WEB ISSN 2535-0242
PRINT ISSN 2535--0234

SOIL TILLAGE INFLUENCE ON THE AGGREGATE STABILITY

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***Abstract**: The Importance of the Problem "Stability of Soil Aggregates" The assessment of soil quality indicators and their interpretation should be considered as a process in which all soil resources are assessed in terms of soil functions and the changes that would occur in these functions as a result of Natural or specific stresses and / or certain human activity. The process of formation of soil aggregates or organominerals complexes from primary particles and humic and other bounding substances, is called aggregation. It is the first step in the development of soil structure. Humified organic matter, with its long polymer chains and electric charge balanced by polyvalent cations, is a very effective cementing agents. Structural stability is the ability of a soil to retain its arrangements of solids and void space when external forces area applied. External forces can be natural or anthropogenic. The aggregate stability depends on the bonding agents involved in cementing the particles together.*

***KEY WORDS**: SOIL QUALITY INDICATORS, AGGREGATE STABILITY*

Introduction

Soil has 5 specific features that are of particular importance:

- maintain biological activity, diversity and fertility;
- regulate and distribute water and soil solution;
- perform filtering, buffer, degradation and immobilization activities, as well as detoxify organic and inorganic materials, including industrial and urban waste, and absorb atmospheric overlaps;
- to store and carry out cyclical nutrients and other elements within the Earth's biosphere;
- maintain socio-economic structures and preserve the archaeological values associated with human activity, [17].

Definition of Soil Aggregate Stability: Soil aggregates are groups of soil particles that are tied to each other more tightly than other nearby particles, [16,17, 18].

The stability of soil aggregates directly affects the dynamics of erosion processes, air and water movement in the soil and the development of the root system of plants. It is desirable that soil aggregates be resistant to the destructive action of raindrops and surface water runoff. Broken aggregates that break down from water or raindrops can break and fill the pores and seal the surface of the soil against water penetration into it. This breakdown helps to form a soil crust, defines another way for water movement in the soil and restricts the germination of the seeds.

Material and method

The binding agents involved at each stage of aggregation can be grouped in three main categories: transient - such as polysaccahides and microbial products; temporary – roots, fungal hyphae and microbial byproducts; persistent – humic substances, organo-mineral compex, dehydrated humic materials and humic-sesquioxides complexex13, 14, 15].

The strength of the soil aggregates refers to the ability of aggregates to withstand disruptive forces such as traffic, intensive raindrop impact, annual soil tillage, root development. The information related to the soil’s response to tillage or machines passing on the surface is important to calculate the aggregate strength. From one side, the factors affecting the soil strength are the water and organic matter content, size of the soil particles, texture and clay minerals, [16, 17]. From an another side the soil strength depends on the contact points between the aggregates. The repeat cycles of draying and wetting play a major role in aggregation through shrinking and swelling that lead to formation of aggregates, table 1.

Table 1.Components of an aggregates:

Components	Size range	
Clay	2	µm
Domain, quasi crystal, or Packets	2-5	µm
Microaggregate	5-500	µm
Aggregate	0,5 – 5	mm
Compound structure	➢ 5	mm

The process of seedbed preparation is the most destructive for soil porosity process. The pore space and size distribution due to the change of the soil volume is serious. In fact, due to repeat annual ploughing only 2% of the soil volume is occupied by pores, [17]. Also, the machinery traffic have significant impact on the soil structure. The strategy to use crop residue and reduced number of passed throughout the soil surface is also useful tool to protect the soil structure, [5].

The Aggregate strength may be determined by the raindrop technique. i.e. by evaluation of the kinetic energy required to disrupt the aggregates. Dry soil aggregate strength may be evaluated by a procedure that evaluate the crushing strength, [6].

It is of particular importance to emphasize that the assessment of soil quality indicators includes the chemical, biological and physical properties and processes that take place on this basis. To interpret the results of the assessment, all measurements should focus on the sustainability of the processes over time and the long-term use of soil resources, [18].

The distance between soil aggregates determines the size of the pores for holding and exchanging air and water. Stability of soil aggregates refers to the ability of aggregates to remain undisturbed by applying an external force that is in most cases associated with the impact of water, 16]. The stability of soil aggregates is not the same as the stability of aggregates in a dry state, which is used to determine wind erosion.

Optimal conditions indicate a wide variety of pores. It includes both large pores formed between aggregates and micropores. Macropores are extremely important for water movement and air exchange. These pores also include the areas of instability through which the roots of the plants must penetrate. If the soil volume has a low bulk

WEB ISSN 2535-0242
PRINT ISSN 2535--0234

density or a large area of pores, aggregate stability is not particularly important. For example, sandy soils have low stability of their aggregates but are water and air-permeable.

Factors influencing the stability of soil aggregates

Stability of soil aggregates influences soil texture, dominant soil clay, soluble iron and catholytes, soil organic matter content, and the size and size of microbial populations. Some soils swell when adsorbing water. Expansion and contraction of clay particles can change the soil and form cracks, which in turn can change the structure of soil aggregates. The calcium ion associated with clay generally helps aggregation, while the sodium ion helps to destroy it.

Soils with a content of more than 5% iron oxide show excellent stability of soil aggregates.

Soils that have a high organic content have high stability of their aggregates. Regular introduction of organic matter (OM) favors this process as active microbiological activity is observed. Soil microorganisms produce various organic compounds that help preserve soil aggregates. The type of microorganisms is important. Mycelium mycelium consolidates soil aggregates to a greater extent than microorganisms.

Stability of soil aggregates increases when the soil is captured or planted with alfalfa.

Measurement of soil aggregates stability

There are a number of methods to measure the stability of soil aggregates. The standard method of the National Center for the Study of soil (NRCS - USA) can be used in the field or laboratory testing. This procedure involves repetitive trials with aggregates in distilled water.

• The alternative procedure does not require weighing the sample. The measurements were carried out with an oven-dried soil which is passed through a mesh with a pore diameter of 2 mm and held in a sieve with a pore diameter of 1 mm thick. The size of these 1-2 mm aggregates is placed in a small open container with a sieve at the bottom. This container is placed in distilled water. After 20 minutes, this container is removed and the amount is dried. The dried soil is removed and the soil aggregates are destroyed visually. These materials, which are at least different from the original aggregates, have the highest stability.

• Soils containing sludge, often show low stability of the soil aggregates, if considered after drying than in field studies, as water destroys the structure.

Determination of a sustainable fraction in the soil

In order to determine the sustainable fraction of the soil, soil samples can me be taken in advance. As field studies, soil density has to be measured and determined.

Sequence of actions:

• The soil sample is taken from a depth of not more than 0.10 m.

• Soil is then taken from the samples taken to determine soil pH and wet sifting.

• Determine the content of organic matter in the soil sample.

Wet sieving method

Determination of the soil aggregates stability after wetting is based on the principle that unsustainable aggregates break down more easily than persistent when immersed in water.

The appliance has 8 caps mesh screens (each sieve has 60 holes). They are filled with soil 5 mm below their upper edge. So filled they are immersed for a certain time in water and subtracted. At the end of the procedure, only the insoluble mineral part (sand) and plant residues remain in the cups.

The ratio between the mass of resistant aggregates versus the total mass of the sample (the soil used for the analysis) gives the stability index.

Sequence of execution

Take a soil sample and measure 4g soil with a soil aggregate fraction of 1-2mm. These soil aggregates are placed in the chalk sieve of the apparatus. The mass of the materials in each cup is determined after weighing them on an electrical balance. Remove the mass of the cup from the weighted mass. The dispersion mass in the second cups where the spray solution is placed is 0.2g. This mass must be pulled out of the weight of the weighed material.

The resistant fraction is equal to the mass of soil obtained in the dispersion cups, divided by the sum of the masses measured in the dispersion cups and the distilled water cups.

The result obtained shows the resistance of soil aggregates expressed as a percentage.

Four concurrent analyzes are performed, with the average value being the final result.

Results and discussions

Soil tillage play an important role in the aggregate stability building and destruction as well.

A number of experiments are carried out during the period 2014-2017 in the fields of Ruse, Dobrich and Silistra districts.

The aggregate stability tests are carried out after ploughing, discking, strip till and no till techniques.

It is suitable to made dispersion analysis. One-factor DISPERSION ANALYSIS FOR SUSTAINABILITY OF SOIL AGREGATES – 2015 is presented, [7, 8, 9.

Factor A - sampling point. Six locations are selected and soil aggregates are measured. They are - A1 – Ryahovo, Ruse District; A2 – Voynovo, Silista District; A3 – Izvor, Shumen District; A4 - E. Joseph, Ruse District; A5 Cherven, Ruse District; A6 – Slaveevo, Dobrich Desitrict
The results related to the unsustainability of the soil aggregates is: table 1.

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PRINT ISSN 2535--0234

Table 1. Statistical analysis of the unsustainability of the soil aggregates

Effect	Univariate Tests of Significance for $Y_{\text{неу ст.}}$ (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	30715,70	1	30715,70	293,1535	0,000000
A	4759,13	5	951,83	9,0843	0,000189
Error	1885,98	18	104,78		

The type of the dispersion model is:

$SS = SS_A + SS_E = 4759{,}13 + 1885{,}98$

Factor A – the geography place which refers to the specific soil type has a significant impact on unsustainable aggregates, which is confirmed by the probability value p = 0.000189, which is significantly less than the significance level α = 0.05.

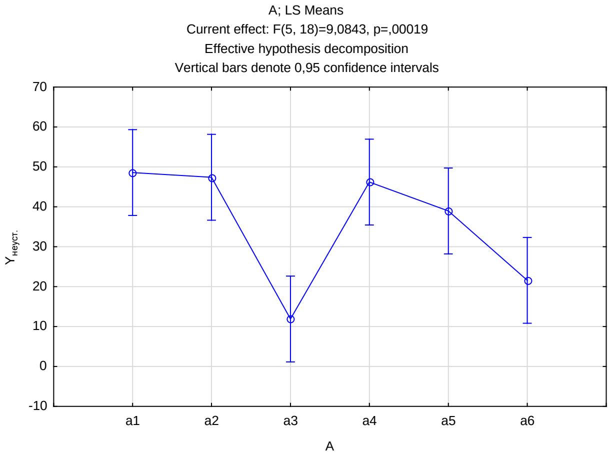

Fig.1. Graph presentation of the aggregate unstability by geography location.

Rezults related to the aggregate stability

Type of dispersion model: $SS = SS_A + SS_E = 4759{,}13 + 1885{,}98$

Factor A has a significant impact on unsustainable aggregates, which is confirmed by the probability value p = 0.000189, which is significantly less than the significance level α = 0.05, table 3.

Table 3.Statistical analysis of the soil aggregates stability

Effect	Univariate Tests of Significance for $Y_{\text{у ст.}}$ (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	98997,70	1	98997,70	944,8433	0,000000
A	4759,13	5	951,83	9,0843	0,000189
Error	1885,98	18	104,78		

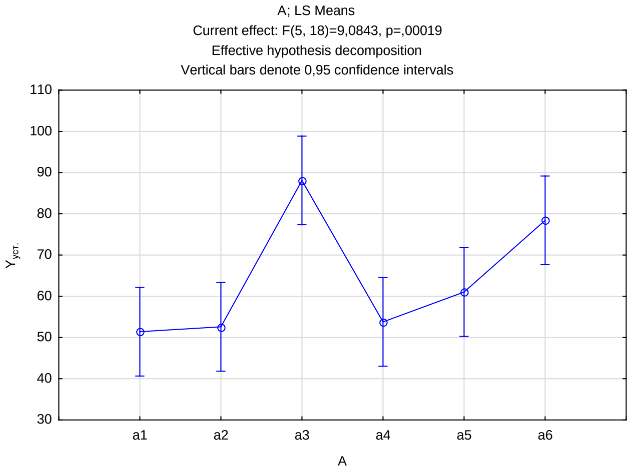

Fig.2. Graph presentation of the aggregate stability by geography location.

From the graphs, it can be seen that in the third level the factor A differs significantly from the other levels.

Multifactory dispersion analysis for sustainability of soil aggregates

Factor A - the same as for single factor analysis and the same levels

Factor B - year of sampling. B_1 - in 2014; B_2 – in 2015

Table 2.Analysis of the soil aggregates stability

Effect	Univariate Tests of Significance for $Y_{\text{у ст.}}$ (Spreadsheet1) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	150543,7	1	150543,7	1876,532	0,000000
A	5960,4	5	1192,1	14,859	0,000000
B	3245,3	1	3245,3	40,452	0,000000
A*B	2224,0	5	444,8	5,544	0,000693
Error	2888,1	36	80,2		

Type of dispersion model:

$$SS = SS_A + SS_B + SS_{AB} + SS_E$$
$$= 5960{,}4 + 3245{,}3 + 2224 + 2888{,}1$$

Both factors, as well as their mixed interaction, have a significant impact on the percentage of sustainable aggregates. This is confirmed by their much lower probability p values than the level of significance of 0.05.

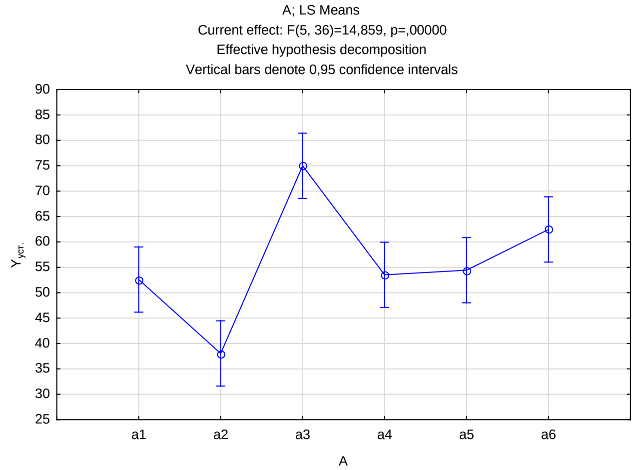

Fig.3. Graph presentation of the aggregate stability by geography location.

Examined separately for each factor, the results show that factor A at its third level is significantly different from other levels. Factor C on its second level gives higher scores for the percentage of persistent aggregates. The graph of the mixed interaction of both factors indicates that factor B with its second level results in improved performance at all levels of factor A.

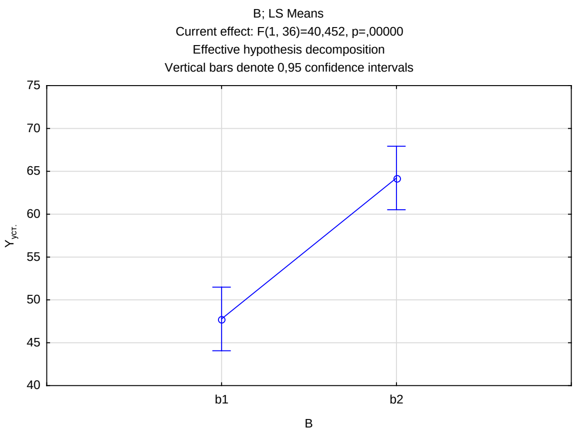

Fig.4. Influence the year when the samples are taken

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PRINT ISSN 2535--0234

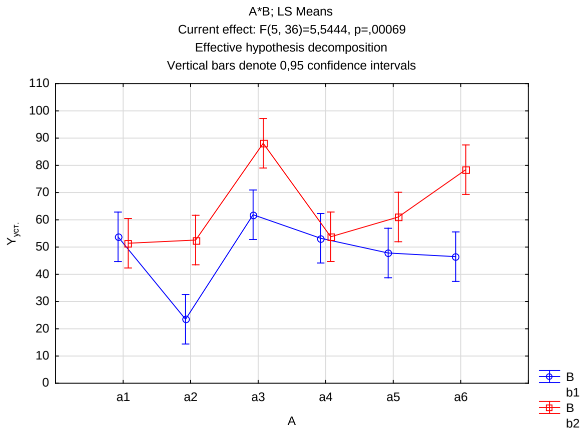

Fig.5. Joint influence the factors A and B on the soil aggregate stability

Conclusions:

Aggregate stability depends on many factors, but the most important are the organic matter content, traffic and soil type.

Due to the fact that Bulgarian soil map is presented by many soil types, the aggregate stability can be managed after analysis of the physical properties in each location.

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