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Research regarding soil erosion and its effects in the Balota area, Dolj County

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Abstract

The research presented in this paper was carried out during three years of study (2018-2020) and aimed at studying soil erosion and losses of humus and major macroelements (nitrogen, phosphorus, potassium) based on the precipitation regime that produced runoff on the slope. The research was carried out on a stagnic vertic preluvosoil with a slope of 4%, with a moderate acid reaction and a medium supply of nitrogen and potassium, and weak supply of phosphorus from Balota de Sus area, Dolj County, comprising 3 crops practiced in the area: wheat, corn, alfalfa compared to the field black (uncultivated) and spontaneous vegetation (natural).
Following the researches, it was found that the most significant runoff on the slope was recorded in black fallow 471.98 mc/ha and corn 252.62 mc/ha, and the lowest were recorded in wheat 183.43 mc/ha and alfalfa 118.87 mc/ha (25.14% compared to the black fallow).
Soil erosion, or soil losses, recorded high values also in the case of corn cultivation 6.84 t/ha (39.42%) and in the case of black fallow 17.35 t/ha (100%).
The humus in the soil was lost in the largest quantities also in the corn crop 198.19 kg/ha (40.56%) and black fallow 488.58 kg/ha (100%) and in quite small quantities in the case of alfalfa 89.20 kg/ha (18.25 %).
Nutrients in the soil have been lost, both by runoff water on sloping soil and by eroded soil, with higher amounts lost through eroded soil.

Keywords: *soil, erosion, nutrients, runoff*

Rezumat. Cercetări privind eroziunea solului și efectele acesteia în zona Balota, județul Dolj

Cercetările prezentate în această lucrare s-au desfășurat pe parcursul a trei ani de studiu (2018-2020) și au vizat studiul eroziunii solului și al pierderilor de humus și macroelemente de ordin principal (azot, fosfor, potasiu) pe baza regimului de precipitații care au produs scurgerile pe pantă.
Cercetările s-au efectuat pe un preluvosol vertic stagnic cu o reacție moderat acidă și o aprovizionare în azot și potasiu mijlocie, slab aprivizionat cu fosfor, cu pantă de 4% din comuna Balota de Sus, județul Dolj, cuprinzând 3 culturi care se practică în zonă: grâu, porumb, lucernă comparativ cu ogorul negru (nelucrat, necultivat) și vegetația spontană (naturală).
În urma cercetărilor efectuate s-a constatat că cele mai însemnate scurgeri pe pantă s-au înregistrat la ogorul negru 471.98 mc/ha și porumb 252.62 mc/ha, iar cele mai reduse au fost înregistrate la grâu 183.43 mc/ha și lucernă 118.87 mc/ha (25.14% fața de ogorul negru).
Eroziunea solului, sau pierderile de sol, a înregistrat valori mari tot în cazul culturii de porumb 6.84 t/ha (39.42 %) și în cazul ogorului negru 17.35 t/ha (100%).
Humusul din sol s-a pierdut în cele mai mari cantități tot la cultura de porumb 198.19 kg/ha (40.56%) și ogor negru 488.58 kg/ha (100%) și în cantități destul de reduse în cazul lucernei 89.20 kg/ha (18.25%).
Nutrienții din sol s-au pierdut, atât prin scurgerile de apă pe solul în pantă, cât și prin solul erodat, mai mari fiind cantitățile pierdute prin solul erodat.

Cuvinte-cheie: *sol, eroziune, nutrienți, scurgeri*

Introduction

Soil is the basis of production in agriculture activities. The combination of intensive farming activities, improper farming practices, rainfall regimes, and topography conditions that take place in agricultural land lead to the soil erosion problem. Soil erosion is the major constraint to agriculture that affects the yield production and degraded environmental sustainability. Furthermore, soil erosion that occurs in the agricultural area has jeopardized the sustainability of agriculture activities (Nasir Ahmad et al., 2020).

Despite almost a century of research and extension efforts, soil erosion by water, wind and tillage continues to be the greatest threat to soil health and soil ecosystem services in many regions of the world.

Soil erosion is not only an agricultural problem. It is associated with a host of environmental, social and economic issues. It has also been acknowledged as a major setback for food security and a serious problem for sustainable development (Telles et al., 2011).

The erosion phenomenon is strongly influenced by the vegetation in the area, and the agricultural crops greatly influence the stability of the aggregates. The application of anti-erosion crop measures can lead to a decrease in soil erosion (Filiche, 2011).

The process of erosion leads to the gradual destruction of the soil's properties (Cassol & Lima, 2003; Bertoni & Lombardi Neto, 2008), since it not only carries away soil particles but also nutrients, organic matter and pesticides (Bronick & Lal, 2005), preventing or retarding the normal plant development (Montgomery, 2007).

Soil erosion is a major concern for the environment and natural resources leading to a

serious threat to agricultural productivity and one of the major causes of land degradation.

The nutrients uptake by plants from the soils or by water runoff, result in a decrease of the contents of nutrients (Dodocioiu et al., 2011) and the gradual decline of soil production capacity. Thus, nutrients consumption by crops and decreased nutrient availability through natural processes are necessary to be compensated by applying of fertilizers (Dodocioiu et al., 2013).

Degraded soils cause crop yield decrease due to the removal of the richest layer of organic matter (Dodocioiu et al., 2013). Minimizing degradation and improving productivity requires studies on soil and agricultural management practices. Soil loss due to water erosion threatens the environment and generally exceeds soil formation time (Falcão et al., 2020).

Among various land degradation processes, soil erosion is recognized as a major environmental problem causing a loss of top soil and nutrients, reduced soil fertility (Zhao et al., 2013), and as a consequence, reduced crop yields (Telles et al., 2011).

Nutrients losses are significantly affected by different crop covers and increase with increase in the amount of rainfall (Singh et al., 2020).

A cover crop canopy can reduce the soil erosion from cultivated fields during the peak season. The adequate ground cover canopy protects the land like an umbrella. The cover crop consists of cover that can reduce raindrop impact, reduces water velocities, decreases runoff, and increases water infiltration in the soil. Therefore, cover crops are one of the ways to reduce soil erosion (Nasir Ahmad et al., 2020).

Erosion caused changes in soil carbon dynamics and non-point source water pollution are important environmental impacts. While erosion (e.g., detachment and transport) can lead to emission of trace gases into the atmosphere, deposition can bury and sequester some of the carbon (Lal, 2001).

At the same time, many of erosion's impacts occur far from the source, as demonstrated by agrochemical runoff that can pollute and eutrophize water sources downstream, which further raises the importance of considering soil erosion control as an issue warranting tangible public support.

Understanding the processes and mechanisms affecting runoff generation and subsequent soil erosion is essential for the development of improved soil and water conservation management practices.

The study area is located in the northern hilly area of the Getic Piedmont, Dolj County (coordinates 44°33'38.0"N 23°47'36.0"E), being represented by interfluvial fields separated by valleys or plateaus, bordered by hillsides with variable slopes (2-20%). The last level of relief is occupied by the soils affected by the stagnation processes (Fig. 1).

The climate is temperate continental with slight Mediterranean nuances, the precipitations being of 525-535 mm. The altitude is 210-230 m, eastern exposure, Murgași area, Balota de Sus village.

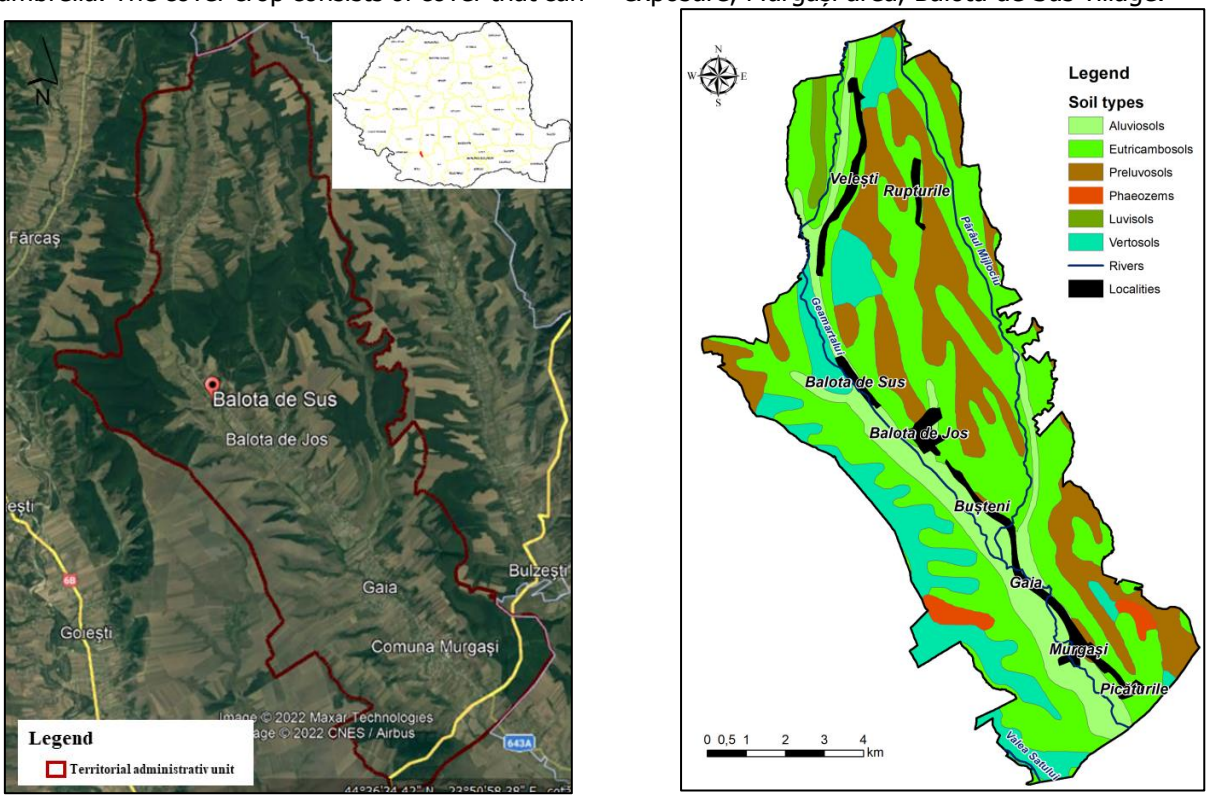

Fig. 1: Location of study area: left - Google Earth (accessed November 2021) ; right - Soil map (after Soils map of Romania, sc. 1:200.000)

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Material and methods

The researches were carried out in Balota area, Dolj County, on a stagnic vertic preluvosoil with a slope of 4%, comprising 3 crops that are practiced in the area: wheat, maize, alfalfa compared to black fallow (uncultivated) and spontaneous vegetation (natural). These were framed within experimental plots with an area of 100 square meters. Each plot was delimited on all its sides with the help of plastic plates that were inserted into the soil to a depth of 10 cm. In the downstream part of the plot, a runoff collection system was built, from a concrete triangle vessel finished with a collector tube that drains into a vessel. At the end of the collector tube was installed a metal sheet divider with a row of 7 holes, each hole being then separated into 7 parts so that the volume of runoffs collected represents only 49 parts of the total amount on the plot (Fig. 2).

Fig. 2: Experimental plots located in Balota area

Within these plots, in the period 2018-2020, the precipitation regime was followed, which caused the surface runoff and soil erosion, as well as the loss of soil, humus and nutrients. The results are listed in Tables 1-6.

The soil on which it was experienced was a stagnic vertic preluvosoil, weakly-strongly decarbonated, formed on swollen clays with clay-loam texture, loamy-clay texture (***, 2012), with formula EL $_{vs\text{-}st\text{-}w2\text{-}\ k5\text{-}d5\text{-}TT}$ (52)/AL (62) Spa-NI-e_{11}, with the following horizons: Ao, A/B, Btw_2, Bt_2w_1.

On the horizon Ao the apparent density is moderate, the total porosity is moderate, the soil is poorly compacted, the wilting coefficient is very high, and the permeability is low. The soil reaction is moderately acidic (pH = 5.28-5.41).

The degree of insurance with nitrogen is medium (0.14-0.17%), the degree of insurance with phosphorus is low (1.2-3.1 ppm P), the degree of insurance with potassium is medium (51.30-62.40 ppm K) and the humus content is low (1.8-2.1%) - as well as in the research conducted by Grecu, 2010.

The content of total nitrogen, phosphorus and potassium was determined on soil and water samples, lost by erosion, in different crops, thus establishing the losses of nutritive elements on the area where experiments are placed.

The pH was determined potentiometrically, in aqueous suspension at a soil to water ratio of 1/2.5 using the Mettler Toledo pH-meter.

The humus content was determined by the Walkley-Black method in concentrated sulfuric acid and potassium dichromate, titrating the excess oxidizing reagent with Mohr salt solution.

The mobile phosphorus content was determined in ammonium lactate acetate extract (Enger-Riehm-Domingo method) for the extraction of mobile phosphates from the soil (Ailincăi et al., 2009), and the obtained extract was treated with a coloring reagent consisting of ammonium molybdate and ascorbic acid. The solution was photocolorimetered to the UV-VIS spectrophotometer, V-530 Jasco, at a wavelength of 660 nm.

The mobile potassium content of the soil was determined by the Egner-Riehm-Domingo method in the same extract obtained for the determination of mobile phosphorus, and was read on the Jenway PFP-7 flamophotometer.

The total nitrogen content was determined by the Kjeldhal method which involves two distinct phases: the mineralization of the organic matter in the soil, which was done using the Raypa MBC-6 digester and the distillation, which was carried out using the PRO-NITRO 1 distillation unit.

The reflectometer RQ-FLEX with kits for each indicator was used to determine the nitric, ammoniacal and total nitrogen present in the runoff water.

Results and disscusions

In 2018, only the precipitation regime or the rainy events that produced the runoffs and therefore erosion of the crops presented above were analyzed, in May, June and July. The values were of 60.90 mm in May, 40.70 mm in June and 28.90 mm in August, totaling 7 rain events.

Table 1 shows the monthly and annual data (total) and the intensity of monthly precipitation (mm), the volume of runoff (m^3/ha) and soil losses (erosion t/ha).

From the data analysis it results that May was the month with the most intense rain events that caused a stronger erosion of the soil. Thus, the monthly runoff was in May between 45.0 m^3/ha and 184.52 m^3/ha, and the erosion recorded values between 0.79 and 8.76 t/ha eroded soil.

From the experienced crops it results that, for this month, the lowest soil losses (poor erosion) are recorded in alfalfa and wheat (0.79 t/ha), crops that

cover the soil better and have a fascicular root system, well developed in the first 10 cm from the ground. At the opposite pole is the maize crop, which is a weeding crop with a distance between rows almost 7 times greater than that of wheat and alfalfa (leaving a good part of the land free, uncontrolled by roots), where the eroded soil is at 5.30 t/ha, 7.5 times higher than in the case of wheat and alfalfa.

Table 1: The regime of the monthly precipitations that produced the runoffs at Balota in 2018

Crop	Month											
	May			June			July			Total		
	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)
Wheat	60.90	77.30	0.79	40.70	51.69	0.5291	28.90	36.70	0.475	130.50	156.69	1.794
Maize	60.90	138.80	5.30	40.70	92.79	1.343	28.90	65.89	0.953	130.50	297.48	7.596
Alfalfa	60.90	45.06	0.791	40.70	32.56	0.488	28.90	20.51	0.324	130.50	98.13	1.603
Black fallow	60.90	184.52	8.76	40.70	123.32	5.860	28.90	85.14	4.16	130.50	392.98	18.78
Natural vegetation	60.90	108.42	6.65	40.70	62.49	0.651	28.90	46.24	0.462	130.50	217.15	7.763

And in the case of spontaneous vegetation that does not cover the land so well, there is a high level of erosion (6.65 t/ha), which only partially covers the soil due to the abusive grazing.

Of course, when using the black fallow as a term of comparison with other crops, it produces the strongest soil erosion 8.76 t/ha, 10-11 times higher than wheat and alfalfa and almost double compared with maize.

Surface runoff and erosion evolve in the same direction in June and July, only the values are lower due to the lower volume of precipitation.

Annually, the direction of erosion events is the same: on the first place in terms of erosion is the black fallow with 18.78 t/ha eroded soil, followed by maize with 7.596 t/ha eroded soil. Erosion in the case of wheat and alfalfa is very low.

Table 2: Losses of nutrients and humus in 2018

Crop	Through the water running down the slope						Through the soil entrained by runoff water				
	Runoff (mc/h)	$N\text{-}NO_3$ (kg/ha)	$N\text{-}NH_4$ (kg/ha)	N_{total} (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Eroded soil (t/ha)	Humus (kg/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Wheat	156.69	0.174	0.153	0.327	0.056	0.744	1.799	69.231	3.12	0.304	0.623
Maize	297.48	0.321	0.284	0.505	0.094	1.285	7.596	200.798	9.03	0.689	1.581
Alfalfa	98.13	0.118	0.109	0.227	0.032	0.583	1.603	53.254	2.39	0.247	0.511
Black fallow	392.98	0.421	0.396	0.817	0.124	1.642	18.720	460.334	20.73	0.935	3.105
Natural vegetation	217.15	0.292	0.254	0.546	0.075	0.916	7.763	203.492	9.15	0.711	1.611

Analyzing nutrient and humus losses (Table 2) through water runoff and eroded soil this year shows:

- through the water drained on the slope, it was lost between: 0.227 - 0.817 kg N/ha, 0.032 -0.124 kg P_2O_5/ha and 0. 583-1.642 kg K_2O/ha.

- the highest losses are recorded in the crops in which the highest volume of runoff was recorded: 0.505 and 0.817 kg N/ha; 0.094 and 0.124 kg P_2O_5/ha, 1.285 and 1.642 kg K_2O at maize and black fallow.

- the lowest nutrient losses were recorded in the crops that had the lowest volume of runoff, respectively wheat and alfalfa: 0.327 and 0.227 kg N/ha; 0.056 and 0.032 kg P_2O_5/ha; 0.744 and 0.583 kg K_2O/ha.

Through the soil eroded (entrained) by liquid runoff, larger amounts of fertilizing nutrients have been lost due to the fact that only soluble nutrients are entrained in the runoffs.

Thus, the amount of humus lost was between 53.254 kg/ha at the alfalfa crop and 460.334 kg/ha at the black fallow.

The amount of nitrogen lost through the eroded soil is 2.39 kg N/ha under the alfalfa crop and 20.73 kg N/ha in the black fallow.

The amount of phosphorus lost through the eroded soil has values between 0.247 kg/ha for alfalfa cultivation and 0.935 kg/ha for black fallow.

The amount of potassium lost through the eroded soil is between 0.511 kg/ha under alfalfa cultivation and 3.105 kg/ha in the black fallow.

Analyzing the experimental results from 2018, it is obvious that alfalfa and wheat crops are very good protectors of the soil against erosion and nutrient losses from the soil.

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Tabel 3: The regime of the monthly precipitations that produced the runoffs at Balota in 2019

Crop	Month														
	April			May			June			Iuly			Total		
	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)
Wheat	78.7	92.09	1.65	24.5	29.6	0.671	22.1	26.07	0.594	55.4	64.88	1.26	180.7	212.64	4.17
Maize	0.00	0.00	0.00	24.5	53.21	2.021	22.1	37.54	1.48	55.4	88.25	2.82	102.0	179.0	6.32
Alfalfa	78.7	58.87	1.211	24.5	19.11	0.426	22.1	17.09	0.411	55.4	37.11	1.09	180.7	132.18	3.138
Black fallow	78.7	241.60	5.48	24.5	74.97	2.23	22.1	67.18	2.04	55.4	169.42	4.11	180.7	553.17	13.86
Natural vegetation	78.7	110.96	1.96	24.5	32.11	0.93	22.1	27.19	0.782	55.4	72.23	1.73	180.7	242.49	5.40

In 2019, there were 8 rain events that determined the erosion in the months during the vegetation period of the respective experienced crops in April, May, June and July. The total value of the precipitation that caused the erosion is 180.7 mm, except the value of 102 mm for maize (which in May was barely sown, this month not being taken into account).

The total liquid runoffs were between 132.18 m^3/ha and 553.17 m^3/ha. The lowest volume of runoff was recorded in alfalfa and wheat 132.18 and 212.64 m^3/ha, and the highest in spontaneous vegetation and black fallow 242.49 and 553.17 m^3/ha. In the same sense, the erosion evolved with higher values for black fallow and maize 553.17 m^3/ha and 179 m^3/ha, while for alfalfa crop the erosion registered only 132.18 m^3/ha.

Tabel 4: Losses of nutrients and humus in 2019

Crop	Through the water running down the slope						Through the soil entrained by runoff water				
	Runoff (mc/h)	$N\text{-}NO_3$ (kg/ha)	$N\text{-}NH_4$ (kg/ha)	N_{total} (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Eroded soil (t/ha)	Humus (kg/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Wheat	212.64	0.283	0.261	0.544	0.094	0.992	4.178	150.142	7.402	0.571	1.351
Maize	179.0	0.191	0.167	0.358	0.083	0.725	6.32	188.26	9.336	0.627	1.789
Alfalfa	132.18	0.158	0.135	0.393	0.047	0.611	3.137	106.254	5.341	0.368	0.973
Black fallow	553.17	0.623	0.552	1.275	0.323	2.344	13.861	384.261	19.112	1.459	3.486
Natural vegetation	242.49	0.316	0.276	0.592	1.125	1.183	5.403	171.521	8.206	0.615	1.655

Nutrient losses have been higher this year for maize (weeding crop) and black fallow, and low for wheat and alfalfa crops that better cover the land (Mocanu et al., 2013).

Thus, through the liquid runoffs, higher amounts of nutrients were entrained in the case of maize crops, black fallow, spontaneous vegetation, respectively: 0.358; 1.275; 0.592 kg N/ha; 0.083; 0.323; 1.125 kg P_2O_5/ha and 0.725; 2.344; 1.183 kg K_2O/ha.

For crops that cover the soil well and have a well-developed root system such as wheat and alfalfa, nutrient losses through runoff are much lower: 0.544; 0.393 kg N/ha; 0.094; 0.047 kg P_2O_5/ha; 0.922; 0.611 kg K_2O/ha.

Through the eroded soil, smaller amounts of humus and nutrients have also been lost in the case of wheat and alfalfa crops: 150.42; 106.254 kg humus/ha; 7.402; 5.341 kg N/ha; 0.571; 0.368 kg P_2O_5/ha; 1.351; 0.973 kg K_2O/ha and larger quantities for maize and black fallow: 188.26; 384.261 kg humus/ha; 9.366; 19.112 kg N/ha; 0.627-1.459 kg P_2O_5/ha and 1.789-3.486 kg K_2O/ha.

So, even this year, regardless of the volume of precipitation that causes erosion, soil losses through erosion and fertilizer elements is higher in the case of maize (weeding crop), black fallow, spontaneous vegetation and lower in the case of wheat and alfalfa, plants which covers much better the entire surface of the soil.

In the year 2020, there were 6 rain events that generated surface runoffs and erosion, the total value of the precipitation that caused the erosion is 149.8 mm, except the value of 117.3 mm for maize (which in May was barely sown, this month not being taken into account).

As in other years, the largest runoff, the most severe erosion and the highest losses of humus and nutrients were recorded in the case of maize crops, spontaneous vegetation and especially in the black fallow, and the smallest in wheat and alfalfa (Table 5 and 6).

Table 5: The regime of the monthly precipitations that produced the runoffs at Balota in 2020

Crop	Month												Total		
	April			May			June			Iuly					
	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)	Rainfall (mm)	Runoff (mc/ha)	Erosion (t/ha)
Wheat	32.5	48.75	0.76	28.9	33.35	0.676	48.7	54.31	1.231	39.7	44.55	0.928	149.8	180.96	3.595
Maize	0.0	0.0	0.0	28.9	70.81	2.44	48.7	119.32	2.41	39.7	91.26	1.780	117.3	281.39	6.630
Alfalfa	32.5	27.8	0.685	28.9	24.27	0.624	48.7	40.91	1.25	39.7	33.34	0.839	149.8	126.32	3.398
Black fallow	32.5	112.5	4.72	28.9	99.71	4.24	48.7	142.5	5.64	39.7	115.09	4.831	149.8	469.80	19.431
Natural vegetation	32.5	46.08	0.821	28.9	41.03	0.821	48.7	69.15	1.77	39.7	55.37	1.017	149.8	211.63	4.429

Table 6: Losses of nutrients and humus in 2020

Crop	Through the water running down the slope						Through the soil entrained by runoff water				
	Runoff (mc/h)	$N\text{-}NO_3$ (kg/ha)	$N\text{-}NH_4$ (kg/ha)	N_{total} (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Eroded soil (t/ha)	Humus (kg/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Wheat	180.96	0.196	0.171	0.377	0.171	0.787	3.595	125.22	5.99	0.440	1.125
Maize	281.39	0.311	0.268	0.579	0.368	1.411	6.63	205.31	10.08	0.717	1.845
Alfalfa	126.32	0.148	0.129	0.277	0.077	0.706	3.192	108.10	5.621	0.378	0.992
Black fallow	469.80	0.496	0.421	0.917	0.663	1.933	19.491	621.16	30.42	2.174	5.591
Natural vegetation	211.63	0.289	0.258	0.556	0.179	0.903	4.489	166.10	8.04	0.581	1.494

On average, over the three years of determination, a value of liquid runoff was recorded on the slope between 118.87 and 471.98 m^3/ha. Of course, the most accentuated runoffs were in the case of the black fallow 471.98 m^3/ha (100%) and the lowest in alfalfa 118.87 m^3/ha (25.14%) of the runoffs in the black fallow) and wheat 183.43 m^3/ha (38.86% of black fallow runoff).

The average annual humus losses were between 89.20 kg/ha for alfalfa and 488.58 kg/ha for black fallow (Table 7).

Table 7: Runoff losses, erosion and humus -total values over the three years of study (2018-2020) and their annual averages

Crop	Total values				Annual averages					
	Rainfall	Runoff	Erosion	Humus	Runoff		Erosion		Humus	
	mm	mc/ha	t/ha	kg/ha	mc/ha	%	t/ha	%	kg/ha	%
Wheat	461.0	550.29	9.559	344.593	183.43	38.86	3.18	18.30	114.86	23.50
Maize	349.8	757.87	20.546	594.368	252.62	53.52	6.84	39.42	198.19	40.56
Alfalfa	461.0	356.63	7.813	267.608	118.87	25.18	2.71	15.61	89.20	18.25
Black fallow	461.0	1415.95	52.07	1465.755	471.98	100	17.35	100	488.58	100
Natural vegetation	461.0	671.27	17.592	541.113	223.75	47.40	5.88	33.89	180.35	36.89

Under natural rainfall conditions, the change in runoff was consistent with the change in monthly precipitation. Runoff volume increased with the increase in monthly precipitation (Xiao-na et al., 2021).

Erosion was also higher in the case of black fallow 17.35 t/ha and spontaneous vegetation 5.88 t/ha and the lowest level was obviously recorded in alfalfa 2.71 t/ha and wheat 3.18 t/ha, representing only 15.61 % and 18.30 % of the volume of black fallow erosion.

Analyzing the average annual nutrient losses on the slope, we find the following:

- the annual average of nitrogen losses through runoff is between 0.299 kg/ha for alfalfa (10.83 % of total losses) and 1.003 kg/ha for black fallow (36.31 % of total losses).

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Nitrogen losses through eroded soil are much higher, 14-23 times through eroded soil than through runoff water. Thus, in the case of the alfalfa that registers the lowest value, it amounts to 4.45 kg/ha (8.68 % of the total) and of 23.42 kg/ha in the case of the black fallow (45.66 % of the total).

- the annual average of phosphorus losses is much lower than that of nitrogen losses, both through runoff water and through eroded soil, with values between 0.052-0.370 kg/ha through drained water and 0.430-1.500 kg/ha through soil eroded. This is due to the fact that phosphorus is more insoluble than nitrogen, being better fixed in the soil than this and to a much lesser extent lost through the phenomenon of erosion.

- the annual losses of potassium (as average annual values) are also lower than those of nitrogen, but higher than those of phosphorus. Potassium is also lost on sloping soils in larger quantities in weeding crops (maize) 1.14 - 1.733 kg/ha and black fallow 1.97 - 4.06 kg/ha (35.31 % - 44.66 % of total) and in smaller quantities for crops that cover the land better: wheat 0.84-1.03 kg/ha and alfalfa 0.63-0.82 kg/ha, respectively 9.02-11.29 % of the total losses.

Table 8: Nutrients losses on the slope - total values for the 3 years of study and their annual averages

Crop	N						P_2O_5						K_2O					
	Total		Annual average				Total		Annual average				Total		Annual average			
	Run off kg/ha	Soil kg/ha	Run off kg/ha	%	Soil kg/ha	%	Run off kg/ha	Soil kg/ha	Run off kg/ha	%	Soil kg/ha	%	Run off kg/ha	Soil kg/ha	Run off kg/ha	%	Soil kg/ha	%
Wheat	1.248	16.51	0.416	15.06	5.50	10.72	0.321	1.315	0.107	12.89	0.430	12.10	2.52	3.09	0.84	15.05	1.03	11.17
Maize	1.442	28.44	0.480	17.38	9.46	18.45	0.545	2.035	0.181	21.80	0.670	18.82	3.42	5.21	1.14	20.43	1.73	18.76
Alfalfa	0.897	13.35	0.299	10.83	4.45	8.68	0.156	0.991	0.052	6.27	0.730	9.26	1.90	2.47	0.63	11.29	0.82	8.89
Black fallow	3.009	70.26	1.003	36.31	23.42	45.66	1.110	4.50	0.370	44.58	1.500	42.13	5.91	12.18	1.97	35.31	4.06	44.04
Natural vegetation	1.694	25.39	0.564	20.42	8.46	16.49	0.379	1.907	0.120	14.46	0.630	17.69	3.00	4.76	1.00	17.92	1.58	17.14
Total	-	-	2.762	100	51.29	100	-	-	0.830	100	3.56	100	-	-	5.58	100	9.22	100

The anthropic intervention was generated by soil compaction, hardpan formation, soil erosion through improper soil tillage along the slope. Human-induced compaction of agricultural soil can be the result of using tillage equipment during soil cultivation or result from the heavy weight of field equipment.

Conclusions

The research conducted during the period 2018-2020 regarding the losses of soil, humus and nutrients on the stagnic vertic preluvosoil from Balota, Dolj County with a slope of 4%, during the vegetation period of wheat, maize, alfalfa crops compared to black fallow, soil with spontaneous vegetation, highlighted, as an average for 3 years, the following:

- most significant runoffs on the slope were recorded at the black fallow 471.98 m^3/ha and maize 252.62 m^3/ha, and the lowest were recorded at wheat 183.43 m^3/ha and alfalfa 118.87 m^3/ha (25.18 % compared to the black fallow).

- soil erosion and soil losses, recorded high values also in the case of maize cultivation 6.84 t/ha (39.42 %) and in the case of black fallow 17.35 t/ha (100%).

- the humus from the soil was lost in the largest quantities also for maize crops, 198.19 kg/ha (40.56 %) and black fallow 488.58 kg/ha (100%) and in quite small quantities in the case of alfalfa 89.20 kg/ha (18.25 %).

- soil nutrients have been lost both by runoff water on sloping soil and by eroded soil, with higher amounts lost through eroded soil.

Regardless of the analyzed nutrient (nitrogen, phosphorus, potassium), the highest losses are recorded, as well as in soil and humus, under the culture of maize, black fallow and spontaneous vegetation.

In order to reduce the loss of soil and nutrients through the erosion processes on the slope, it is necessary to take remedial measures that consist of:

- reduction of soil acidity by using calcareous amendments in doses of 4.8-5.3 t $CaCO_3$/ha;

- to favor better absorption of clay-humic complex is recommended to use, once every 3 years, 25 t manure or other organic fertilizers existing in the area to increase the content of soil microorganisms, the content of organic matter and, implicitly, to increase the content of macroelements in the respective soil;

- it is recommended to incorporate all organic waste into the soil by plowing in order to increase the content of organic matter and improve the absorption capacity of the clay-humic complex (Dodocioiu et al., 2009);

- it is recommended that all soil tillage to be done in the direction of contour lines.

As a result of liquid and solid runoffs, significant amounts of nutrients are lost from agricultural land, leading to a decrease in soil fertility, with serious repercussions on the production capacity and health of agricultural land (Filiche, 2011).

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