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A NEW BODY INVESTIGATION FOR SURFACE SOIL FRAGMENTATION BY USING GIS

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Abstract

Despite the recently hyped No Till, Strip Till, Min Till, etc. systems tillage remains the most widely used system for agricultural production. The soil has the specific feature of providing the conditions for the growth, development and productivity of plants. The economic importance of soil is determined by its general characteristic fertility, which is its ability to supply plants with the necessary nutrients, water and air. The fertility of the soil depends on its condition, which is quantitatively expressed through its properties of porosity, density and humidity. Investigate a new body of active machine for surface soil treatment during a different values of soil humidity and velocity. The Results are arranged using statistical program for dates. From the results of the statistical operations are received regression equations. The received regression equations are introduced into GIS and presented in varied information layers. By these layers can be prepared a digital system to manage the soil aggregate composition.

Key words*: soil treatment, soil aggregate composition, GIS.*

INTRODUCTION

As a natural fact, soil is the product of long and extremely complex processes that have been going on for millennia. Nowadays, soils are considered as natural multifunctional systems. It occupies the surface earth layer and is at a depth of 20-50 cm (in rare cases it reaches 1-1.5 m). It is strongly influenced by changes in external conditions, changing its condition within wide limits due to its construction. Importance of soil from an economic point of view is determined by its general characteristic fertility, which is its ability to supply plants with the necessary nutrients, air and water.

The soil and its fertility depends on its condition, which is expressed quantitatively by its properties humidity, porosity, density. The change in properties is due to its structural construction and all the influences to which it is subjected.

Methods of mechanical tillage with a rational technology of cultivation of agricultural crops, strive to create optimal conditions for the growth and development of plants, that is give the soil a condition in which at the depth of processing it becomes clear of weeds, has a certain density and porosity, providing better seed germination, better conditions for absorbing moisture and preserving it from evaporating, which ultimately allows getting high programmed yields (Mamatov et al., 2021). However, in some cases, the required soil condition during mechanical processing performed by existing machines and tools can be achieved only with multiple passes of the units. The currently accepted technology of cultivation of agricultural crops provides for up to 10-12 operations (Mamatov et al., 2020; Aldoshin et al., 2020; Mirzaev et al., 2019).

Particularly a huge number of operations are required when developing some unusual crops like cotton. Rehashed passes of totals through the field adversely influence the compaction of the soil and cause the devastation of protuberances of the foremost ideal sizes, which leads to diminish in trim yields. In this respect, an unused innovation of development of agrarian crops has ended up widespread in all nations of the world - the combination of operations, which permits, at the side an increment in edit surrender, to extend labour efficiency by 1.5-3 times and diminish costs per unit of yield (Mamatov et al., 2020; Aldoshin et al., 2019; Mirzaev et al., 2019).

Kurdyumov et al. (2013), Vilde et al. (1986) and others were conducted research on creation and utilization of machines for handling and planning soil for sowing on edges, examining

their execution markers, and defending the parameters of working bodies.
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).
When tilling the soil, we have a mechanical impact of the working organs of the agricultural machines, with the aim of reaching a certain structure under the agrotechnical conditions for growing a given crop. for a certain time, on a certain volume of soil.
It is known that high-quality pre-sowing treatment of the soil can be achieved with just one pass of the tiller, while the amount of soil particles with a size of 0.25 to 25 mm, characterizing the good structure, is 3-3.5 times more large compared to those obtained in the operation of passive working organs. When we talk about machines with active working organs, this indicator is performed much better than machines with passive working organs (Georgieva, 1998). After mechanical processing, good mixing of the soil, especially around the root system, is important for soil fertility (Mandrajiev, 2003, etc.).
Modern agriculture requires the use of new information technologies. The combination of the database for the object and its geographical location allow the introduction of a large volume of information, centralization of data as a means of their management, automation of the design process, visualization and evaluation of incoming and outgoing information according to certain criteria (Dallev and Arnaudova, 2014).
All digital data can be realized and presented by Geographical Information Systems- GIS.

MATERIALS AND METHODS

The aim of the project is to investigate innovative working bodies with active drive, to achieve a higher quality of surface tillage taking into account the existing external and controllable factors.
To achieve the goal, it is necessary to solve the following tasks:
- Design and manufacture of innovative working bodies for surface soil treatment;
- Experimental study of the degree of soil fragmentation of aggregates with innovative working bodies under the conditions;
- Statistical processing of the results and optimization of the work modes of the various innovative work bodies.

Fragmentation is determined for each test by taking several soil samples in the studied area. The samples are dried to an air-dry state and divided into fractions through sieves with openings of 1 and 25 mm.
Machine which carry out the surveys is equipped with a cut discs (Figure 1).

Figure 1. Disk machine

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.
Studies of the aggregate composition of the different type of soil according to the speed and the humidity is done by using a regression model. After a data-processing are derived regression equations describing fragmentation of the three fractions of soil: up to 1 mm; from 1 to 25 mm and over 25 mm.
The next formulas calculated the soil fragments and grouped in 3 levels:
Aggregate composition to 1 mm
$Function=10.54'x-0.27'y^2-0.36'x^2$
Aggregate composition between 1mm-25 mm
$Function=10.54'x-0.27'y^2-0.36'x^2$
Aggregate composition more than > 25 mm
$Function=6.57+0.51'x^2$
The fractions are weighed to the nearest 1g and their percentage composition is determined.

The indicator of erosive - dangerous condition of the soil is characterized by the fraction up to 1 mm in size.
The indicator of agronomically valuable soil is determined by the fraction with sizes from 1 to 25 mm.
Moisture was determined by taking daily samples in the studied area at a given depth. The samples taken in hermetic cups are dried at a temperature of 105°C to a constant mass. The mass before and after drying is measured.
Soil moisture at a given depth is determined as the average of all samples for a given depth.
When choosing a field for conducting the experiments, the following requirements are observed:
- The section has a slope relative to the horizon no greater than 2-3°;
- There are no irregularities, lumps, ridges and furrows on the surface, which ensures safe operation of the given machine.
The necessary materials and date are:
- Cadastral maps and Maps of the recovered property for the surveyed territory;
- Soil maps;
- Soil characteristics - Information source: The Soil Resources Agency and the Institute of Soil Science "Nikola Pushkarov".
Program operating systems is QGIS 3.16 applications were used to visualize individual data and general analyses.

RESULTS AND DISCUSSIONS

In modern technology for growing crops the essential part is prevail tillage. It is necessary linked part of any agricultural production. Basic is the soil depth of which is done tillage and also surface tillage. One of the main objectives of the surface treatment is to create a suitable aggregate composition and structure of the soil fractions for profitable growing of the crops. This study is lead to classify the fragmentation of soil in the studied area operated with active disk authority for the surface treatment of the soil, combining kinematics tillage machine with horizontal axis of rotation and lateral displacement of soil from disk working authority.
The main tasks of tillage are many and varied, but they can be summarized in the following way:
1. To create the necessary ratio between the size of the aggregates inside the solid phase.
2. To give the soil surface and the cultivated layer the necessary microrelief.
The object of the development are territories for the cultivation of various crops.
The studied area is located in South Bulgaria and it is a part of Plovdiv region. The necessary data contents coordinated geographical borderlines of studied area. The study area is situated in the north part of the Upper Thracian plain, covering area of 347 sq. km. and consists of the municipal center Kaloyanovo, and 14 settlements. The selected municipality is good representative for analyzing agricultural practices and making important points of preliminary knowledge about environmental structure.
Today, the territory of Kaloyanovo focus on a number of various good tillage practices to increase ecological innovations and yield. The picture above presents the Municipality of Kaloyanovo situated in Bulgaria map (Figure 2).

Figure 2. Bulgarian map, Plovdiv region and Municipality of Kaloyanovo

Soil moisture is presented as the average of all samples for a given depth. To choose a field of performing experiments have to followg the next requirements (Figures 3 and 4):
- 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 at a certain depth. Samples taken in airtight cups, dried at 105°C to constant weight. Measure the weight before and after drying.
Simulation experiments have been carried out to study soil fragmentation in case of parametric instability of the factors determining fragmentation.

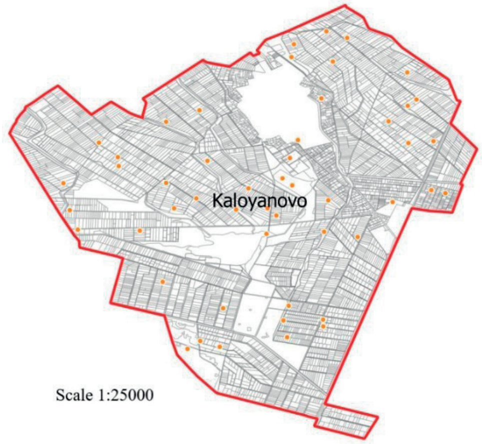

Figure 3. Studied area of Kaloyanovo and the location of soil moisture samples

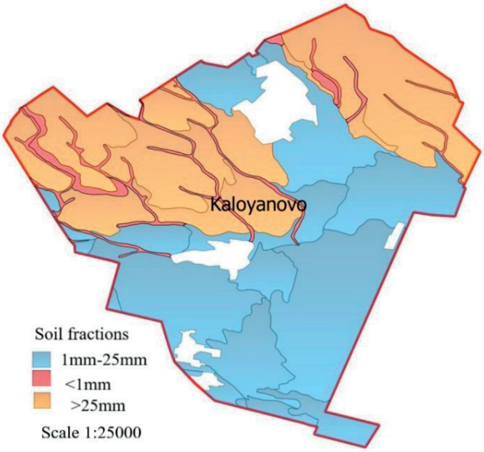

Figure 4. Map of Soil aggregate fractions with speeds V1 = 1.89 km/h

To visualize the results of the simulation experiments, GIS maps were created, visualizing soil fragmentation in the range of 3 levels:

- Up to 1 mm;
- Between 1 mm and 25 mm;
- More than 25 mm.

The soil aggregate fractions are calculated with speeds of machine in 3 variants: V1 = 1.89 km/h; V2 = 5.48 km/h; V3 = 7.97 km/h and presented in the Figures 4 and 5.

At a forward speed of 5.48 km/h, the percentage of the size fraction from 1 to 25 mm corresponds to the agrotechnical requirements. When changing the speed to 1.89 km/h and speed 7.97 km/h under the same conditions, the proportion of aggregates from 1 to 25 mm does not sufficiently correspond the requirements, which shows that the kinematic index at increased soil moisture has a determining influence on the useful fraction in soil fragmentation (Figure 6).

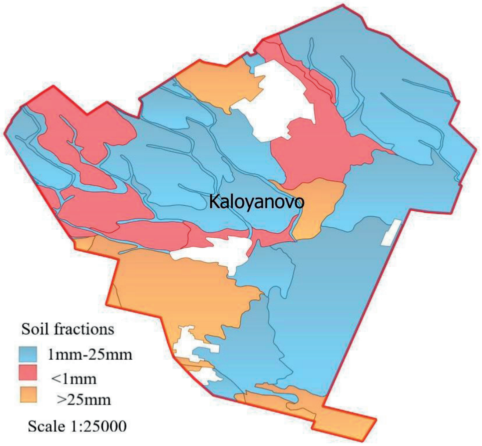

Figure 5. Map of Soil aggregate fractions with speeds V2 = 5.48 km/h

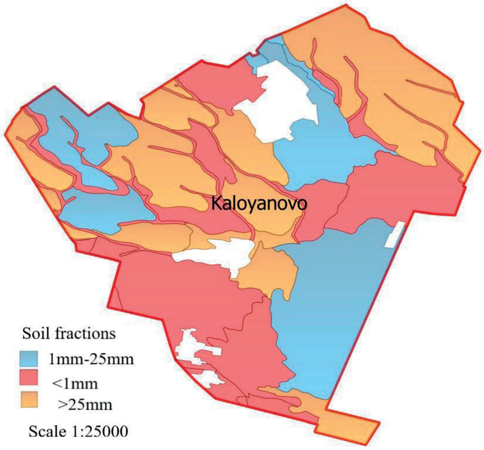

Figure 6. Map of Soil aggregate fractions with speeds V3 = 7.97 km/h

In the GIS environment, a simulation model of soil fragmentation in the range from 1 to 25 mm has been synthesized with parametric instability of the factors soil moisture and forward speed of the machine. The simulation model of soil fragmentation under parametric instability of the factors soil moisture and forward speed of the machine allows prediction and optimization of the aggregate composition of the soil in the range of 1 to 25 mm.

On the basis of the conducted research, it was found that to achieve an aggregate composition in the range of 1 to 25 mm in soils with a good clay content of about 50%, the studied tillage machine meets the requirements.

Agronomically, the most valuable are aggregates with a size of 1-25 mm. The greater their quantity, the better the soil structure. In the absence of aggregates smaller than 0.25 mm and large lumps, the conditions for plant development worsen. For example, in cases where the mass of aggregates smaller than 1 mm reaches more than 50% of the total mass of the soil, it becomes susceptible to wind erosion.

CONCLUSIONS

The research is based on creating a range of working bodies to achieve optimal aggregate composition during surface tillage.

Surface active cultivation machinery soil led to a suitable condition for conducting subsequent operations sowing or planting. This condition is characterized by soil aggregates size from 1 to 25 mm up to 70%.

The implementation of working bodies in practice will enrich the soil fragmentation data base, which would in turn lead to a greater choice of tillage bodies for soil erosion control.

The use of the GIS database will help to increase the knowledge of the working steps related to the correct selection of the areas, the choice of the appropriate production direction and variety structure, the use of modern technological solutions, the application of good agricultural practices for development of the sector.

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