula:

$Z = Aggr < 1\ mm = 8.67 + 3.2V - 0.28V^2 - 0.11V.M$ (Dallev et al., 2015);

For aggregate composition between 1 - 25 mm:

$Z = Aggr1\text{-}2mm = - 7.84V + 6.54M + 0,.61V^2$ (Dallev et al., 2015);

For aggregate composition > 25 mm:

$Z = Aggr > 25\ mm = 73.75 + 5.74V - 4.75M - 0.3V^2$ (Dallev et al., 2015), where M is soil moisture content and V is the speed.

Disk machine with R = 250 mm (Dallev, 2013)

Materials and data necessary for research:

Map of the the studied area in digital model;

Cadastre maps- The digital model formats are ZEM, CAD. Information source: the Geodesy, Cartography and Cadastre Agency.

Soil map in digital form;

Soil characteristics - Information source: The Soil Resources Agency and the Institute of Soil Science "Nikola Pushkarov";

QGIS 3.16 applications were used to visualize individual data and general analyses.

RESULTS AND DISCUSSIONS

The development of modern agriculture is unthinkable without complex mechanization of all production processes. In agriculture, mechanization and individual processes are leading to the industrialization of all branches. This is the development of new machine systems, the improvement of a given technology in growing a given crop, the provision of tillage machines with great operational reliability, and a significant increase in labor productivity. It has been established that with different types of agricultural machinery on the same soil we have a different final appearance of the cultivated area, a different fraction of the soil. And all this again depends on all the indicators of the type of soil.

The object of the development are territories for the cultivation of various crops. The studies were carried out on the territory of the land of the village of Kaloyanovo, Plovdiv region.

The necessary data contents coordinated geographical borderlines of villages in the Municipality of Kaloyanovo.

Situated in the north part of the Upper Thracian plain, covering area of 347 sq. km., the municipality is part of the region of Plovdiv and consists of the municipal center Kaloyanovo, and 14 settlements as well - Begovo, Glavatar, Gorna Mahala, Dolna Mahala, Duvanlii, Dalgo Pole, Zhitnitsa, Ivan Vazovo, Otets Paisievo, Pesnopoy, Razhevo, Razhevo Konare, Suhozem and Chernozemen. This is the most developed agricultural region for different agricultural production. Today, Municipality of Kaloyanovo faces a number of various soil treatments and ecological innovations and yield increased challenges. The development and implementation of an environmental action plan for the valleys are associated with the strategy position and closely connection with another neighbour agricultural areas. The picture above presents the Municipality of Kaloyanovo situated in Bulgaria map (Figure 1).

Figure 1. Bulgarian map and Municipality of Kaloyanovo

In the municipality are situated 14 villages with one center city, named Kaloyanovo (Figure 2). The relief is plane to hilly and average elevation is 250 m. The climate is transcontinental, characterized with an open winter and a hot summer. These factors are essential and favorable for agricultural developing.

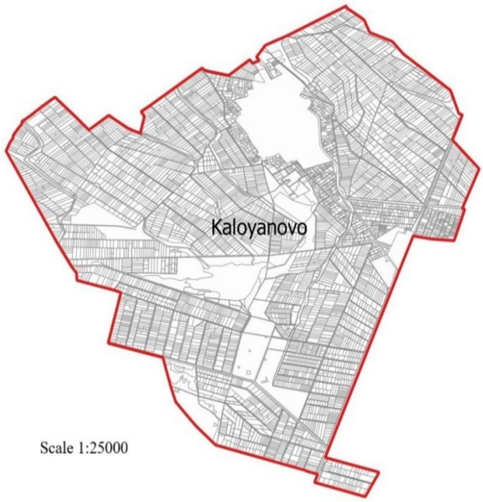

Figure 2. Map of the village Kaloyanovo

Next map (Figure 3) presents information about soil distribution in the studied area. Dominant soil types are sandy-clay and loamy, presented in the next map. These soil characteristics are useful for cultivation of various plants - both grain-legume and vegetable.

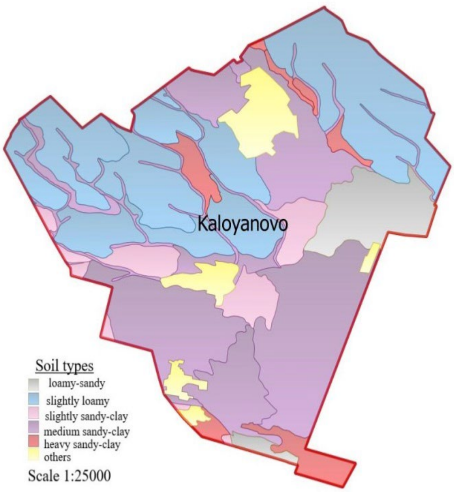

Figure 3. Map of Soil type in the studied area

Soil moisture at depth is defined as the average of all samples for a given depth (Figure 4).

When choosing a field of performing experiments with the following requirements:
The plot has a slope to the horizon is not more than 2-3°.
Surface no bumps, lumps, ridges and overthrew that provides safe operation of a machine.
The moisture content is determined by taking daily samples before and after lunch on the test area. Samples taken in airtight cups, dried at 105°C to constant weight. Measure the weight before and after drying.

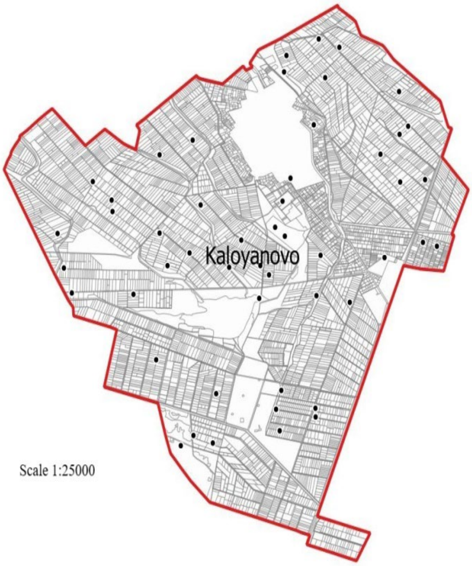

Figure 4. Map of the soil samples of moisture in the village Kaloyanovo

To visualize the results of the simulation experiments, GIS maps were created, visualizing soil fragmentation in the range of 3 levels:
- up to 1mm;
- between 1mm and 25 mm;
- more than 25mm.

With the implementation of the database in GIS, the method is developed for each property, array or the entire considered territory within one or several lands.
The soil aggregate fractions are calculated with speeds V1 = 1.89 km/h; V2 = 5.48 km/h; V3 = 7.97 km/h and respectively presented in the next three maps (Figures 5, 6, 7).

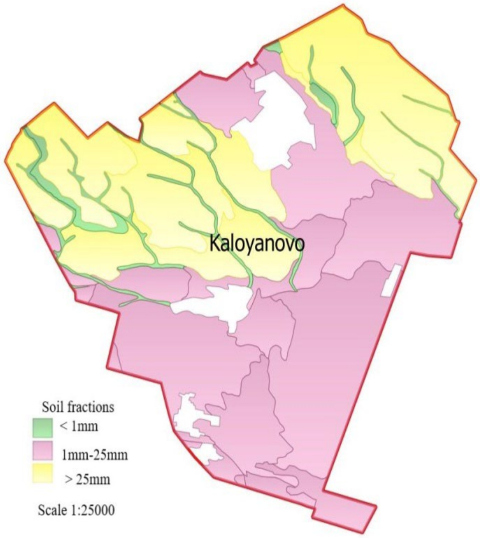

Figure 5. Map of Soil aggregate fractions with speeds V1 = 1.89 km/h

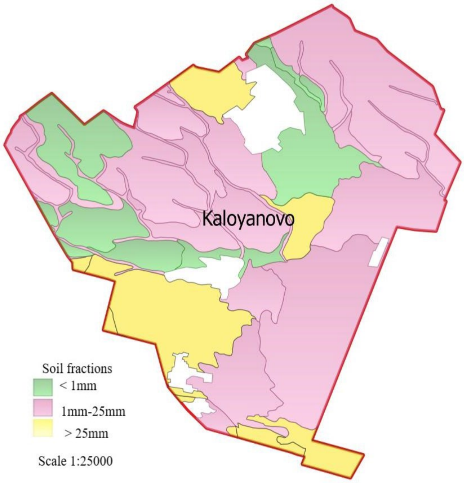

Figure 6. Map of Soil aggregate fractions with speeds V2 = 5.48 km/h

In order to observe agrotechnical requirements, units from 1 to 25 mm to be 70%, respectively, while those to 1 mm and over 25mm up to 30%, the measured values of moisture can be seen that it is impossible. Closest values to agrotechnical requirements are obtained at a speed of the unit around 5 km/h.
During this process, the following will occur aggregate composition:
- to 1 mm - 10%;

- from 1 to 25 mm - 60%;
- over 25 mm - 30%.

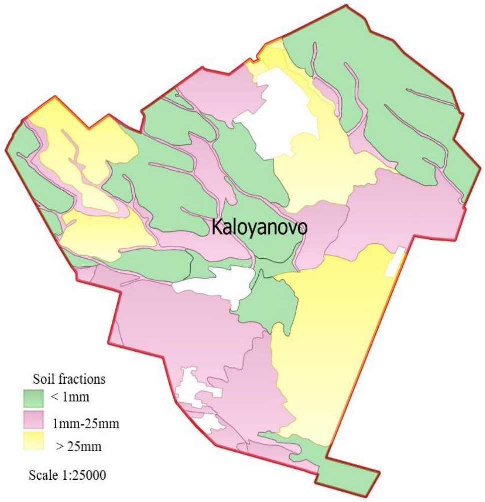

Figure 7. Map of Soil aggregate fractions with speeds V3 = 7.97 km/h

In all variants of the conducted experiments, humidity has a significant influence on the crushing of the machine under investigation.

CONCLUSIONS

This approach of presenting, harmonizing and analysing a lot of diverse information gives a clear picture for the cultivation of different types of crops in the land of the village of Kaloyanovo. When cultivating the soil, an important indicator is the achievement of a certain aggregate composition of the soil, necessary for the development of the cultivated crop. The cultivation of the soil with active working organs becomes extremely important, both from an agronomic and economic, as well as from an ecological point of view.

The indicator for the erosive dangerous condition of the soil is characterized by size fraction to 1 mm. Indicator valuable agronomic soil is determined by the fraction size of 1 to 25 mm.

Village of Kaloyanovo is good area for agricultural development. All natural factors-soil distribution, water resources and relief factors will have positive effects on crops development.

The implementation of information from real research and its transformation into a spatial database through GIS enables a modern and up-to-date analysis and summarization of the existing state of the studied territory.

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