CHARACTERIZATION OF THE STABLE AGGREGATES OF THE SOIL SPECIFIC TO THE NORTHERN PLATEAU OF THE REPUBLIC OF MOLDOVA

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Abstract. The importance of the aggregates studies could be presented from the following perspectives: elaboration of the soil studies to substantiate the projects of arrangement, organization and exploitation of the meadows; elaboration of (naturalistic) soil studies prior to the preparation of forestry arrangements; elaboration of the soil studies necessary to substantiate the projects of complex arrangement of the slopes in order to prevent and control erosion on agricultural land in non-irrigated regime; elaboration of the soil studies in order to recover the lands degraded by social-economic activities. The researches consists in highlighting the influence of the shelterbelts on the evolution of the soil in the immediate area of it, compared with the soil developed inside the shelterbelt, starting from the premise: degraded lands, recovered through shelterbelts, in order to ensure full protection of agricultural crops, it must also have a high degree of soil amelioration, a low risk of erosion and erosivity.

Keywords: dry aggregate stability method, macro-structure of soil, micro-structure of soil, particles of soil

INTRODUCTION

The soil aggregate stability is one of the indicators of soil quality (Papadopoulos, 2011), through which is estimated the ability of soil aggregates to resist degradation (Singh et al., 2019). Degradation of soil can be manifested when soil is exposed to different external forces, such as: wind erosion, water erosion, and land use (Torri et al., 1998), or soil management techniques (Tuo et al., 2017), such as: fertilization, and tillage. The formation of soil aggregates occurs due to interactions of primary soil particles, and stability of soil aggregates is affected by dozens different factors for which individual effects are hardly discernable (Šimanský et al., 2017).

The stability of soil aggregates is influenced by soil texture, the predominant type of clay, extractable iron and cations, the amount and type of organic matter, the type and size of microbial population (USDA Natural Resources Conservation Service). One of the most important binding agents for forming stable aggregates is soil organic matter, which can be retained in various size fractions of aggregates, and Šimanský and Bajčan (2014), concluded that if aggregates are water-resistant, they retain more carbon.

Soil aggregation and aggregates stability have been evaluated using various indexes such as the geometric mean diameter, mean weight diameter, water-stable aggregation, and normalized stability index (Nichols and Toro, 2011 cited by Martínez-Trinidad et al., 2012). However, there is no universal prescription as to which of these methods should be preferred or used for specific cases.

The results regarding this paper have the aim to present the primary structural elements (aggregates) which are mineral and organic in composition. The specificity of the primary particles is the quality of their surface, determined by the nature of the particle surfacing. The soil may be characterized by the macrostructure of the soil, which follows the aggregates structure (the mode of grouping of the soil matter), as a mass of soil (earth) that can be separated in different diameter regimes with small dimensions, from 8-10 mm to fractions of a millimeter. Aggregates are consisting of particles of different size categories - sand, powders – dust, loams, clay or humus.

The typical (ideal) aggregates structure can occur through the aggregate structure of various sizes, with the predominance of 1-5 mm in size. The stability of the structure, the shape and the placement of the aggregates determine the conditions of porosity, cohesion and permeability (Regelink et al., 2015). Also, the development of this study could follow to determine the linkages between soil structure and physical–chemical soil properties (Regelink et al., 2015), which are still poorly understood due to the wide size-range at which aggregation occurs and the variety of aggregation factors involved (Nimmo, 2005; Masciandaro et al., 2018).

MATERIAL AND METHODS

The aggregate stability can be measured in several ways: (a) wet aggregate stability method, and (b) dry aggregate stability method (Garey, 1954; Chiriță, 1955; Rogowski, 1964; Nichols, 2011; Ćirić et al., 2012). The results presented in this article are obtained by dry aggregate stability method. Through this method aggregate stability is measured as a percentage of aggregates that are with the diameter larger than 0.25 mm. The qualitative interpretation of the results was established by applying the scales and indicators mentioned by Chiriță.

The analyzed soil samples come from two with installed shelterbelts. The perimeters belongs to Edinet district, located in the Northern Region (Tara de Sus), Republic of Moldova. The soil samples coded with <N> and <NP> come from Corpaci area (Republic of Moldova), located in the immediate vicinity of the Prut river, respectively the Costești-Stînca accumulation lake. The soil samples encoded with <T>, <TP> and <G> come from the immediate vicinity of Terebna area (Republic of Moldova) (Fig. 1).

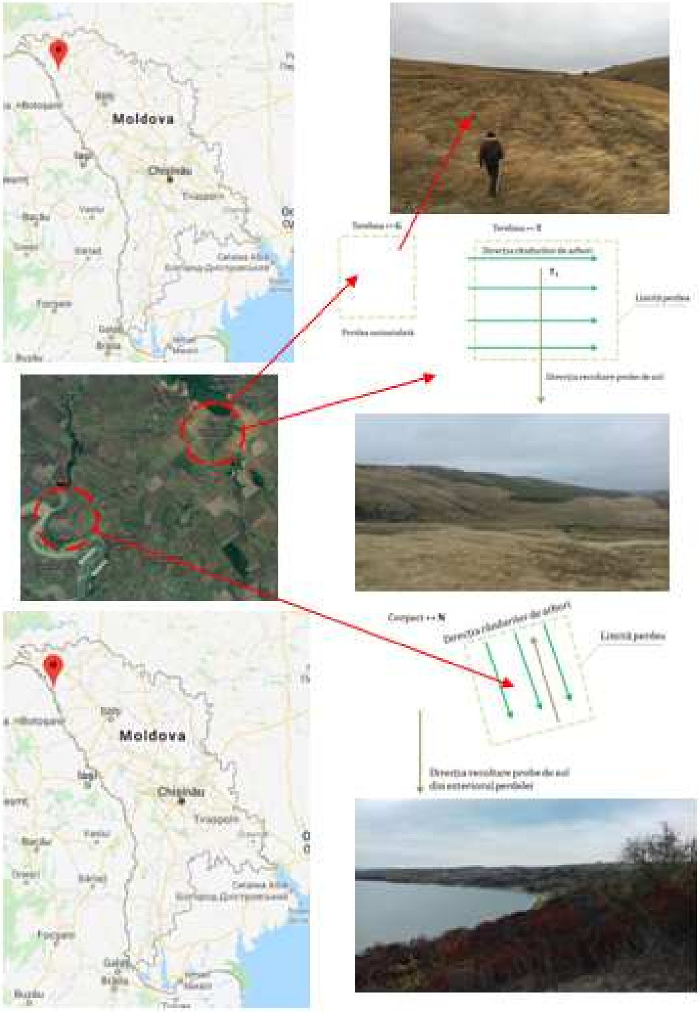

Figure 1. Schematic location of sampling sites of soil studied from the perimeter of Terebna and Corpaci (Republic of Moldova)

The categories of complexity of the analyzed perimeters can be delimited by the following aspects:

→ the perimeter of Terebna 1 research (coded G) is located on the south orientation slope, the area in which the installation of the shelterbelts was tried;

→ the perimeter of Terebna 2 research (coded TP and T) is on the north-west orientation slope, the area with a installed shelterbelt about 9 years ago;

→ the perimeter of Corpaci research (coded NP and N) is located in the river Prut, on the western orientation slope, the area with a shelterbelt about 19 years ago;

→ the perimeter of Cucunoşti research (coded P) is located in the river Prut, in the south of the Corpaci perimeter, on the slope with the same orientation as Corpaci, the area with a installed shelterbelt about 17 years, with a very varied, fragmentized micro-relief.

Following the observations made in the field, the following situations regarding the condition of the Terebna and Corpaci shelterbelts were found:

→ some specimens from the curtain were cut to the ground;

→ spontaneously sprouted shoots were identified;

→ the smallest consistency is 0.4; the average being between 0.6 and 0.7;

→ the maintenance works performed are: clearing and cleaning;

→ the curtains have an aspect of "herbaceous forest".

Figure 3. Soil sampling, preparation of samples for transport and storage, respectively making determinations regarding the classes of aggregates resulted from sieving soil samples

In each perimeter the following actions were taken:

1. In the perimeter of Terebna 1 (G) - the uninstalled shelterbelt, with specific formations for the manifestation of soil erosion:

(a) eight soil samples were collected, of which: four on 0-20 cm depth, and four on 20-40 cm depth;

(b) laboratory studies were carried out consisting of the differentiation of each soil sample into four categories of aggregates and three categories of soil particles;

(c) the differentiation of the aggregates was done in four repetitions, resulting in a data set consisting of:

8 soil samples X 7 sieving determinations X 4 replications = 224 determinations

(d) results reporting was done in % by weight of the soil.

2. In the perimeter of Terebna 2 (T) – installed shelterbelt and area only with herbaceous vegetation, without formation specific to soil erosion:

(a) 16 soil samples were collected, of which: eight on 0-20 cm depth and another eight on 20-40 cm depth;

(b) laboratory studies were carried out consisting of the differentiation of each soil sample into four categories of aggregates and three categories of soil particles;

(c) the differentiation of the aggregates was done in four repetitions, resulting in a data set consisting of:

16 soil samples X 7 sieving determinations X 4 replications = 448 determinations

(d) mass reporting was done in % of the weight of the soil.

3. In the perimeter of Corpaci (N) – installed shelterbelt and area only with herbaceous vegetation, with specific formations for soil erosion:

(a) 16 soil samples were collected, of which: eight on 0-20 cm depth and another eight on 20-40 cm depth;

(b) laboratory studies were carried out consisting of the differentiation of each soil sample into four categories of aggregates and three categories of soil particles;

(c) the differentiation of the aggregates was done in four repetitions, resulting in a data set consisting of:

16 soil samples X 7 sieving determinations X 4 replications = 448 determinations

(d) mass reporting was done in% of the weight of the soil.

The research activities covered the following aspects:

- presentation of the analyses regarding the quantity of aggregates (% of soil weight) with a diameter greater than 2.0 mm for the five types of land use, carried out in four laboratory replications, for each soil sample, taken from:

  - cod G – uninstalled shelterbelt Terebna;
  - cod TP – installed shelterbelt Terebna;
  - cod T – in proximity of installed shelterbelt Terebna;
  - cod NP – installed shelterbelt Corpaci;
  - cod N – in proximity of installed shelterbelt Corpaci.

- presentation of the analyses regarding the quantity of aggregates (% of soil weight) with the diameter between 2.0 and 0.25 mm for the five types of land use, carried out in four laboratory replications for each soil sample;

- presentation of the quantities of particles with a diameter of less than 0.25 mm.

- presentation of the qualitative index of the structure, representing the ratio between the sum of categories I, II and III - large, medium and medium-sized aggregates, respectively with a diameter greater than 2.0 mm and the sum of categories IV and V - small aggregates with a diameter between 2.0 and 1.0 mm, respectively small aggregates with a diameter between 1.0 and 0.5 mm:

$$\mathrm{I_{s\ macro}} = \frac{\mathrm{Category_{I+II+III}}}{\mathrm{Category_{IV}} + \mathrm{Category_{V}}}$$

- presentation of the qualitative index of the structure, representing the ratio between category IV - small aggregates with a diameter between 2.0-1.0 mm and the sum of categories V and VI - small aggregates with a diameter between 1.0-0.5 mm, respectively very small aggregates with a diameter between 0.50-0.25 mm:

$$\mathrm{I_{s\ micro}} = \frac{\mathrm{Category_{IV}}}{\mathrm{Category_{V}} + \mathrm{Category_{VI}}}$$

Soil mass resulting from sieving with size less than 0.25 mm, are considered as soil particles. Aggregates larger in diameter of 2 mm, have been classified into three broad categories:

- category I - large aggregates with a diameter greater than 5 mm;
- category II - medium aggregates with a diameter between 5-3 mm;
- category III - sub-medium aggregates with a diameter between 3-2 mm.

From each soil sample collected from the field, four soil samples were extracted for laboratory determinations. Laboratory determinations were reported in % of soil weight. The aggregates with the diameter between 2.0 and 0.25 mm, are classified in three other major categories:

- category IV - small aggregates with a diameter between 2.0-1.0 mm;
- category V - small aggregates with a diameter between 1.0-0.5 mm;
- category VI - very small aggregates with a diameter between 0.50-0.25 mm.

RESULTS AND DISCUSSIONS

For aggregates larger than 2 mm, on the depth of 0.00-0.20 m, the smallest percentage of soil weight is 32.9% (uninstalled shelterbelt Terebna - code G), and the highest of 57.0% (installed shelterbelt Terebna - TP code) (Table 1). Statistically comparing the limit differences (p5% = 5.15; p1% = 6.80, p0.1% = 8.75), on the depth of 0.00-0.20 m, compared to the content of aggregates with the larger diameter of 2 mm, we obtained very significant differences for the samples from the shelterbelt Terebna (TP code) (57.0% aggregates with a diameter greater than 2 mm) and outside it (T code) (45.5% aggregates with a diameter greater than 2 mm), but compared to the samples from the Corpaci shelterbelt (NP code) (39.9% aggregates with a diameter greater than 2 mm), the difference recorded is only distinctly significant. Between the samples from the Terebna uninstalled shelterbelt and the samples outside the Corpaci shelterbelt (code N), there is a difference of 2.4%, not statistically insured.

For aggregates larger than 2 mm, on a depth of 0.20-0.40 m, the smallest percentage of soil weight is 36.5% (samples from outside the installed shelterbelt Corpaci), and the largest is 59, 0% (samples from the Terebna installed shelterbelt) (Table 2). Statistically comparing through the limiting differences (p5% = 5.15; p1% = 6.80, p0.1% = 8.75), between the soil samples from the Corpaci installed shelterbelt (NP code) and outside it (N code), compared to the results for the uninstalled shelterbelt Terebna, there are registered differences not statistically insured. The difference of 17.4%, of the percentage of aggregates larger than 2 mm from the installed shelterbelt Terebna, if it is compared to the uninstalled shelterbelt Terebna, is significantly higher. Between the percentage of aggregates larger than 2 mm, determined for the perimeter outside the installed shelterbelt Terebna and the percentage determined for the perimeter of the uninstalled shelterbelt Terebna, there is a difference of 7.5%, statistically significant difference.

Table1.

Differences recorded for stable aggregates larger than 2 mm, on the depth of 0.00-0.20 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	32.9	Controller	
Installed shelterbelt Terebna (code TP)	57.0	24.10***	Very significant differences
Proximity of installed shelterbelt Terebna (code T)	45.5	12.58***	
Installed shelterbelt Corpaci (code NP)	39.9	6.97**	Significantly distinct difference
Proximity of installed shelterbelt Corpaci (code N)	35.3	2.42-	Difference uninsured statistically

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 2.

Differences recorded for stable aggregates larger than 2 mm, on a depth of 0.20-0.40 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	41.6	Controller	
Installed shelterbelt Terebna (code TP)	59.0	17.40***	Very significant differences
Proximity of installed shelterbelt Terebna (code T)	49.1	7.45**	Significantly distinct difference
Installed shelterbelt Corpaci (code NP)	43.1	1.53-	Difference uninsured statistically
Proximity of installed shelterbelt Corpaci (code N)	36.5	-5.07-	

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 3.

Differences recorded for stable aggregates with diameter 2-1 mm, on the depth of 0.00-0.20 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	17.5	Controller	
Installed shelterbelt Terebna (code TP)	16.8	-0.65-	Difference uninsured statistically
Proximity of installed shelterbelt Terebna (code T)	20.3	2.83-	
Installed shelterbelt Corpaci (code NP)	21.7	4.25-	
Proximity of installed shelterbelt Corpaci (code N)	19.9	2.43-	

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 4.

Differences recorded for stable aggregates with diameter 2-1 mm, on a depth of 0.20-0.40 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	17.0	Controller	
Installed shelterbelt Terebna (code TP)	16.5	-0.52⁻	Difference uninsured statistically
Proximity of installed shelterbelt Terebna (code T)	17.9	0.90⁻	
Installed shelterbelt Corpaci (code NP)	20.5	3.48⁻	
Proximity of installed shelterbelt Corpaci (code N)	20.1	3.13⁻	

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 5.

Differences recorded for stable aggregates with diameter 1.0-0.5 mm, on the depth of 0.00-0.20 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	14.6	Controller	
Installed shelterbelt Terebna (code TP)	11.1	-3.50⁻	Difference uninsured statistically
Proximity of installed shelterbelt Terebna (code T)	12.9	-1.68⁻	
Installed shelterbelt Corpaci (code NP)	16.3	1.65⁻	
Proximity of installed shelterbelt Corpaci (code N)	15.9	1.33⁻	

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 6.

Differences recorded for stable aggregates with diameter 1.0-0.5 mm, on a depth of 0.20-0.40 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	12.1	Controller	
Installed shelterbelt Terebna (code TP)	10.4	-1.70⁻	Difference uninsured statistically
Proximity of installed shelterbelt Terebna (code T)	12.6	0.50⁻	
Installed shelterbelt Corpaci (code NP)	15.7	2.63⁻	
Proximity of installed shelterbelt Corpaci (code N)	14.3	2.28⁻	

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 7.

Differences recorded for stable aggregates with diameter 0.5-0.25 mm, on the depth of 0.00-0.20 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	14.2	Controller	
Installed shelterbelt Terebna (code TP)	6.0	-8.22^{oo}	Significantly distinct difference
Proximity of installed shelterbelt Terebna (code T)	8.4	-5.85^{o}	Significant differences
Installed shelterbelt Corpaci (code NP)	8.9	-5.35^{o}	
Proximity of installed shelterbelt Corpaci (code N)	8.9	-5.37^{o}	

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 8.

Differences recorded for stable aggregates with diameter 0.5-0.25 mm, on a depth of 0.20-0.40 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	11.2	Controller	
Installed shelterbelt Terebna (code TP)	5.4	-5.85^{o}	Significant difference
Proximity of installed shelterbelt Terebna (code T)	7.4	-3.80^{-}	Difference uninsured statistically
Installed shelterbelt Corpaci (code NP)	8.4	-2.78^{-}	
Proximity of installed shelterbelt Corpaci (code N)	8.7	-2.53^{-}	

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

For the small aggregates (diameter 2.0-1.0 mm) (Table 3 and Table 5) and small (1.0-0.5 mm) (Table 4 and Table 6), regardless of depth, statistically comparing the boundary differences (p5% = 5.15; p1% = 6.80, p0.1% = 8.75), statistically uninsured differences are found for all the values obtained, in the four areas compared to the samples from the uninstalled shelterbelt Terebna. For very small aggregates (0.50-0.25 mm), on the depth of 0.00-0.20 m (Table 7), a lower percentage is observed in all the four perimeters analyzed compared to the perimeter of the uninstalled sheletrbelt Terebna. The difference of 8.22% aggregates with the diameter between 0.5-0.25 mm, the difference between the uninstalled shelterbelt (14.2% aggregates with the diameter between 0.5 and 0.25 mm) and the installed sheletrbelt Terebna (6, 0%) is distinctly statistically significant.

For very small aggregates (0.50-0.25 mm), on the depth of 0.20-0.40 m (Table 8), there is a statistically significant difference only between the soil samples from the uninstalled shelterbelt and soil samples from the Terebna installed shelterbelt.

Table 9.

Differences recorded for soil particles smaller than 0.25 mm, on the depth of 0.00-0.20 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	20.9	Controller	
Installed shelterbelt Terebna (code TP)	9.1	-11.78^{ooo}	Very significant differences
Proximity of installed shelterbelt Terebna (code T)	13.0	-7.85^{oo}	Significantly distinct difference
Installed shelterbelt Corpaci (code NP)	13.3	-7.58^{oo}	
Proximity of installed shelterbelt Corpaci (code N)	20.0	-0.85^{-}	Difference uninsured statistically

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

Table 10.

Differences recorded for soil particles smaller than 0.25 mm, depth 0.20-0.40 m

Origin of soil samples	Average of observations Aggregates > 2 mm [% of soil weight]	Interpretation of differences recorded	
Uninstalled shelterbelt Terebna (code G)	18.1	Controller	
Installed shelterbelt Terebna (code TP)	8.8	-9.30^{ooo}	Very significant differences
Proximity of installed shelterbelt Terebna (code T)	13.0	-5.05^{-}	Difference uninsured statistically
Installed shelterbelt Corpaci (code NP)	12.3	-5.85^{o}	Significant difference
Proximity of installed shelterbelt Corpaci (code N)	20.35	2.23^{-}	Difference uninsured statistically

DL ($p_{5\%}$) 5.14
DL ($p_{1\%}$) 6.80
DL ($p_{0.1}$%) 8.75

For soil particles (diameter less than 0.25 mm), at depths of 0.00-0.20 m (Table 9), there is a very significant difference between the samples from the uninstalled shelterbelt and the installed Terebna shelterbelt, respectively distinct significant differences between soil samples Terebna uninstalled shelterbelt and soil samples outside the Terebna and Corpaci installed shelterbelts. Between the percentage of particles smaller than 0.25 mm from the uninstalled shelterbelt Terebna and outside the shelterbelt Corpaci, there is a statistically uninsured difference.

For soil particles (diameter less than 0.25 mm), on the depth of 0.20-0.40 m (Table 10), there is a very significant difference between the samples from the uninstalled shelterbelt and the installed Terebna shelterbelt. Between the percentage of particles smaller than 0.25 mm coming from the Terebna uninstalled shelterbelt and those coming from outside the Terebna and Corpaci shelterbelts, there is a statistically uninsured difference. The significant difference of 5.9% particles with a diameter of less than 0.25

mm, statistically ensured, is recorded between the soil from the Terebna uninstalled shelterbelt and the Corpaci installed sheletrbelt.

CONCLUSIONS

Using the recommendations given by CHIRIȚĂ, regarding the qualitative indices of the structure, it can be concluded that the soil from the Terebna uninstalled shelterbelt (Code G) is on the depth of 0.00-0.20 m, a g**ood soil** from the point of view of macro-aggregates (I s macro = 1.0) and a **medium soil** from the point of view of micro-aggregates (I s micro = 0.6). On the depth of 0.20-0.40 m, it is a **good soil** from the point of view of macro-aggregates (I s macro = 1.4), and a **medium soil** from the point of view of micro-aggregates (I s micro = 0.7).

The soil from the Terebna installed shelterbelt (NP Code) is on the depth of 0.00-0.20 m, a **very good soil** in terms of macro-aggregates (I s macro = 2.0), and a **medium soil towards good** in terms of micro-aggregates (I s macro = 0.98). On the depth of 0.20-0.40 m, we can observe an improvement of the quality indicators regarding the macro aggregates (I s macro = 2.2) and the micro aggregates (I s macro = 1.05), being able to say that on this depth there is **a very good soil**, from the point of view of macro-aggregates, and **a good soil** from the point of view of micro-aggregates.

The soil from outside the installed shelterbelt Terebna (Code T) is on the depth of 0.00-0.20 m, **a good soil** from the point of view of macro-aggregates (I s macro = 1.4), and **a medium soil towards good** from the point of view of micro-aggregates (I s micro = 0.95). On the depth of 0.20-0.40 m, it tends towards **a very good soil** from the point of view of macro-aggregates (I s macro = 1.6), but it is a **medium soil** from the point of view of micro-aggregates (I s micro = 0.90).

The soil from outside the installed shelterbelt Corpaci (Code N) is on the depth of 0.00-0.20 m, **a good soil** from the point of view of macro-aggregates (I s macro = 1.05), and **a medium soil** from the point of view of micro-aggregates (I s micro = 0.9). On the depth of 0.20-0.40 m it is **a good soil** from the point of view of macro-aggregates (I s macro = 1.2), and **a medium soil** from the point of view of micro-aggregates (I s micro = 0.9).

The soil from the Corpaci installed shelterbelt (NP Code) is on the depth of 0.00-0.20 m, **a good soil** from the point of view of macro-aggregates (I s macro = 0.99), and **a medium soil** from the point of view of micro-aggregates (I s micro = 0.80). On the depth of 0.20-0.40 m it is **a good soil** from the point of view of macro-aggregates (I s macro = 1.06), and **a medium soil** from the point of view of micro-aggregates (I s micro = 0.87).

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