

The Influence of Land Fertilization with Fertilizers from Animal Manure on Hydric Soil Erosion

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Abstract

Plants in agricultural crops begin to develop rapidly in the spring and need the food supplement provided by fertilizers. Carrying out the basic fertilization is necessary together with the works for the preparation of the germinal bed in view of the spring sowing. On pastures, especially those that are to be used for both grazing and forage, it is also important to apply fertilizers in early spring. According to the Code of Good Agricultural Practices, starting from March 15, the spreading of solid organic fertilizers on arable land and pastures is also allowed. Liquid, semi-liquid and solid manures from animal farms as well as effluents from silos contain large amounts of nutrients. For this reason, the application of fertilizers derived from them have, in addition to the positive effects of increasing the fertility of the land and increasing the organic matter content of the soil, and a very important negative one, namely the acceleration of the eutrophication of surface waters in the case of their penetration into the bodies of water, even small amounts of these substances.

The paper analyses these aspects of soil fertilization with fertilizers from animal manure, respectively the influence of this process on hydric soil erosion on watershed hillslopes. The Water Erosion Prediction Project software, developed by USDA-ARS, USA, was used for the soil loss study.

Keywords: animal manure, soil erosion, soil loss, runoff, land fertilization.

1. Introduction

The increasingly global population, increasing pressure on natural resources, climate change and global warming require the development of a strategic vision in the field of agriculture and soil protection against degradation. Globally, the demand for food is expected to increase by 70% by 2050, as a result of the ever-larger population and rising incomes [1].

There is a need for a sustainable development of the agricultural and animal husbandry sector, in order to be able to satisfy the food requirements of the population.

Soil nutrients are one of the most important factors for proper plant development and a

successful harvest. While some lands are fertile and suitable to support optimal plant development, there are also nutrient-deficient agricultural lands where human intervention will be necessary through the application of fertilizers. For the best possible productivity, farmers adapt the type of fertilizer, depending on the crop they want to establish.

Among the main types of fertilizers used are organic/natural fertilizers, respectively manure and bird droppings. Liquid, semi-liquid and solid manures from animal farms as well as effluents from silos contain large amounts of nutrients.

Manure is one of the most used types of natural fertilizers, being used especially in vegetable cultivation. It is normally applied to the soil with autumn fertilization, but the process can be repeated later if it has been missed.

Poultry manure, although not very popular with farmers due to the difficulty with which it is

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applied to the field, poultry manure is a fertilizer rich in nitrogen, potassium and phosphorus. It is applied dry or in liquid form, mixed with water, but it is not recommended to use it fresh, as it will lead to an increase in soil acidity [2].

Among the benefits of using organic fertilizers are:

- contributes to the maintenance of soil fertility, through the gradual release of microelements and macroelements, under the influence of soil microorganisms or environmental factors. Therefore, overdosing the soil with fertilizers is almost impossible;
- increasing the fertility of the land;
- increasing the organic matter content of the soil;
- improve the water retention and infiltration capacity in the soil, but also the soil structure;
- reduce soil erosion;
- can be obtained in one's own household, without incurring additional production costs [2].

However, organic fertilizers also have disadvantages:

- because, in the case of organic fertilizers, the release of nutrients into the soil is slower, plants that urgently need minerals could be affected by the lack of the necessary elements in an optimal period, which could lead to a decrease in production;
- the application of organic fertilizers is more difficult than that of chemical fertilizers, and the workload and, implicitly, labor costs will be significantly higher;
- if organic fertilizers cannot be obtained in one's own household, their purchase will prove to be more expensive than that of chemical fertilizers.
- the acceleration of the eutrophication of surface waters in the case of their penetration into the bodies of water, even small amounts of these substances [2].

Plants in agricultural crops begin to develop rapidly in the spring and need the food supplement provided by fertilizers. Carrying out the basic fertilization is necessary together with the works for the preparation of the germinal bed in view of the spring sowing. On pastures, especially those that are to be used for both grazing and forage, it is also important to apply fertilizers in early spring.

According to the Code of Good Agricultural Practices, starting from March 15, the spreading of solid organic fertilizers on arable land and pastures is also allowed [3].

The soil is subjected to a series of degradation processes. Some of these processes are closely related to agriculture: water erosion, wind erosion, inadequate agricultural works; compaction; decrease in the amount of soil organic carbon and soil biodiversity; salinization and sodification and soil contamination (with heavy metals and pesticides or excessive amounts of nutrients).

Soil degradation processes involve the need for protection, maintenance and improvement of soil quality.

Water erosion of the soil is a natural process; the main factors that determine it are the torrential rains, the topography of the land, the low content of soil organic matter, percentage and type of vegetation cover. This process is intensified and accelerated by human activities such as inadequate tillage techniques and harvesting practices, modification of hydrological conditions, deforestation and marginalization or abandonment the lands [4].

Organic matter in soil includes all living organisms from the soil and the remains of dead organisms in it different degrees of decomposition. Carbon content organic matter of a soil consists of heterogeneous mixtures of simple and complex carbon-containing substances.

Sources of organic matter are crop residues, animal and vegetable fertilizers, compost and others organic materials. The reduction of organic matter is caused by the presence of decaying organisms in small quantities or at an accelerated rate of decomposition as a result of changes in natural or anthropogenic factors. Organic matter is regarded as an essential component of a healthy soil; reduction it leads to soil degradation [4].

Soil organic matter is a source of food for soil fauna and contributes to biodiversity the soil, acting as a reservoir of nutrients such as nitrogen, phosphorus and sulphur; this is the main thing responsible for soil fertility. The organic carbon in the soil supports its structure, improving it the physical environment for root penetration into the soil. Organic matter absorbs water, being beneficial for vegetation in natural arid and sandy soils. Soils with organic matter are better structured, which improves water infiltration and reduces its predisposition to compaction, erosion, desertification and landslides. The organic carbon content of soil is mainly affected by climate, texture, hydrology, use land and vegetation [4].

2. Materials and methods

The Water Erosion Prediction Project (WEPP) software was used for the soil loss study and for studying the influence of soil composition in organic matter on soil losses through hydric soil erosion.

WEPP is a software for the prediction of erosion processes in watersheds, developed by USDA Forest Service, Agricultural Research Service, Natural Resources Conservation Service, Department of Interior's Bureau of Land Management and Geological Survey from USA, now a day, the most used model in numerous countries.

The WEPP model may be used in both hillslope and watershed applications. The model is a distributed parameter, continuous simulation, erosion prediction model, implemented as a set of computer programs for personal computers. The hillslope component of the WEPP erosion model

requires a minimum of four input data files to run: climate file, slope file, soil file and plant/management file. The watershed component requires a minimum of seven input data files: each hillslope information file, structure file, slope file, soil file, management file, climate file and channel file. WEPP considering the hillslope consist in numerous parallel rills; the surface erosion occurs on interrill surfaces and the dislocated soil particles are transported downhill by rill flow (rill erosion is also considered in calculus).

WEPP produces many different kinds of output, in various quantities, depending upon the user's needs. The most basic output contains the runoff and erosion summary information, which may be produced on a storm by storm, monthly, annual or average annual basis. The time – integrated estimates of runoff, erosion, sediment delivery and sediment enrichment are contained in this output, as well as the spatial distribution of erosion on the hillslope (Figure 1).

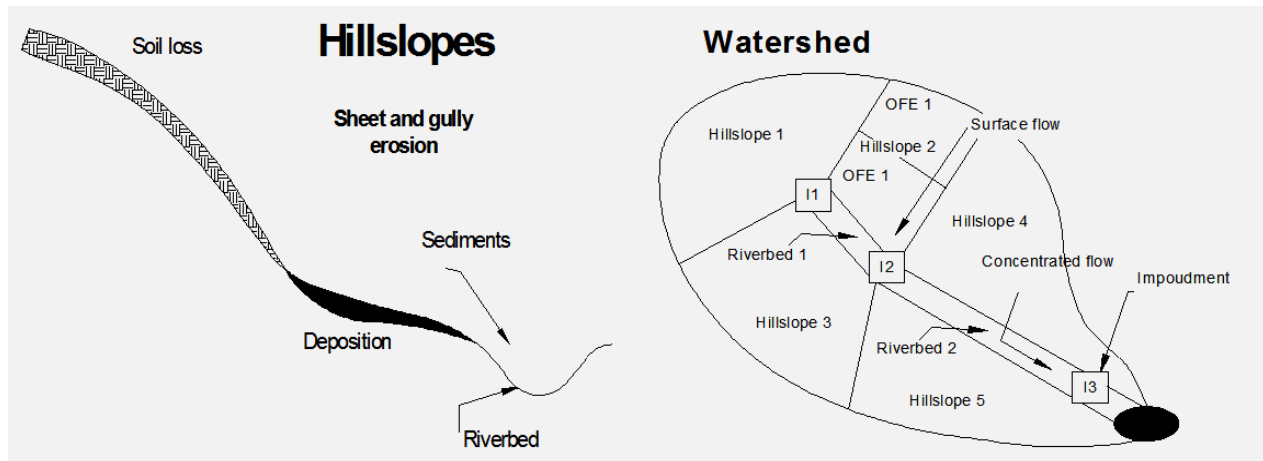


Figure 1. WEPP Model

The model has two basic components:

a). Erosion component

It is based on the continuity equation:

$$\frac{dG}{dx} = D_r + D_i \quad (1)$$

where: G – sediment load ($\text{kg/s}\cdot\text{m}$); x – distance downslope (m); D_r – rill erosion rate (+ for detachment, - for deposition); D_i – interrill sediment delivery ($\text{kg/s}\cdot\text{m}^2$).

Rill erosion is divided into two parts, detachment and deposition. Rill detachment is predicted when the flow shear stress exceeds the critical shear stress of the soil and when the sediment load is below the calculated sediment transport capacity. Deposition in a rill will be predicted when the

sediment load is greater than the sediment transport capacity

b). Hydrology component

The hydrology component of the WEPP model produces four inputs for the erosion component: peak runoff rate, effective runoff duration, effective rainfall intensity, effective rainfall duration.

Infiltration is calculated using the Green - Ampt and Mein – Larson (GAML) equations:

For $F < F_s$:

$$f = i \quad \text{and} \quad F_s = \frac{S \cdot \text{IMD}}{i / K_s - 1} \quad \text{for } i > K_s \quad (2)$$

no calculation of F_s for $i \leq K_s$

For $F \geq F_s$:

$$f = f_p \quad \text{and} \quad f_p = K_s \left(1 + \frac{S \cdot \text{IMD}}{F} \right) \quad (3)$$

where: f – infiltration rate; f_p – infiltration capacity; i – rainfall intensity; F – cumulative infiltration volume; F_s – cumulative infiltration volume required to cause surface saturation; S – average capillary suction at the wetting front; IMD – initial moisture deficit; K_s – saturated hydraulic conductivity of soil [5].

For the soil loss study was chosen one hillslope from Topla Valley hydrographical basin (Figure 2) (with area 60,69 ha, hillslope length 473 m, width 1283 m, longitudinal profile is show in

Figure 3), and considered the following hypotheses:

- the constant intensity of the rain on the entire surface of the hillslope;
- the same soil type for the entire hillslope - Typic Hapludalfs (with more subtypes), of a middle and heavy texture (reduced permeability), being part of the hydrological group C;
- soil use is the same all over the hillslope surface (corn);
- there are no human works to control soil erosion.

The initial soil characteristics are show in Table 1 [6].

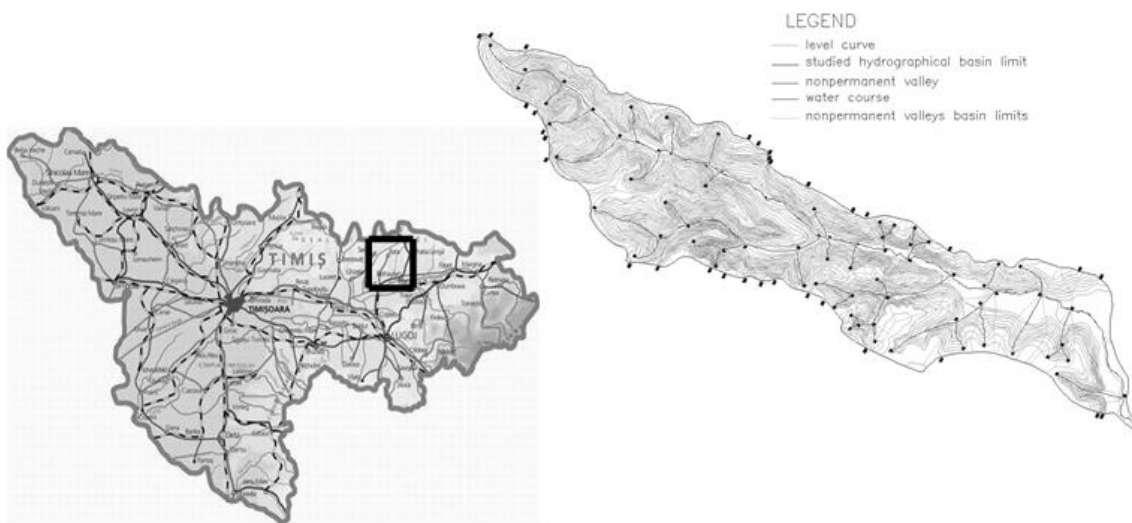


Figure 2. Location of the studied hillslope and area plan of Topla Valley

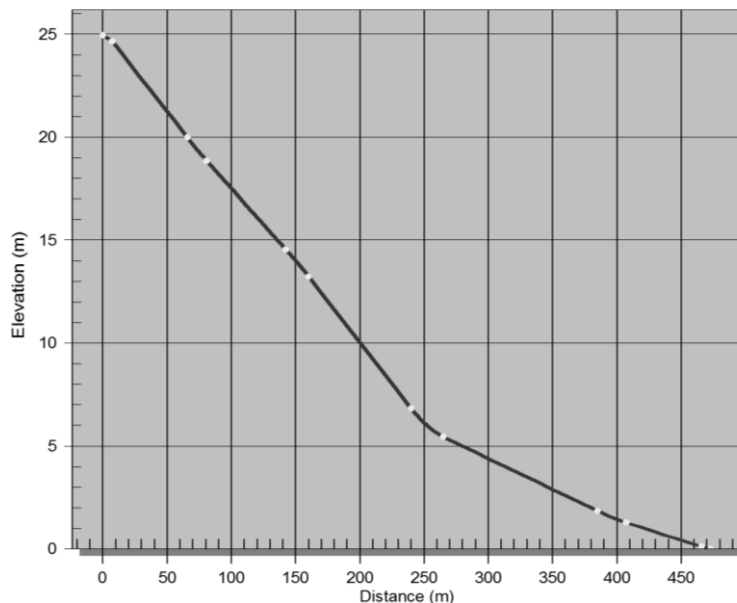


Figure 3. Longitudinal profile of hillslope

Table 1. Soil initial characteristics

Layer	Depth (mm)	Sand (%)	Clay (%)	Organic (%)	CEC (meq/100 g)	Rock (%)
1	150	37.2	21.2	0.100	11.4	0.0
2	360	38.1	20.9	0.100	10.9	0.0
3	680	31.0	30.5	0.100	14.4	0.0
4	870	28.8	36.2	0.001	19.3	0.0
5	1030	29.3	32.0	0.001	18.6	0.0
6	1300	34.4	31.3	0.001	18.3	0.0

WEPP model was applied for the calculus of the soil loses on hillslope during the torrential rain, in four hypotheses (which have resulted from the torrential rain distribution charts with the 10%

assurance and having a duration of 5, 15, 30, 60 minutes, elaborated on the basis of measurements and statistical processing of the meteorological data on the Bega hydrographical basin area (Table 2) [7].

Table 2. Characteristics of torrential rains

Storm Amount (mm)	Storm duration (hr)	Max intensity (mm hr ⁻¹)	% Duration to Peak Intensity
15.00	0.08 (5 min)	189.375	20
23.30	0.25 (15 min)	94.132	20
28.80	0.50 (30 min)	58.176	20
42.00	1.00 (60 min)	42.420	20

For the study of the influence of soil organic matter content from manure fertilization on soil losses, 7 hypotheses were considered, which consisted of increasing by 0.5% the organic matter content of the first three soil layers, starting from initial values.

3. Results and discussion

28 simulations were carried out (4 hypotheses of the production of torrential rains x 7 hypotheses of

degrees of soil fertilization). In Figures 4 and 6 you can see the input data and the simulation results in 2 hypotheses out of 28, for the torrential rain lasting 5 minutes, for the initial state of the soil and after fertilization, when the content in organic matter increased from 0.001% to 3.100%. Figures 5 and 7 are the soil loss graphs in the two hypotheses. It can be observed that both the soil losses and the sediment yield decreased from 0.055 to 0.033 kg/m², respectively from 0.541 to 0.334 t/ha.

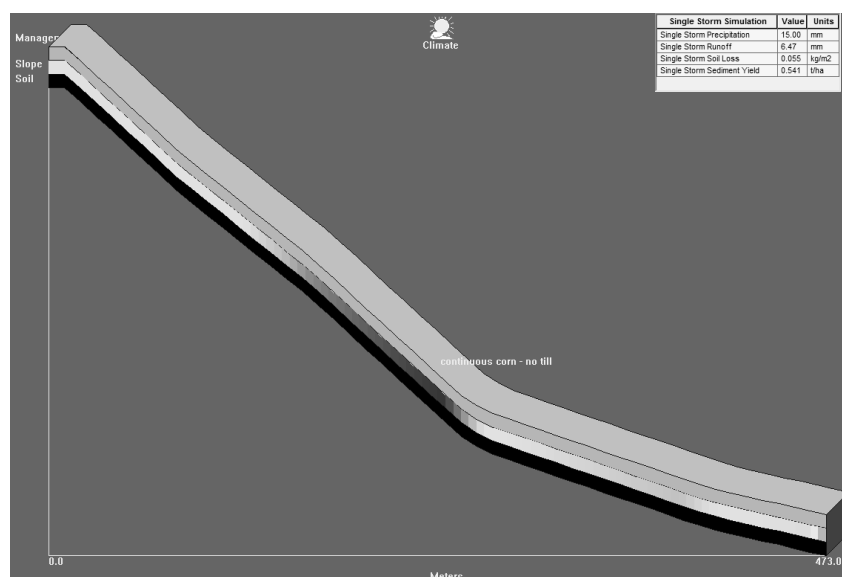


Figure 4. The input data and the simulation results for initial stage of soil

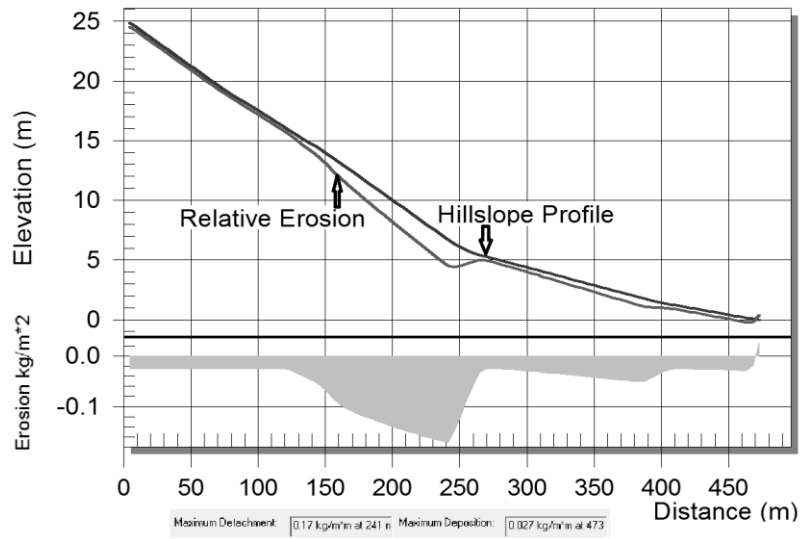


Figure 5. The soil loss graph for initial stage of soil

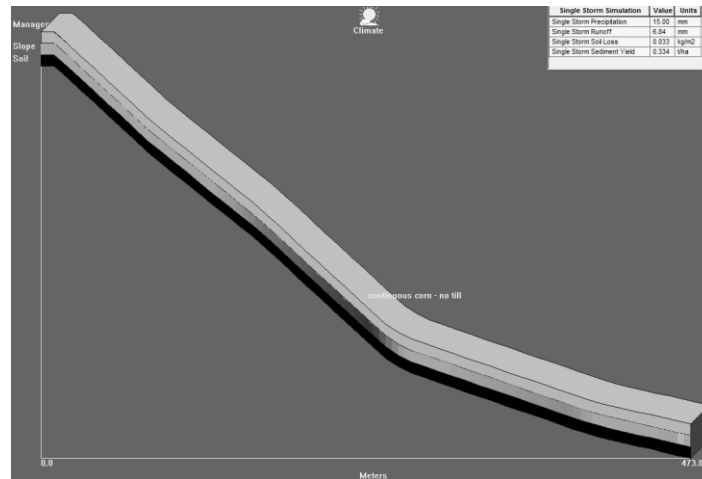


Figure 6. The input data and the simulation results for final stage of soil

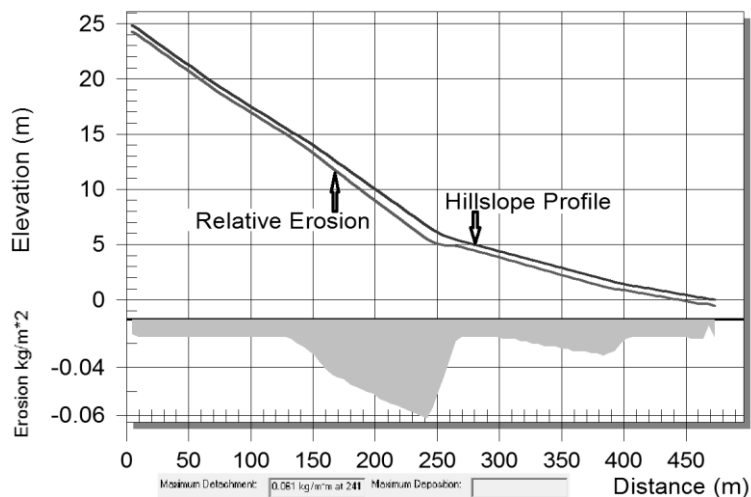


Figure 7. The soil loss graph for final stage of soil

The most intense erosions occur in areas with a change in slope, approximately 241 m from the top of the hillslope. Figures 8, 9, 10 and 11 show the soil loss variations in the 4 torrential rain production scenarios, respectively the correlations

between soil losses and the degree of fertilization. The best correlation is the polynomial one of order 2. The best effect of fertilization on soil losses is observed in the case of torrential rains with high intensity.

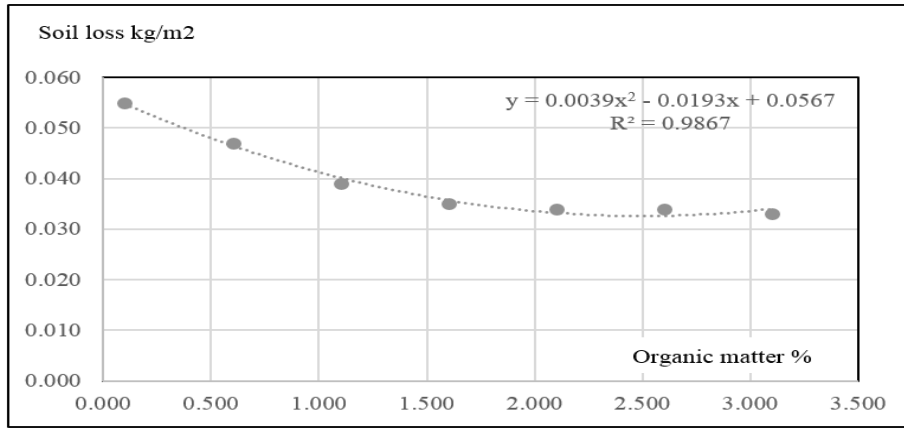


Figure 8. Soil loss variation for 5 minutes torrential rain

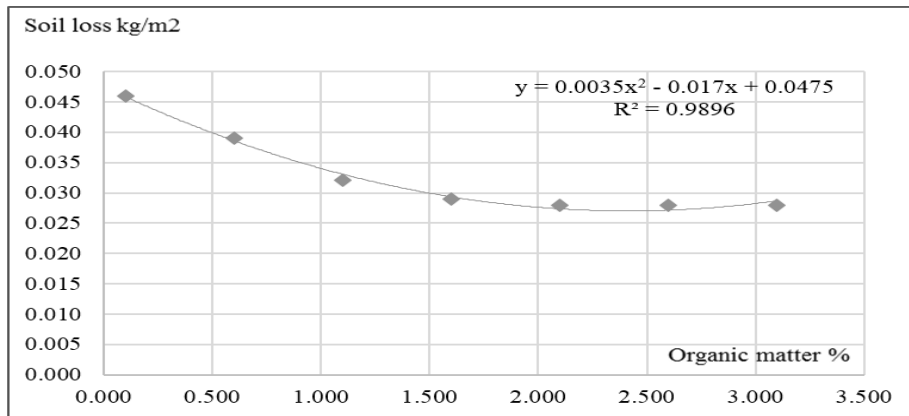


Figure 9. Soil loss variation for 15 minutes torrential rain

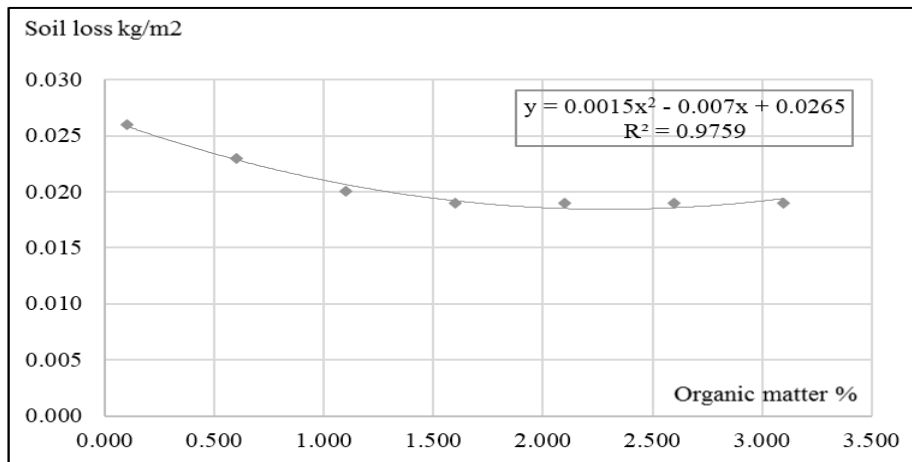


Figure 10. Soil loss variation for 30 minutes torrential rain

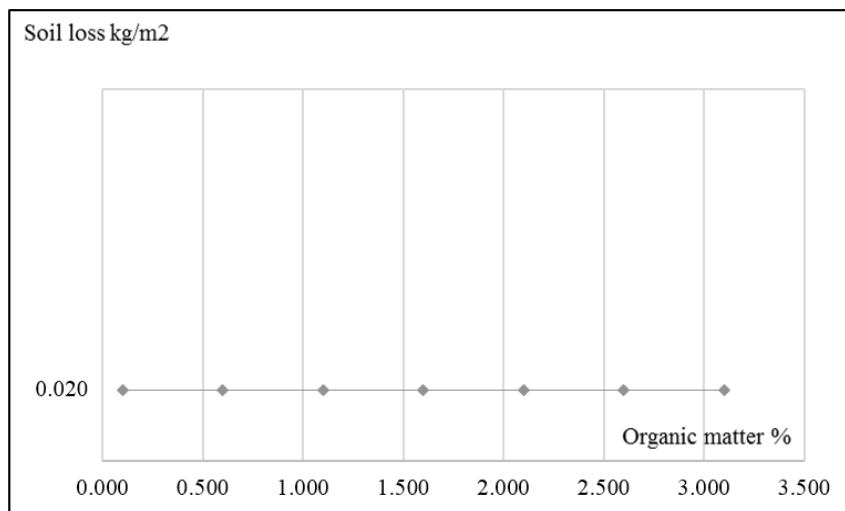


Figure 11. Soil loss variation for 60 minutes torrential rain

4. Conclusions

The soil requires the regular maintenance of its characteristics and especially of its fertility. Naturally, the soil includes very fine rocks, different types of minerals and organic matter from the decomposition of biological species; but they do not help to support and maintain the necessary amounts of nutrients for the plants and it is necessary to apply fertilizers to the soil, which guarantees the plant adequate nutrition during its development.

Chemical fertilizers used exclusively and in large quantities cause damage, both to plants and to all forms of life; polluting the soil and water, and blocking the minerals in the soil.

That is why it was necessary to switch to the application of organic fertilizers that improve the beneficial microbial activity in the soil. The organic fertilizer contains elements that are important for maintaining soil fertility, increasing the amount of humus and improving the structure and texture of the soil, therefore increasing the resistance of the soil both to the water erosion of runoff water from precipitation and to wind erosion. Manure is a complex fertilizer, it positively influences all the physical and chemical characteristics of soils.

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