

Studies on the role of improvement perimeters in preventing and combating soil erosion

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Abstract. Work conducted over the course of a year have had as primary purpose the effect of ecological reconstruction through afforestation and other works (support fences, cross and longitudinal works în ravinees) in improvement perimeters Diviciori 1 (compartment 73) and Diviciori 3 (compartment 49). Forest vegetation was installed 30 years ago in 73, according to afforestation formula 7PiN-2Pa (Fr) -1 seabuckthorn and 50 years in 49, according to the afforestation formula: 5PiN-2Pi-3Mo. Stands were led using silvotechnic works were just regarding hygienization, in the first years. However, in the recent past, the trees have suffered due to abiotic factors that favored the emergence of disease and pests (*Lophodermium* ssp. and *Diprion pini*). So as to obtain more relevant scientific data, test surfaces were placed following the methods used in the agricultural field, modified as to fit the forest field, so the data could be statistically processed and allow the recommendation of adequate technical solutions regarding the ecological reconstruction of the damaged terrains. Eight test areas were placed in the forests and limitrophe to them, the collected data concerning the volume of rainfall, the quantity of runoff on each surface, respectively material collected in the designated tanks. Therefore the collected data has been processed in the laboratory, ultimately uncovering the quantity of eroded material and comparing it between the two compartments and the limitrophe land, having the following values: 0.0912 t/ha in 49, 0.1718 t/ha outside 49, 0.0939 t/ha in 73 and 0.1657 outside 73.

Keywords: Improvement perimeter, runoff plots, erosion, rainfall, forest bottom.

INTRODUCTION

Since prehistoric age, man has had to find a balance between increasing food production on existing soil resources and conserving them. Along with demographic growth, the agricultural areas were also extended, damaging the natural vegetation, intensifying the management of agricultural soils, being tightly tied to the growth of the rate of erosion (Vanwallewghem *et al.*, 2017; Lal, 2015).

The phenomena of erosion occurring naturally, has

been active throughout the geological eras, modelling the surface of dry land to the present day. Today, this phenomena it produces a lot of damage towards the environment and human activities (BĂDESCU, 1971; Julien, 2010).

According to Lasanta *et al.* (2019), soil degradation is currently one of the major worldwide environmental problems, being land abandonment one of its main causes. In the last decades an important number of

researchers from five continents have studied the interactions between land abandonment and soil degradation.

The latter accelerate erosion process, transport and sedimentation, the most damaging being deforestation, cutting and incineration of vegetation (Moțoc *et al.*, 1959; Yan *et al.*, 2019). Besides sedimentation, erosion damages agricultural lands, reducing their productivity. In certain circumstances, the erosion rate could be 100 times or even 1000 times greater than the geological erosion (25 tons/sq.km/year) (Giurgiu, 2004).

In the geographical conditions of Romania, where the downhill terrain represents up to 67% of national territory and sustained by a complex number of natural factors, also the intense human intervention in the late 19th century and the early 20th century, the wildlife and the soil are confronting major ecological imbalances. As consequence, the soil quality has dropped and the rising recurrence of torrential processes is favoring the surfacing of areas with the typical aspect of semi-desert (Constandache *et al.*, 2010).

After years of research, the issue of soil erosion still persists, despite the fact that in most situations there are adequate technical solutions that could be applied. This raises the question of why soil preservation isn't implemented sooner (del Campo, 2019; Pop, 2012). Studies show that the application of soil conservation measures depend on a multitude of factors, but, also, it is obvious that rapid shifts in agricultural systems only occurs when the farmer has a clear economic stimulus (Govers *et al.*, 2017; Lazar *et al.*, 2017).

If at first the focus was not on the development of erosion fighting norms, once the "ruski cernozem" (Russian Cernoziom) paper was released by researcher Vasili DOKUCEAEV (n. 1.03.1846-d. 11.08.1903), the first anti-erosion works became fundamental.

The ecological reconstruction is essential for the rehabilitation of damaged areas and for the protection of biodiversity, ecosystem services and human well-being. The use of functional features in order to plan improvement strategies have been suggested, because these represent the main ecological qualities that stand at the foundation of ecosystem processes and services. With all this being said, few studies have translated the ecological theory into real reconstruction practices that can be easily used by the different interested parties (Giannini *et al.*, 2017; Helmana *et al.*, 2014).

In Romania, the afforestation of damaged fields got a lead after 1948, and the most used species were pines, especially the black pine and the Scots pine (Constandache, 2004).

In Transylvania, many degraded lands are found along the main rivers that pass through the territory. Many of the field affected by erosion, were afforested before 1989 using softwoods, because they develop relatively quickly, being outside their natural area (Moldovan *et al.*, 2018).

Strategies regarding the afforestation of degraded lands at that time, on one hand, were the improvement and introduction to the forest circuit of said lands, on the other hand, the creation of forests made up of softwood species outside their natural area, growing rapidly, with short production cycles (around 50 years), dedicated to the cellulose industry.

Work conducted over the course of a year have had as primary purpose the effect of ecological reconstruction through afforestation and other works (support fences, cross and longitudinal works in ravines) in improvement perimeters Body Perimeter Diviciori 1 (compartment 73) and Body Perimeter Diviciori 3 (compartment 49).

The forest vegetation was installed 30 years ago in the compartment 73, according to the afforestation formula 7PiN-2Pa (Fr) -1 seabuckthorn and 50 years in the compartment 49, according to the afforestation formula: 5PiN-2Pi-3Mo (PiN-Black pine, Pa-Maple, Fr-ash, Pi-Scots pine, Mo-Spruce). In both perimeters the planting schemes were of 1x1 meters, that is 10,000 seedlings per hectare.

The surfaces studied were pastures, which deteriorated due to overgrazing, causing, according to the elderly people in the area, soil entrainments, on the principle of the snowball effect, reaching people's yards or unto the road.

Because these stands produced wood that could not be appraised, in the absence of options for cellulose, care work, especially thinning, was no longer carried out. Thus, the only works performed were the sanitation works, but they were also precarious. Because of this, lately, the trees have suffered due to abiotic factors (isolated windfalls, ruptures, drought), which have favored the emergence of diseases and leaf pests (*Lophodermium* ssp. and *Diprion pini*) (Tăut *et al.*, 2018).

MATERIALS AND METHODS

The works, studies, analysis were carried out in the improvement perimeters of Diviciori 1 (compartment 73) and Diviciori 3 (compartment 49), managed by Forest District Gherla, forests located in the area of Diviciorii Mari, Cluj county. The forest vegetation was installed 30 years ago in the compartment 73 and 50 years ago in the compartment 49 on degraded lands, with the aim of stopping the erosion phenomena (Figure 1).

The stands, although at the time of planting the schemes consisted of species such as Scots pine, Norway maple and ash, today they appear as disseminated species, the dominant species being black pine and spruce in compartment 49, and in compartment 73 black pine, acacia and surprisingly, pubescent oak. The consistency of the two stands is quite variable, in compartment 49 between 0.6 and 0.8, and in compartment 73 between 0.7 and 0.9. The main cause of



Figure 1. Location of runoff plots.



Figure 2. Water catchment system in the forest.



Figure 3. Water catchment system outside of the forest.

the differences in consistency is the isolated windfalls within the stands. Also, the slope is quite inhomogeneous, especially in case of 73, where there are areas where it exceeds 45 degrees. The soils on which the two improvement perimeters are located and implicitly on which the runoff plots have been located, have a sandy-loamy texture, medium and a granular structure, thus the compactness being reduced, the soil being weakly compact even during dry periods, facilitating water infiltration.

In order to achieve the proposed purpose and objectives, test areas (runoff plots) were placed, using the agreed methodology in the field of agriculture, which involves their placement in areas with continuous slope, at the base being installed collection systems, which will conduct drained water to a basin (Gabriel and Gabriela, 2014; Yan *et al.*, 2019; Xu *et al.* 2019).

The dimensions of the runoff plots were established at 200 square meters, the side where the water collection systems were located 10 meters, and the basin having the dimensions of 1 meter length and width, and depth of 0.5 meters, the equivalent to 0.5 cubic meters, lined with foil, for water retention (Figures 2 and 3).

Within the compartment 49 3 runoff plots were located, and adjacent to it being located a plot with the same dimensions and characteristics, considered as a control. Sample surface 1 (P1) is located on a slope of 38 degrees, the consistency of the forest is 0.8. 25 trees were inventoried, of which 22 black pine, 3 walnut. The underwood has a degree of coverage of 30%, the composition being common privet, common hawthorn and the seedling with a degree of coverage of 20%, where 10% turkey oak, 5% sessile oak, 5% walnut. The cover with herbaceous blanket is 10%. Plot 2 (P2) is located on a slope of 28 degrees, the forest consistency is 0.7. 33 black pine were inventoried. The underwood has a degree of coverage of 10% the composition being common privet, common hawthorn and the seedling with a degree of coverage of 20%, where 10% sessile oak, 5% turkey oak, 5% walnut. The cover with herbaceous blanket is 5%. Plot 3 (P3) is located on a slope of 30 degrees. The consistency of the forest is 0.8. 21 trees were inventoried, of which 17 spruce trees, 4 black pine trees. The underwood and seedling are missing. The coverage with herbaceous cover is 10%, and with moss 30%. The plot outside the forest (A1) is located on a slope of 30 degrees. The cover with herbaceous species is 90%, with shrubs 10% (common privet), and with forest seedling 5% (turkey oak, sessile oak).

Within the compartment 73 were located 3 runoff plots and adjacent to it being located a plot with the same dimensions and characteristics, considered as a control. Plot 1 (P1) is located on a slope of 24 degrees, the forest consistency is 0.9 and 24 trees were inventoried, of which 17 black pine, 7 false acacia. The underwood has a coverage of 10% common hawthorn, and the seedling

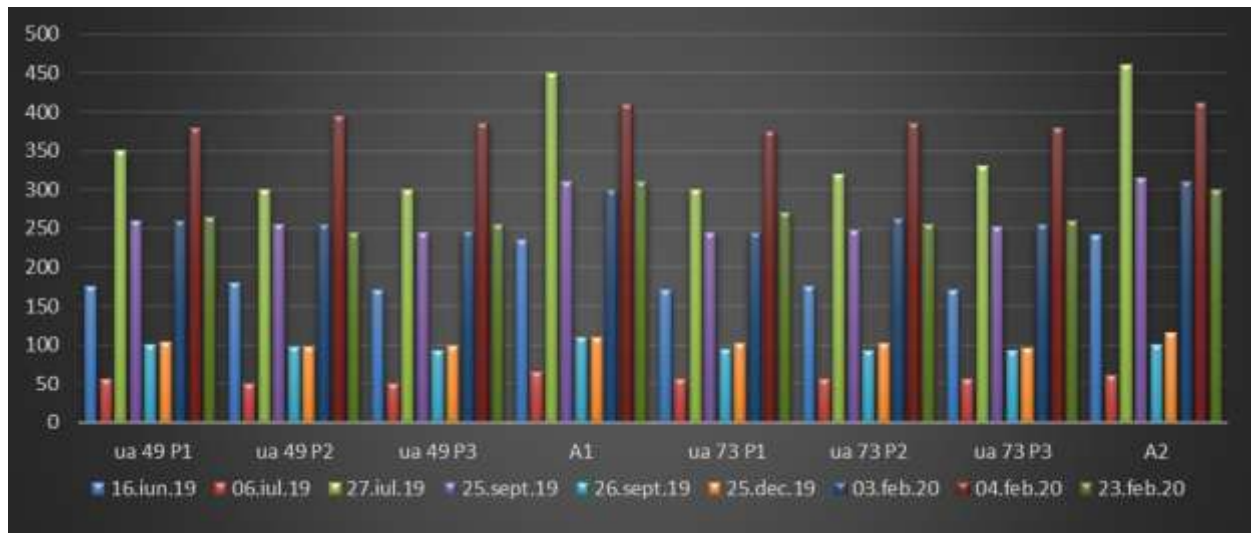


Figure 4. Surface leakage from experimental surfaces, correlated with rainfall intensity (L/basin).

with a coverage degree of 30%, where 10% sessile oak, 10% pubescent oak, 10% turkey oak. The cover with herbaceous blanket is 15%, and with moss is 10%. Plot 2 (P2) is located on a slope of 26 degrees, the forest consistency is 0.7 and 25 trees were inventoried, of which 19 black pine, 6 false acacia. The underwood has a degree of coverage of 20% and is composed of common hawthorn, common privet and the seedling with a degree of coverage of 20%, where 10% sessile oak, 10% pubescent oak. The cover with herbaceous blanket is 20% and with moss is 10%. Plot 3 (P3) is located on a slope of 30, the consistency of the forest is 0.8 and 32 trees were inventoried, of which 28 black pine, 4 pubescent oak. The underwood has a coverage of 5% common hawthorn, and the seedling with a coverage of 15%, where 10% sessile oak, 5% pubescent oak. The herbaceous cover is 5%. The plot outside of the forest (A2) is located on a 26 degrees slope. The herbaceous cover is 70%. In all the test areas, both the diameters and the heights of the trees are close to the average of the stands in which they are found, this fact highlighting the homogeneity of the forests.

In addition to the criteria of slope continuity, the consistency of the stands and inclination of the terrain were taken into account, so that the data collected and the results obtained were in line with the existing situation on the ground. Thus, the runoff plots were placed on different slopes and consistencies, within a perimeter.

In the stands, in addition to the species that have been planted and that have been maintained, more or less, atypical seeds have appeared, such as sessile oak, turkey oak, walnut, beech, pubescent oak. These species settled due to the birds nesting in the crowns of trees, which brought seeds from the forests in the area, in the case of sessile oak, turkey oak, walnut and beech, and in

the case of pubescent oak, the seeds were brought from distant areas, such as Sântejude, Sântioana.

In the upstream part of the plots, delimitation ditches were made, there one of which did not exist naturally, to divert the leaks coming from outside the plots.

Also, for rainfall monitoring, rain-gauges were installed both in the forest and outside the forest. For a more accurate determination of the level and intensity of rainfall, rainfall periods were measured in minutes and the intensity formula was applied: $i = P/T$, where P = volume of precipitation (l/m^2) and T = duration of rainfall (minutes) (Dirja *et al.*, 2010).

Three samples of alluvium water were collected from each basin in 0.5 liter containers for laboratory analysis. The water was filtered through paper filters, the remaining alluvium being dried in the oven, then weighed using the electronic balance.

Specialized calculation programs were used for statistical analysis and calculation.

RESULTS

The data collected from the field were analyzed comparatively in the test areas in the forest and those outside the forest, taking into account the amount of precipitation, respectively the intensity of rains.

Flows were analyzed comparatively after each rain, between June 16, 2019 and February 23, 2020. Their amount is directly influenced by rain intensity (Figure 5), slope, soil texture and moisture, and obstacles encountered within the test surface, such as would be trees, subshrub, seedling, herbaceous blanket, litter, etc.

The leaks measured in the field and presented in Figure 4 show a certain uniformity inside the forest,



Figure 5. Rainfall intensity of the analyzed period (L/m²).

Table 1. Anova results on eroded material.

	F	P-value	F crit
Eroded material (gr/1.5 L)	0.086	0.994	2.409
Eroded material (gr/bazin)	0.026	1.000	2.409
Eroded material compartment 49+outside	1.313	0.290	2.947
Eroded material compartment 73+outside	1.448	0.247	2.901

respectively a slight differentiation outside the forest, although they came from precipitation with low and medium intensities (on July 27, 2019, February 4, 2020 and February 23, 2020). The largest leaks were recorded in plot A2 outside the forest, near compartment 73, being located in completely uncovered land, with a southern exposure, where insolation and evapotranspiration is much stronger, affecting the installation of vegetation.

Applying the unifactorial anova test on the eroded material inside the forest, compared to the eroded one outside the forest (Table 1), determined from laboratory analyzes, highlighted the fact that there are no significant differences, a fact explained by low and medium intensity of the rains, although the deviations from the average are considerable.

Regarding the deviations from the average in the runoff plots, we find that in the case of 49, plot 1 (Figures 6 and 7) are the largest, the cause being the steep slope, the litter, the herbaceous blanket, and shrubs having an uneven distribution in the contents of the plot.

The uniformity of the results is given by the rains with small and medium intensities, by the density of the forest, shrub and herbaceous vegetation, which come to compensate for the lower slope (25 degrees) in the compartment 73 compared to the compartment 49, where the average slope is 36 degrees, but where the general

consistency is 0.7, compared to 0.8-0.9 in 73.

Based on the results obtained on each basin, the erosion per hectare was calculated for each perimeter taken in the study and comparatively the erosion outside the forest was determined, during the period during which the study was carried out (Figure 8).

We notice that the erosion differences in the forest are by 0.0806 t/ha (46.92%) smaller in case of compartment 49, compared to A1, and in compartment 73 they are by 0.0718 t/ha (43.33%) smaller than in A2.

Based on the obtained results, it can be stated that the forests within the studied perimeters fulfill their role of reducing the erosion caused by rainwater, with approximate 40% compared to the plots located outside the forest, though silvotehnic works (thinnings) were not executed, even if in compartment 49 the projected age limit has been reached, to fulfill the protection functions. This is also due to the installation of the underwood and the seedling.

DISCUSSION

The results presented refer to the erosion measured with the help of runoff plots, but unlike the experiments conducted up to the date of this paper, they were performed

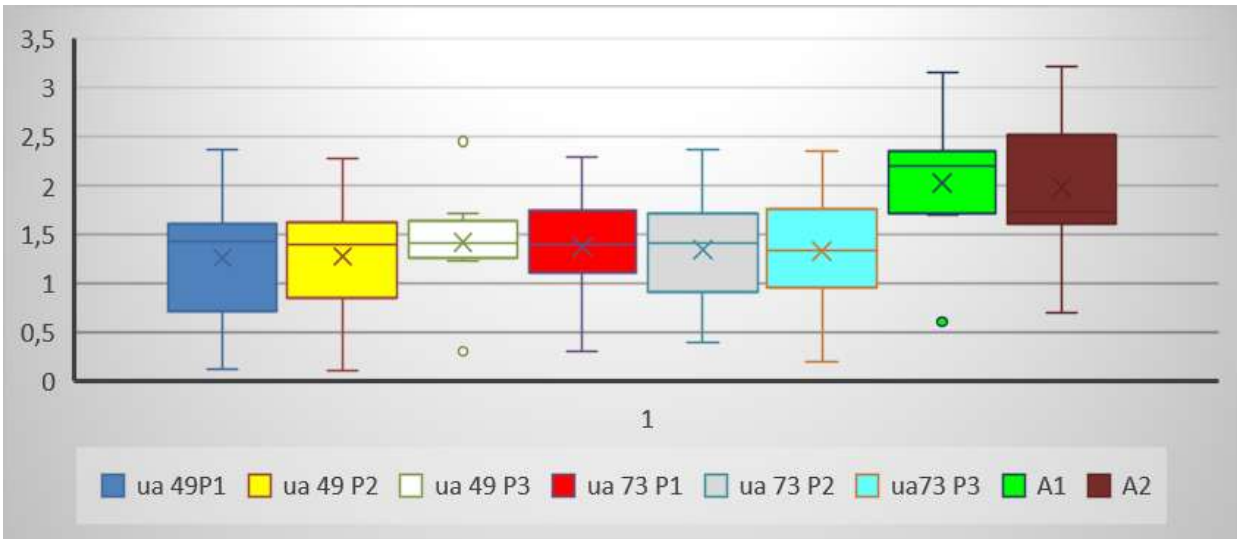


Figure 6. Eroded material from the samples taken (g/0.5 L).

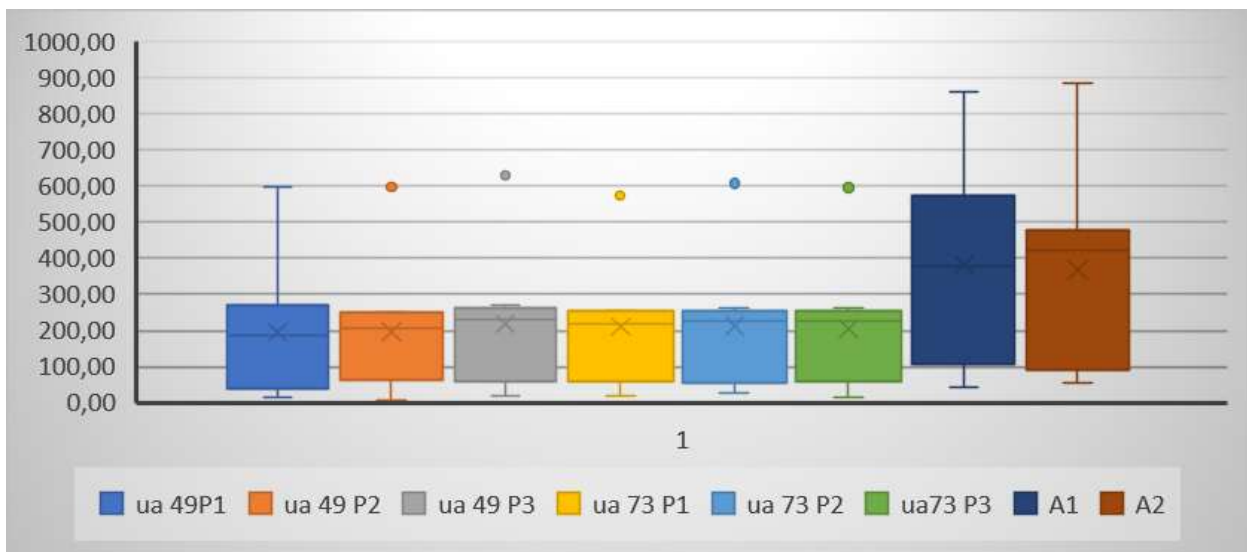


Figure 7. Eroded material on the experimental surface (grams).

by capturing low and medium intensity rains, which produced leaks (Cai *et al.*, 2020).

These experiments were carried out in forests planted on degraded lands, the average slope being between 26 and 36 degrees, the soil being a sandy-loamy one, its particles being easily entrained by water, reaching large pieces.

Forests were created to significantly reduce soil erosion and thus protect downstream objectives (houses, roads, crops, etc). The afforestation technology involved planting seedlings at 1x1 meters, resulting in 10,000 seedlings per hectare. Care and management work had

to be carried out on them, depending on their state of development, in particular cleaning and thinning. These works have not been executed, the main reason being of an economic nature.

Although the number of trees per hectare is high, due to the lack of works, especially thinning, the trees are poorly formed, the crowns narrow, the trunks quite thin, being susceptible to breakage in the crown and windfalls. Compared to a forest where cultural operations were carried out, where the trees are well formed, the broad crowns, the thick trunks, they develop a smaller leaf area and implicitly a thin and sometimes interrupted litter

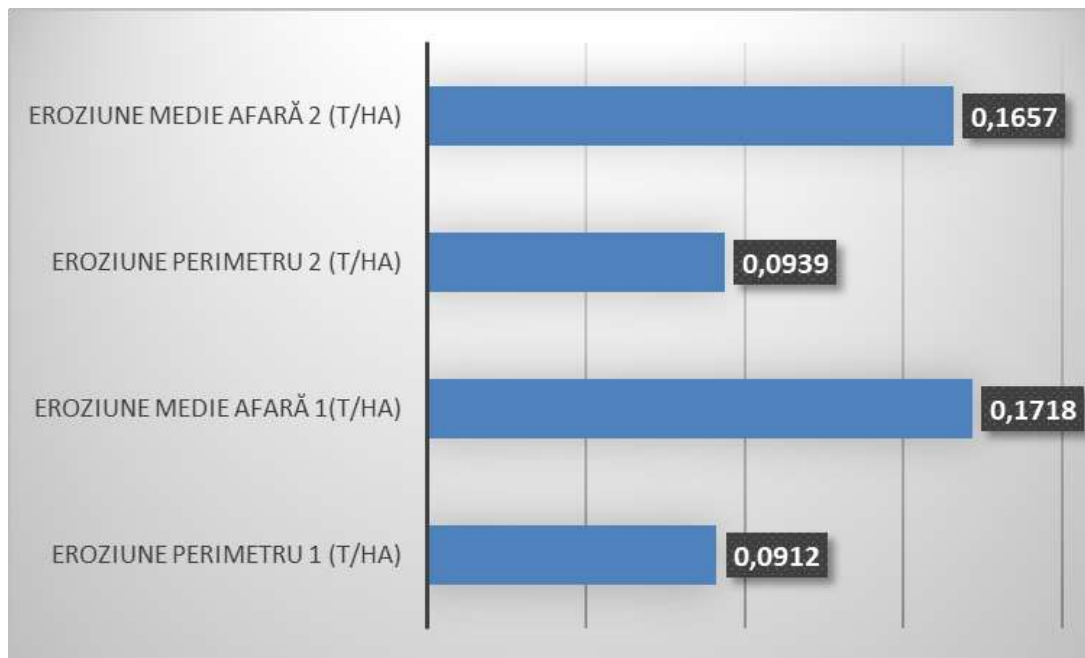


Figure 8. Determination of erosion in plots 49 and 73 and limitrophe.

(Marchi *et al.*, 2018). Another consequence of the large number of trees per hectare, they suffer from diseases, especially *Lophodermium pinastri*, a disease that causes damage only in case of repeated attack.

Due to these reasons, the water retention both in the canopy and in the litter is low, reaching the ground, thus producing leaks and implicitly erosion.

Thus, the erosion in the studied forests is about 40% lower than in grassy lands, although the percentage should have been higher (Chen *et al.*, 2018).

CONCLUSION

The results presented in the paper refer to the erosion measured during a year, this being done using modern methodologies adapted to the forestry field, namely the method of runoff plots for measuring the erosion in the medium and short term.

The present paper is part of an extensive research on some forests installed on degraded lands, where the links between the impact of forests on degraded lands, environmental factors and the evolution of the forest in terms of growth and phytosanitary status are followed. The runoff from low and medium intensity rains, as well as the erosion caused by them, were analyzed.

The purpose of studies, analyzes and research is to determine the anti-erosion efficiency of plantations established on degraded land. It was necessary to perform detailed analyzes of the two perimeters, respectively of the adjacent areas, in order to install the

runoff plots, knowing that their installation must take into account the existence of a continuous slope, a uniform consistency and the presence of other vegetation.

After their identification and location, field measurements were performed, where the volume of precipitation fell, the amount of water drained from the plots was determined and three samples of 0.5 liters were collected from each basin. The samples were filtered through paper filters, dried in an oven and weighed using an electronic balance. After weighing the samples and processing the data, the amount of eroded material both inside and outside the forest and the differences in erosion in and out of the forest were determined.

They are 0.0806 t/ha (46.92%) lower in case of 49, compared to A1, and in 73 it is 0.0718 t/ha (43.33%) lower than in A2. Differences in eroded material occur due to the retention of rain by the crowns of trees, the retention of runoff in the litter, the reduction of water speed by the stems of trees, shrubs.

In order for the antierosion efficiency of the studied forests to be maximum, it was necessary to apply thinning, these works having a beneficial effect both on the mechanical and phytopathological stability of the stands (Marchi *et al.*, 2018) and on surface runoff. Being executed in time, through these works the weakest conforming trees were extracted, making space for the remaining trees, which could develop their trunks, crowns, foliage. Also, the spaces resulting from the application of thinning contribute to the installation of grass cover and shrubs, which contribute to the retention

of rainwater and thus to surface runoff.

As a result of the data obtained from this study, it is recommended to maintain and promote the installed seedling, by the gradual thinning of the mature stand, by applying the care works (cuttings and hygiene cuttings). And also, the adaptation of some forest treatments to exploit the maximum seasonal conditions with the cultural ones.

An interesting element identified during the research was the composition of the present seed. The large proportion of participation and the multitude of species is due to the birds nesting in the crowns of the trees, which brought seeds from the forests in the area, in the case of sessile oak, turkey oak, walnut and beech, and in the case of pubescent oak, the seeds were brought from distant areas, such as Sântejude, Sântioana.

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