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AGRONOMICALLY VALUABLE SOIL AGREGATS WITH INOVATIVE CULTIVATION TILLAGE

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Abstract

The final process of mechanical impact of the working soil tillage tools is the achievement of a certain aggregate composition regarding the size of the fractions. The object of the study is Innovative working bodies and the certain values of soil fragmentation. The indicator of agronomically valuable soil is determined by the fraction with sizes from 1 to 25 mm. The data are processed at three different indicators regarding the speed of the machine-tractor unit, at two different soil terrains. The experiment was carried out with a tillage mill with non-standard, disk working bodies with a horizontal axis of rotation. The percentage of soil fragmentation into aggregates is determined for each experiment, by taking 5 soil samples at equal distances along the length of the experimental field. The results after the experiment show that with innovative disks at certain indicators such as soil type, humidity and speed, optimal values of the soil aggregate composition are reached.

***Key words**: soil tillage machines, agronomically valuable soil, percentage of soil fragmentation.*

INTRODUCTION

The main purpose of soil tillage machines is to cultivate the soil in a way that provides the best opportunity for the development of the cultivated crop (Delibaltova et al., 2024; Mitkov, 2023). Another important vocation is to preserve soil fertility and create equal conditions for the germination and emergence of seeds from agricultural crops. Last but not least, of course, the economic aspect of the operation must meet the minimum for reducing production costs and increasing income from the cultivated crop. As a natural resource, soil is a product of long-term and extremely complex processes that have been occurring for millennia. It occupies the surface layer of the earth 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 state to a large extent due to its structure. The importance of soil from an economic point of view is determined by its generalized characteristic fertility, which is its ability to supply plants with the necessary nutrients, air and water. The change in its properties is due to its structural structure and all the impacts to which it is subjected (Bileva et al., 2022; Manhart & Delibaltova, 2022). The soil as a composition is a complex system. Its properties change with every passing moment. Its technological properties depend on the ratio between the liquid and gaseous phases in the soil (Hristova et al., 2022). The necessary soil treatments are determined primarily by agro-technical expedients, which are widely used in all countries with developed and mechanized agriculture. This treatment system also has a number of disadvantages. The main economic disadvantage is that a lot of energy, labor and resources are spent on the large number of treatments (for trench crops up to 10-12 per year). The main agrotechnical disadvantages are that with repeated passes of themachinery, the physical properties of the soil deteriorate, it quickly compacts, and maintaining it in a loose state when there are no developed crops facilitates water and wind erosion. All this has necessitated the search for ways to optimize soil cultivation in order to maintain high soil fertility while significantly reducing cultivation costs. By using high-performance machinery and properly combining shallow cultivation with periodic deep cultivation. The creation of innovative machinery with the aim of reducing cultivation, or the so-called Regenerative Agriculture, is environmentally friendly. It is a system of principles and practices that seek to restore and improve the entire ecosystem of the farm from the point of view of sustainability, including improving human health and economic prosperity. This is a method of agriculture that places a serious priority on soil health and improves the quality of the resources it uses (soil, water, biodiversity, etc.). Improving and restoring both the ecosystem and the soil to its natural fertile state begins with stopping degradation and saving soils from erosion. Therefore, Regenerative Agriculture is based on Conservation Agriculture, which has been practiced, developed and disseminated for over 60 years on large-scale industrial farms. Conservation Agriculture is an agricultural system that promotes minimal soil disturbance (i.e. no tillage), maintenance of permanent soil cover and diversification of plant species. The aim is to improve biodiversity and natural biological processes above and below the ground surface, which contribute to increased efficiency of water and nutrient use and improved and sustainable crop production. After a number of studies, Innovative active working bodies lead precisely to Regenerative Agriculture, reduced tillage and incorporation of all types of preparations, preservation of in the soil. For the conduct of the study, and not only for growing any crop, the type of soil or the so-called soil analysis is of utmost importance (Bakhtin, 1969). In modern agriculture, new information technologies, Geographic Information Systems - GIS, are increasingly used. Geographical Information Systems (GIS) consists of various components, starting with the incorporation of geographical data from remote sensing sources or maps and is then converted into a computer-readable form (Baniya, 2008). For establishing sustainable plants cultivation all collected data is transformed into spatial data for using GIS application (Malczewski, 2004).

MATERIALS AND METHODS

The research aims to:

Investigate innovative working bodies with active drive, for surface soil cultivation, combining the kinematics of a soil tillage machine with a horizontal axis of rotation and the horizontal displacement of the soil by a disk working body, to obtain agronomically valuable (Figure 1).

Regenerative Agriculture. To achieve the goal, it is necessary:

- Design and manufacture of new working bodies.
- Assembly of the working bodies to the horizontal shaft, with a certain angle of operation.
- Soil analysis.
- Conducting experiments.
- Data processing.
- A schematic diagram of the arrangement of the working bodies relative to the shaft is given. Both models are made with a different profile of 65G steel.

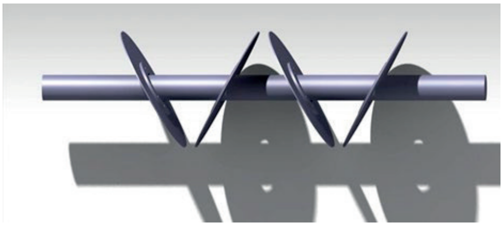

Figure 1. Disk with a horizontal axis of rotation and the horizontal displacement

Where the experiments were carried out Perushtitsa background: on plowing and the soil is a representative of TGP, heavy clay soil with a content of 50% physical clay.

The machine is an aggregated TK-80 with an active machine whose working width is Bp-0.76 m, PTO speed 540 min-1, at a speed of movement of the unit V = 2.5; 4.4; 7.5 km/h, and a set processing depth a = 12 cm, and the humidity is from W = 11% to W = 26%.

Through laboratory tests using the Kaczynski method (pipette method) it was established that the soil is a representative of TGP (heavy clay soil) with a content of 50% physical clay. 3. The percentage of soil fragmentation into aggregates is determined for each experiment, by taking 5 soil samples at equal distances along the length of the experimental bed in the following way: a box without a bottom measuring 400 x 230 x 230 mm is driven in. The bottom is inserted under it and the box with the soil is removed. The samples taken are left indoors, where they are dried to an air-dry state and divided into fractions through sieves with openings of 1 and 25 mm. The permissible deviation must be within ± 5%. degree of saturation - 70% of the soil aggregates should be from 1 to 25 mm in size, and aggregates up to 1 mm in size should be below 30% and the

soil surface should be level with an allowable ridge height of 20% of the processing depth.
The fractions are weighed with an accuracy of 1 g and their percentage composition is determined.
The indicator of soil erosion hazard is characterized by the fraction with a size of up to 1 mm (Figure 2).
The indicator of agronomically valuable soil is determined by the fraction with sizes from 1 to 25 mm.
The studies of the aggregate composition in soil background plowing are based on speed and moisture and are carried out using a regression Equations are derived after processing the data describing the fragmentation of the three soil fractions: up to 1 mm; from 1 to 25 mm and over 25 mm.
The following formulas calculate the soil fragments and are grouped into 3 levels: three soil fractions: up to 1 mm; from 1 to 25 mm and over 25 mm.

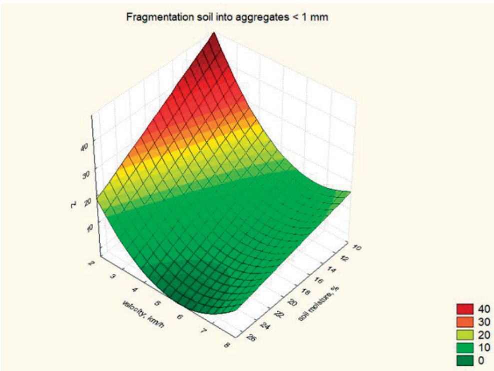

Figure 2. Fragmentation soil into aggregates < 1 mm

Aggregate composition up to 1 mm
Function=$110.52-2.21*W-25.25*V+1.77*V^2+0.21*W*V$ [%]
The graph shows that the soil moisture is a significant factor, with its increase in aggregates < 1 mm decreasing and the agronomically valuable structure increasing by % from 1 to 25 mm in the speed range V of 2.5 km/h (Figure 3).
Aggregate composition between 1 mm-25 mm
Function=$-18.57+1.02*W +31.26*V -3.62* V^2$ [%]
The graph shows that at a speed of 4.4 km/h and soil moisture W 22.1%, the agronomically valuable structure from 1 to 25 mm is the best, with a high % amount of soil.

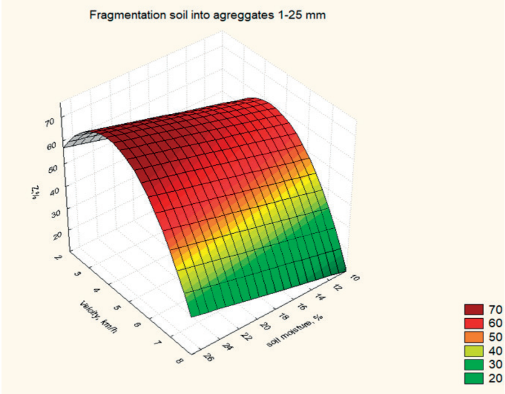

Figure 3. Fragmentation soil into aggregates 1-25 mm

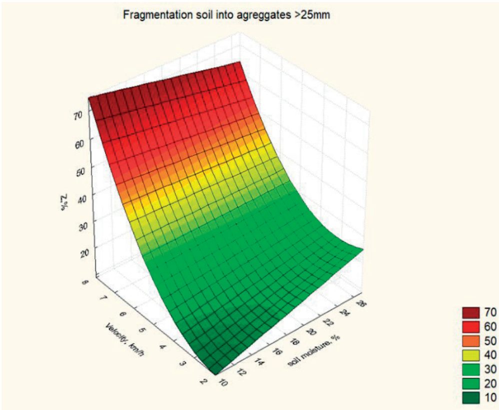

Figure 4. Fragmentation soil into aggregates > 25 mm

Aggregate composition above > 25 mm
Function=$1.51*W-3.92*V+1.76*V^2*0.27*W*V$ [%] The graph shows that at a speed of 7.5 km/h and increasing soil moisture, the fractions with a size of >25mm decrease, but not significantly (Figure 4).
Methodology is based on using GIS platforms and application for analysing to present the results. All transformation actions of collected data are made by QGIS software and appropriate spatial data filters. The results are thematic maps of studied data.

RESULTS AND DISCUSSIONS

The main tasks of soil cultivation are many and varied, but can be synthesized in the following form:
1. After soil cultivation, to have agronomically valuable soil aggregates as a size.

2. Compliance with a given depth of cultivation.
3. To create a certain ratio between the solid, liquid and gaseous phases.
4. To give the soil surface and the cultivated layer the necessary microrelief.
5. To create the necessary ratio between the size of the aggregates inside the solid phase.
All processing requirements are of essential importance, but the leading factor is the size of the soil aggregates. The profile of an already cultivated area depends on the working bodies that have passed a given area. Each machine has a different profile according to its geometric shape (Figure 5).

Figure 5. Disk with a horizontal axis of rotation and the horizontal displacement mounted on tractor

A determining factor for agricultural machines is the material of manufacture. Recommended materials for durable coatings of details, assemblies and elements of agricultural machinery are indicated and their areas of use are indicated (Penyashki et al., 2003).The cattle livestock has continuously decreased from 5,381 thousand heads in the year 1990 to 2,680 thousand heads in the year 2010, as a result of the dissolution of the agricultural units and of the fact that many old cattle have been slaughtered because of their low production (Zahiu et al., 2010).
Working bodies with which the experiments were carried out (Figure 6).
In the case of soil tillage bodies, the wedge is the basis of the device. It represents a spatial body limited by an unlimited number of surfaces that make a certain angle with each other. The intersection points of these surfaces are lines that play the role of cutting edges when interacting with the soil, respectively, they are subdivided depending on the type and number of their working surfaces. The development of modern agriculture is unthinkable without complex mechanization of all production processes.

Figure 6. Working bodies

Industrialization includes the development of new machine systems, the improvement of a given technology when growing a given crop, the provision of soil tillage machines with high operational reliability and a significant increase in labor productivity (Dimov, 1979). It has been established (Dallev, 2015) that with different types of agricultural machines on the same soil we have a different final type of cultivated area, a different fraction of the soil. And all this again depends on all indicators of the soil type. Soil cultivation with active working bodies is gaining extraordinary development, both from an agronomic and economic, as well as from an ecological point of view.
When cultivating the soil, we have a mechanical impact of the working bodies of agricultural machinery, in order to achieve a certain structure under the agrotechnical conditions for growing a given crop. for a certain time, on a certain volume of soil. In this study, we classify the size of the fragmentation of soil aggregates in the soil under consideration, with a new type of active working bodies. The requirements for soil cultivation are quite diverse and of different nature and aspect. The area of soil samples is above to be equal during the various terrains. Soil background plowing at the specified humidity and speed. In the present analysis, they are:

- Fractions with sizes of agronomically valuable soil aggregates from 1 to 25 mm;
- Good profile of the already cultivated area;
- Minimization of treatments.

The experiments were carried out in the area of Perushtitsa, city of Plovdiv region, Bulgaria (Figure 7).

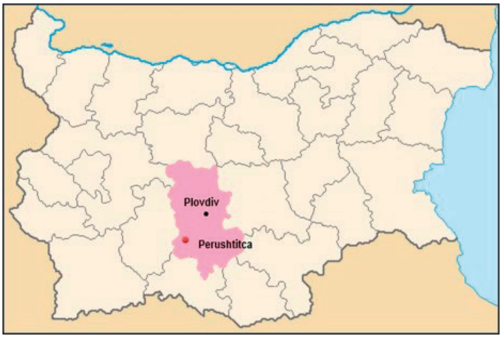

Figure 7. Studied area-Perushtitsa city, Plovdiv region, Bulgaria

All information about the region of study is collected from different scientific, experimental and literary sources. The results are gathered, analysed and presented by thematic maps. The region of Perusthitsa city covers 4871.6 ha, including 2298.9 ha land using area.

The topography of different regions creates a complex mosaic of topoclimates changes from 150 m to 800 m. The relief is various from plane to hilly. The Perushtitza Village belongs to the temperate continental climate zone. However, topographic setting causes to have great variation in climatic condition between the valley basin and the surrounding hilly area. The topography of different regions creates a complex mosaic of topo climates.

By its large resources possibilities, commands and tools, this Geographical Information Systems has a power to action with huge amount of information.

All conditions and factors, which influenced on soil aggregates, are presented by thematic maps (Figures 8-10). Agriculture database activities as collecting, organizing, transforming, analyzing and presenting the results of the studied area by GIS modeling.

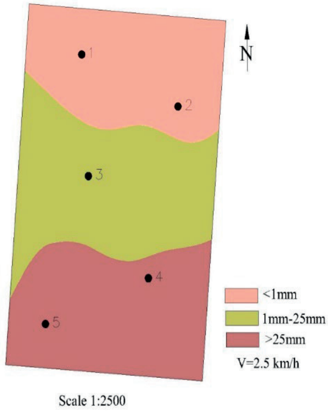

Figure 8. Map of Soil aggregate composition with speed V = 2.5 km/h

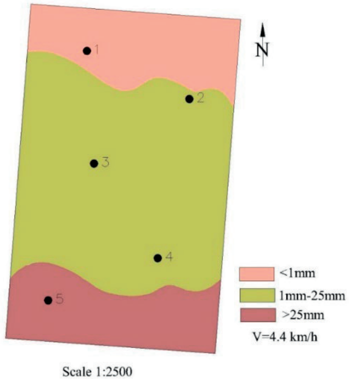

Figure 9. Map of Soil aggregate composition with speed V = 4.4 km/h

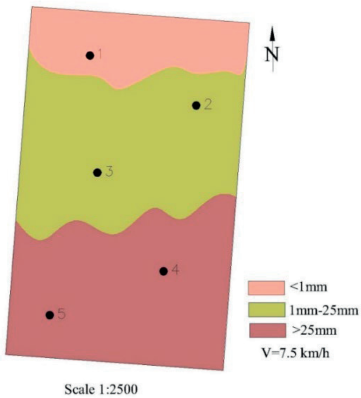

Figure 10. Map of Soil aggregate composition with speed V = 7.5 km/h

CONCLUSIONS

The unification shows that with discs 1 we have a balanced and percentage satisfactory crushing of this size fraction on both soil backgrounds under the specified criteria. The deduction from the analysis of disks 1 on the soil background plowing shows that agronomically valuable soil with fraction sizes of 1-25 mm is obtained at a speed of 4.4 km/h and humidity W 18.9-25.7%. The resulting soil aggregates are of great importance in the cultivation of any agricultural crops. From the placement of the seed in the soil, the planting material to the development of the given crop. The size of the soil aggregates after processing is final and of essential importance.

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