Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 1, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

LOSSES OF SOIL THROUGH EROSION TO THE CHERNOZEM SUBTYPE ARGIC FROM THE PERIMETER OF THE STATION FOR STUDY OF SOIL EROSION LOCATED IN THE HILL AREA OF BUZĂU COUNTY, ROMANIA IN 2023

Alexandra Teodora RADU, Mariana BURCEA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: radualex563@gmail.com

Abstract

The paper aims to present the influence of erosion processes on the Chernozem subtype argic in the Station for the Study of Soil Erosion perimeter, located on the Valea cu Drum hydrographic basin, located of the left slope Slănic from Buzau County, in the area of Aldeni, Romania. The main objectives of this study were to present and interpret the data regarding the annual rainfall regime and the vegetation period, the study of the rains that produced runoff and erosion, respectively the surface runoff determined by these rains and the annual amount of soil washed from the plots control, differentially cultivated. The analysis of the experimental results shows that the year 2023 was dry, the recorded temperatures exceeded 19^{0}C in the June-August period, out of 17 rains recorded at the station during the summer period, 47% were less than 10 mm. Quantitative and qualitative study of the erosion process allowed the assessment of the amount of material washed from the soil surface (this being 41.9 t ha^{-1} on a 15%) by the runoff produced by the rains that fell during the summer.

Key words*: rainfall, watershed, chernozem, erosion, slop.*

INTRODUCTION

Soil erosion is one of the most pressing global environmental problems, leading to soil degradation, reduced land productivity and degraded ecosystem functions (Williams et al., 1984). Lal (1998) shows that about 80% of agricultural land suffers from moderate to severe erosion, and Panagos et al. (2021) points out that the annual soil eroded from agricultural land is 75 billion tons, which is estimated at a cost of loss of 400 billion dollars per year.

The average annual rate of soil loss through erosion at EU level is 2.46 t ha^{-1} year^{-1}, compared to the reference year 2010, and the total annual loss is 970 Mt.

The highest average annual soil loss rate is found in Italy 8.46 t ha^{-1}, followed by Slovenia with 7.43 t ha^{-1} and Austria with 7.19 t ha^{-1}.

Montgomery (2007) argues that effective mitigation of future soil loss requires urgent soil conservation measures on at least 50% of agricultural land with erosion rates above 5 t ha^{-1} year^{-1}.

Mulch is an important factor in soil erosion. In the conditions of current climate change, erosion is the process most directly affected by changes in extreme precipitation, as stated by Eekhout & de Vente in the article Global impact of climate change on soil erosion and potential for adaptation through soil conservation published in Earth-Science (2022).

Many researchers in the field see climate change as the biggest threat, endangering food security as demand for food increases (Micu et al., 2022), Morgan (2009) states that extreme rainfall not only affects soil erosion by detaching soil particles through the impact of raindrops, but also by detaching surface runoff. Boix Fayos et al. (2005) shows that there is a worldwide demand for knowledge of the soil erosion processes that occur in parcels of different sizes and the factors that determine the natural variability, as a basis for obtaining good quality soil loss data.

Research on soil erosion on differently sized and differentially cultivated plots looks at how various agricultural practices and soil management strategies influence this destructive process. The study of soil erosion on plots of different sizes are widely used to measure the amounts of washed soil, being one of the most applied methods for estimating erosion rates over medium and long periods of time (Mutcher et al., 2017).

Studies by Toy et al. (2002) observed that erosion increases with conventional tillage practices, as revealed in the experimental plot, where erosion of 14,779 kg ha^{-1} was measured between March 2008 and January 2009, compared to only 4.5 kg ha^{-1} in pasture plot during the same period, mainly due to decreased soil particle cohesion and infiltration in association with poor vegetative cover.

Chinese researchers Chen et al. (2018) state that the annual soil loss of plots of different land use types decreases in the following order: bare land (1533 t km^{-2} $year^{-1}$); cultivated land (1179 t km^{-2} $year^{-1}$); terraced cultivated land (1083 t km^{-2} $year^{-1}$); orchard land (1020 km^{-2} $year^{-1}$); meadows (760 t km^{-2} $year^{-1}$); terraced orchard land (297 t km^{-2} $year^{-1}$); forest and meadows (281 t km-^{2} $year^{-1}$).

Studies by Bagarello et al. (2018) on slope lengths of 5, 10 and 20 m over four months found that washed soil decreased with increasing plot length.

The erosion processes are considered to be intense under the conditions of our country, with an annual average of 16.3 t/ha and year, a value that places Romania among the countries most affected by erosion in Europe (Earth Science Reviews, vol. 02021). The long-term research (Radu, 1998; Radu et al., 2010) shows that together with the washed soil from agricultural lands, significant qualities of humus (9.6-31.4 t ha^{-1}), mobile phosphorus (22.4-73.1 kg ha^{-1}), assimilable potassium (116.3-380 kg ha^{-1}), essential nutrients for plant growth and ensuring the quality of agricultural products. In the conditions of years with low precipitation, on soils with excessive erosion, net biomass production decreases 10 times compared to that obtained on non-eroded lands.

The data presented are eloquent to determine the negative impact that soil erosion has on the economic potential of sloping land areas and directly on human settlements.

Soil erosion research is crucial for promoting sustainable agricultural practices, conservation of natural resources and responsible environmental management, thereby contributing to the maintenance of ecological balance (Borrelli et al., 2020).

MATERIALS AND METHODS

The research in 2023 was carried out in the experimental field for the study and combating of soil erosion (Figure 1) in the town of Aldeni, a town located 22 km north of the city of Buzău, on the Buzău-Lopătari road. The station is located in the Valea cu Drum basin, a valley located on the right slope of the Slănic hydrographic basin.

Figure 1. The experimental field for erosion, Aldeni, Buzău County

The soil in the premises of the station was formed on clay shale, the texture is medium clay loam with a clay percentage (<0.002 mm) of 34.2%, moderately compacted (Radu et al., 2009), with a slightly acidic reaction (pH=6.6) and with a low content of humus (2.1%-0.6%). It is included in the Cernisols class, being a Chernozem subtype argic (Podhrazska et al., 2023; Yan et al., 2023) according to Romanian Soil Taxonomy System (2012), it has the following profile: Am-AB-Bt1-Bt2-Cn, with a total thickness of 140 cm and is prone to water erosion. Among the physical properties of the soil, the bulk density ρa=1.3 g cm^{-3} and the total porosity TP=40% are noteworthy. In addition, the field capacity of 23.1% and the wilting coefficient of 10.8% have average values in the first 40 cm of the soil profile.

Within the station, 12 plots are set up for the control of V1, V2, V3, V4, V5 and V6, with a total area of 883.67 m^2, located as follows: 6 plots with dimensions of 10 m x 4 m on land with a slope of 15% and 6 plots with dimensions of 25 m x 4 m on land with a slope of 20%. Each plot is provided downstream with appropriate facilities for collecting runoff (water-soil) produced by torrential rains (Figure 2).

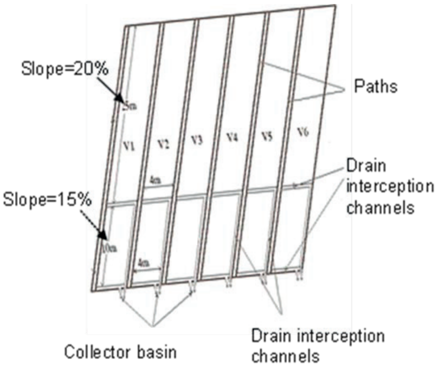

Figure 2. Erosion control plots Aldeni - Buzău Station 2023

To highlight the role of agricultural crops in reducing runoff and erosion, in 2023 the control plots were cultivated differentially, with an emphasis on crops with a high share in the study area. Thus plots V1 were cultivated with beans, plots V2 with wheat, on plots V3 the strip sowing system of wheat was practiced, plots V5 were grassed and plots V6 were cultivated with corn. The V4 plots were kept open to highlight how agricultural crops protect the soil against erosion.

The station is equipped with a weather station and equipment necessary to measure and record precipitation, air and soil temperature. With the help of pluviometers, the structural characteristics of the rains that caused runoff and erosion were analyzed. One of these characteristics, used in the present paper, is the rain aggressiveness indicator expressed by the rain aggressiveness indicator (1) adapted for the conditions of our country (Mihai & Ionescu, 1968):

$$Hi_{15} = h \times Im_{15} \quad (1)$$

in which:

h - the amount of water that fell during the rain (mm);

Im15 - average intensity during the 15-minute torrential core of the rain (mm/min).

The amount of water drained from the control plots was determined volumetrically, by means of the collecting basins within the stationary premises (Figure 2). The mass of drained soil was determined gravimetrically by filtering, drying and weighing.

The amount of soil washed away by erosion was calculated with formula (2)

$$Es = (As^2 \times Mp):10 \ \ t\ ha^{-1} \quad (2)$$

in which:

Es - amount of washed soil (t ha^{-1});

As - the amount of water drained from the control plots (l m^{-2});

Mp - mass of drained soil (g).

RESULTS AND DISCUSSIONS

Erosion reduces soil productivity by losing soil and changing its physical, chemical and biological properties (Wiliams et al., 1984; Lal, 1998).

Climate conditions

The dynamics of the air temperature during the vegetation period and that of the soil at the depth of 10 and 20 cm, recorded at the Aldeni erosion control station is presented in Figure 3. The lowest air temperature values were recorded in April 8^0C. Also during this period the soil temperature in the first 20 cm is between 1.7^0C and in the next 20 cm 5.7^0C in the lowest values. In the months of July and August, the highest air temperature values of 19.8^0C and 20.3^0C were recorded, respectively. During the mentioned period, soil temperatures at the depth of 20-40 cm approached those of the air, 18.2^0C in July and 19.2^0C in August. Note the difference of about 3^0C between the soil temperature of the first 20 cm and that of the next 20 cm in July and August.

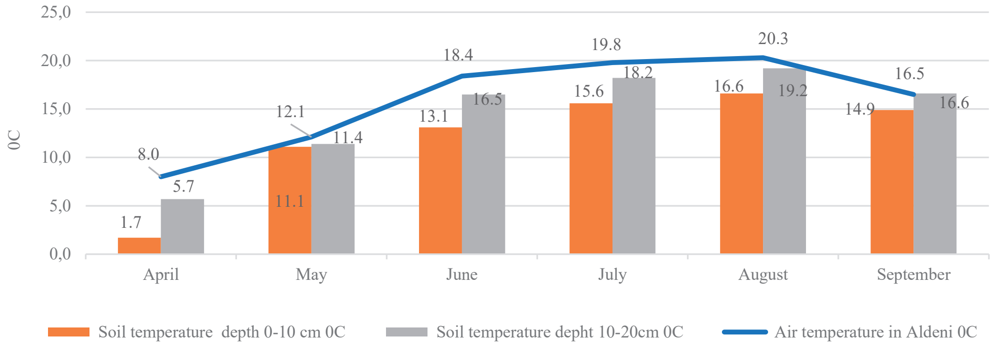

Figure 3. Air and soil temperature dynamics during the vegetation period recorded in 2023 at the Aldeni Station, Buzău County

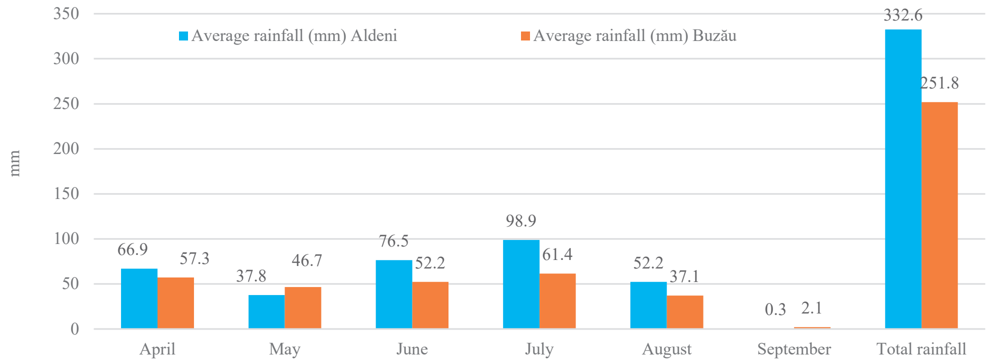

Figure 4. Rainfall dynamics during the growing season recorded in 2023 at the Aldeni Station, Buzău County

The analysis of the April-September data from the station, in relation to the precipitation values recorded at the meteorological station in Buzău (Figure 4) highlights the fact that, except for September, when an absolute minimum is recorded, throughout the mentioned interval the amounts of water were higher in Aldeni. The total amount of water that fell as a result of the rains during the 6 months at the station was 332.6 mm, 80.8 mm more than the amount of water recorded at the Buzău weather station. July recorded the highest amount of water from precipitation of 98.9 mm, followed by June with 76.5 mm. The driest month was September with only 0.3 mm of water from precipitation.

The volume of rains, their distribution over time, their structural characteristics, leave their mark on the intensity of surface runoff and soil lost. In Aldeni, in the year 2023 during the vegetation period, out of the total rainfall, only three were torrential (Figure 5).

These were concentrated in June and July on June 22, July 21 and July 24 and caused runoff and erosion.

The lowest amount of water was the rain on June 24 of 16.7 mm, it lasted 91 minutes with a low aggressiveness index Hi15 = 17.1 (1)

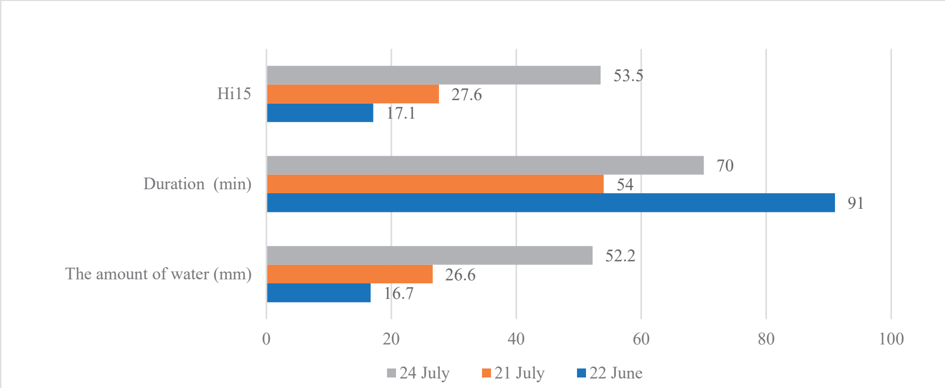

Figure 5. The characteristics of the torrential rains recorded during the vegetation period in 2023 at the Aldeni Station, Buzău County

The highest amount of water was the rain on July 22 of 52.2 mm, which lasted 70 minutes with the rain aggressiveness index Hi15 = 53.5, being the most aggressive torrential rain of the vegetation period.

Analysis of surface runoff

The amount of runoff water expressed in $l\ m^{-2}$ is conditioned by the size and degree of torrentiality of the rain event, in correlation with the slope category and the nature of the crop (Figure 5). The determinations were made on the control plots within the premises of the Aldeni stationary. Surface runoff in the case of plots located on a 15% slope are shown in Figure 6. Compared to the field plots where 21.5 $l\ m^{-2}$ ran off following the three rain events, 18.7 $l\ m^{-2}$ ran off from the bean plot and 18.7 $l\ m^{-2}$ from the wheat plot 11.7 $l\ m^{-2}$. The biggest water losses were caused by the rain on July 22. In the plot cultivated with wheat sown in strips and in the plot with perennial grasses, no leakage was recorded. In the situation of the plots located on the 20% wedge (Figure 7), the highest amount of water runoff caused by the three torrential rains was also recorded in the field 22.3 $l\ m^{-2}$, in the beans 18.7 $l\ m^{-2}$ and of wheat of 14.6 $l\ m^{-2}$. From plots cultivated with strip-sown wheat and those cultivated with perennial grasses, runoff was almost non-existent.

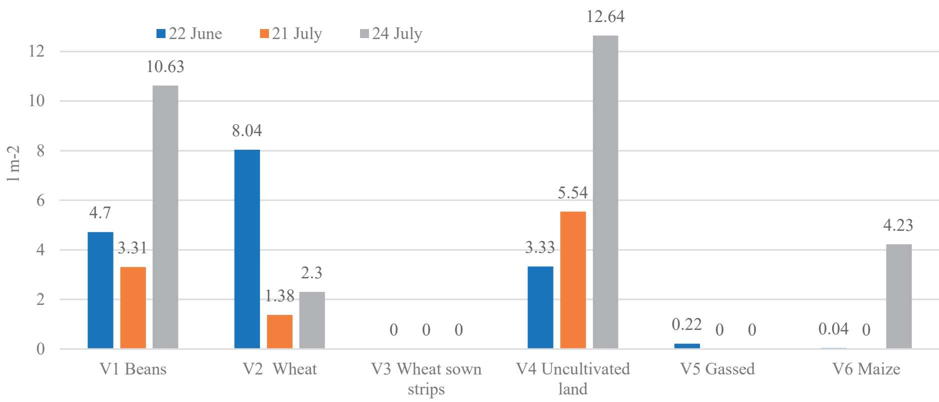

Figure 6. The amount of water drained by the torrential rains depending on the crop, from the control plots located on the 15% slope in the year 2023 at the Aldeni Station, Buzău County

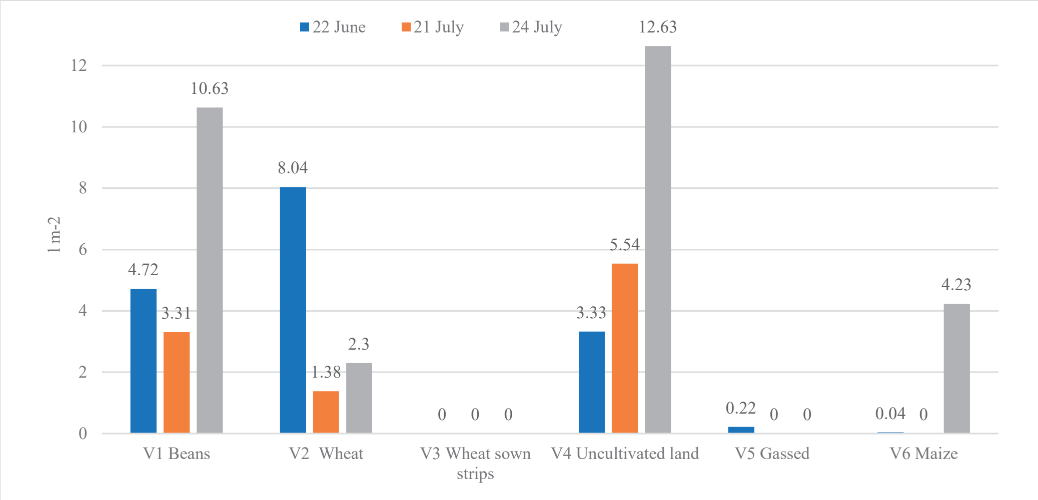

Figure 7. The amount of water drained by the torrential rains depending on the crop, from the control plots located on the 20% slope in the year 2023 at the Aldeni Station, Buzău County

Soil loss analysis

Soil losses are directly influenced by the structural particularities of rainfall events (Figure 5). The data regarding the amount of soil washed by the torrential rains from the control plots located on the 15% slope are shown in Figure 8. From a quantitative point of view the biggest losses were caused by the rain on 24 July when 41.9 t ha^{-1} were recorded in the uncultivated plot, compared to 17.9 t ha^{-1} in beans and 7.9 t ha^{-1} in maize. No soil loss was recorded in the plots with perennial grasses and strip-sown wheat. The soil losses from the control plots located on the 20% slope are shown in Figure 9. And in this case, the greatest soil loss was recorded in uncultivated plots of 46.8 t ha^{-1}, compared to beans of 17.6 t ha^{-1} and corn of 8.2 t ha^{-1}. Perennial grasses and strip-sown wheat showed no soil loss (Radu & Burcea, 2023).

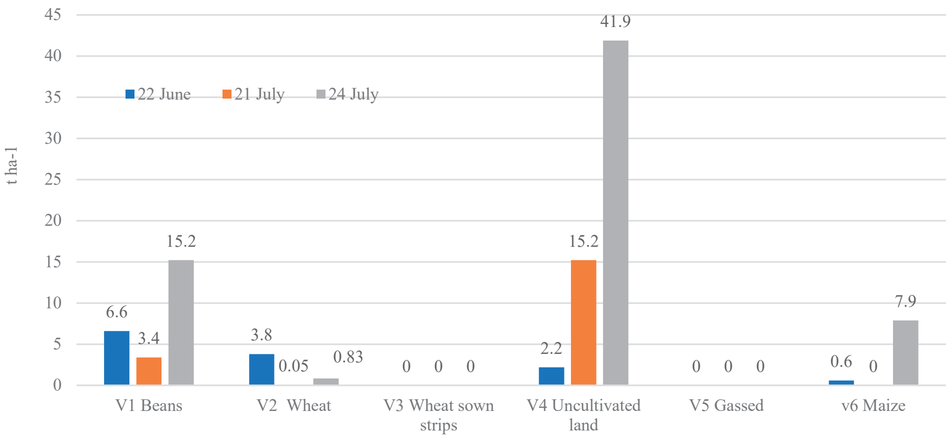

Figure 8. Soil losses from the control plots located on a 15% slope caused by torrential rains in the crop, in the year 2023 at the Aldeni Station, Buzău County

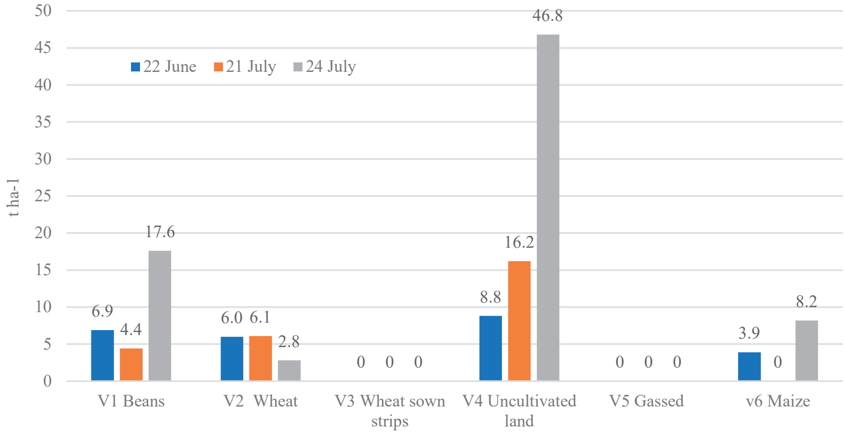

Figure 9. Soil losses from the control plots located on a 20% slope caused by torrential rains in the crop, in the year 2023 at the Aldeni Station, Buzău County

The image about the role of agricultural crops in mitigating erosion processes on large slopes, in the conditions of a capricious year from a meteorological point of view, becomes relevant. In the non-cultivated soil gas with the density of 1.3 g cm^{-3} the erosion of 41.9 t ha^{-1} washed a soil layer of 3.2 mm from the 15% slope train and 3.6 mm on the slope field of 20%. Thu the strip crop of wheat protected the soil as well as the perennial grasses. From the data presented, it follows that anti-erosion techniques applied to agricultural land located on a slope reduce the impact of erosion on the soil even under the conditions of current climate change.

CONCLUSIONS

The total amount of water that fell as a result of the rains during the growing season of 2023 recorded at the Aldeni station was 332.6 mm.

Of the total rainfall, only three were torrential and concentrated in the months of June and July on the dates of June 22, 21 and 24 and caused runoff and erosion.

Compared to the uncultivated plots from which a total of 43.64 l/m^2 was run off, 34.44 l/m^2 was run off in the bean plots.

In strip-sown wheat and perennial grasses, runoff was almost non-existent.

The biggest losses were caused by the rain on July 24 when there were 88.7 t/ha in the uncultivated plot, compared to 31.8 t/ha in beans and 16.1 t/ha in maize. No soil loss was recorded in the plots with perennial grasses and strip-sown wheat

From the unprotected soil with the bulk density of 1.3 g cm^{-3} with a total erosion of 88.7 t/ha, 6.2 mm of soil is lost.

Anti-erosion techniques applied to agricultural land located on a slope reduce the impact of erosion on the soil.

REFERENCES

Bagarello, V., Vito, F. & Flanagan, D. (2018). Predicția pierderii de sol a parcelei prin abordări empirice și orientate pe proces. O revizuire. *Journal of Agricultural Engineering,* 49.1: 1-18. https://scholar.google.com.

Boix Fayos, C. et al. (2005). Concise review of interrill erosion studies in SE Spain (Alicante and Murcia): erosion rates and progress of knowledge from the 1980s. *Land degradation & development,* 16.6: 517–528. https://scholar.google.com.

Boix Fayos, Carolina et al. (2006). Measuring soil erosion by field plots: Understanding the sources of variation. *Earth-Science Reviews,* 78.3-4: 267–285. https://scholar.google.com.

Borrelli, P. et al. (2020). Land use and climate change impacts on global soil erosion by water (2015-2070). *Proceedings of the National Academy of Sciences,* 117.36: 21994-22001. https://scholar.google.com.

Chen, H. et al. (2018). Efectele vegetației și ale tipurilor de precipitații asupra scurgerii de suprafață și a eroziunii solului pe versanții abrupți de pe Platoul Loess, China. *Catena,* 170: 141–149. https://scholar.google.com.

Eekhout, Joris P. C., & de Vente, J. (2022). Global impact of climate change on soil erosion and potential for adaptation through soil conservation *Earth-Science Reviews,* 226: 103921. https://scholar.google.com.

Lal, R. (1998). Soil erosion impact on agronomic productivity and environment quality. *Critical Reviews in Plant Sciences,* 17.4: 319-464. https://scholar.google.com.

Micu, M. M., Dinu, T. A., Fîntîneru, G., Tudor, V. C., Stoian, E., Dumitru, E. A., ... & Iorga, A. (2022). Schimbările climatice - Între „mit și adevăr” în percepția fermierilor români. *Sustenabilitate*, 14, 8689. https://agronomyjournal.usamv.ro/index.php/scientific-papers/guide.

Mihai, Gh., & Ionescu, V. (1968). *Ghid pentru combaterea eroziunii solului*. Bucharest, RO: Agro-Silvică Publishing House.

Montgomery, D. R. (2007). Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences,* 104.33: 13268-13272. https://scholar.google.com.

Morgan, R. P. C. (2009). *Soil erosion and conservation*. John Wiley & Sons. https://scholar.google.com.

Mutchler, C. K., Murphree, C. E. & McGregor K. C. (2017). Laboratory and field plots for erosion research. *Soil erosion research methods*, Routledge, 11-38. https://scholar.google.com.

Panagos, P., Ballabio, C., Himics, M., Scarpa, S., Matthews, F., Bogonos, M., ... & Borrelli, P. (2021). Proiecții ale pierderii solului prin eroziunea apei în Europa până în 2050. *Environmental Science & Policy*, *124*, 380-392. https://scholar.google.com.

Podhrazska, J. et al. (2022). The Effects of Long-Acting Water Erosion on the Hydro-Pedological Characteristics of Chernozems. *Agronomy,* 12.10: 2574. https://scholar.google.com.

Radu, A. T. (1998). Changes in the properties of the soil as a result of the application of works to combat soil erosion on the agricultural lands in the Slănic-Buzău hydrographic basin, PhD Thesis, USAMV Bucharest.

Radu, A. T. et al. (2009). The phizsical and hidrophisical properties of the erodes and the subtype of erodes soil from the Slănic hidrographic basin, Buzău county. *Analele Universității din Craiova-Agricultură, Montanologie, Seria Cadastru,* 39.1: 460–464. https://scholar.google.com.

Radu, A. T. et al. (2010). Studies on the modifications of physico-chemical attributes of arable lands from the water catchment area Valea Harboca, located on the left slope of Slanicul de Buzau, compared with the standard profile. *Scientific Papers. Series A. Agronomy,* 53: 67–72. https://agronomyjournal.usamv.ro/index.php/scientific-papers/guide

Radu, A. T., & Burcea, M. (2023). The study of erosion processes in the hilly area of Buzău County (Romania) in the specific climatic conditions of year 2022. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 23*, Issue 3, 756–767. https://scholar.google.com.

Toy, T. J., Foster, G. R., & Renard K. G. (2002). *Soil erosion: processes, prediction, measurement, and control*. John Wiley & Sons. https://scholar.google.com

Williams, J. R., Jones, C. A., & Tss Dyke, P. (1984). A modeling approach to determining the relationship between erosion and soil productivity. *Transactions of the ASAE,* 27.1: 129-0144. https://scholar.google.com.

Yan, Y. et al. (2023). Effects of grain-forage crop type and natural rainfall regime on sloped runoff and soil erosion in the Mollisols region of Northeast China. *Catena,* 222: 106888. https://scholar.google.com.