Scientific Papers. Series A. Agronomy, Vol. LVII, 2014
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

NATURAL CONDITIONS CONTRIBUTING TO APPEARANCE AND DEVELOPMENT OF SOIL DEGRADATION IN MOLDOVA

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Abstract

The paper aimed to present the natural conditions contributing to soil degradation in Republic of Moldova: geological structure of territory, parental rocks, relief, climatic conditions and vegetative cover. Description of these factors was performed based on the fundamental and applied researches, field and laboratory analyses. Each factor in a greater or lesser measure influences soil degradation and land desertification. Knowing the degree of influence allows developing measures on prevention of factor degradation and measures of restoring fertility of degraded soils. These measures were discussed in state programs for exploitation of degraded soils and low productivity.

Key words*: climate condition, geological structure, parental rocks, soil erosion, vegetative cover.*

INTRODUCTION

Natural conditions of Moldova combined with anthropogenic determine, on the one hand, the intensity and direction of soil formation, and on the other hand, the nature and extent of soil degradation. Depending on the combination of natural and anthropogenic factors change the shape and extent of land degradation.

MATERIALS AND METHODS

Study on natural conditions that contribute to soil degradation and land desertification was conducted in aims to develop the measures to mitigate the consequences, to implementation the elaborations on soil protection and monitoring. Were studied scientific historical literary sources, statistics date, monitoring bulletins and data bank.

RESULTS AND DISCUSSIONS

1. Geological structure, parent rocks and their influence on the process of soil degradation. In the geological history the territory of the Republic of Moldova are two main periods: the geosynclinal and platform. The platform stage led to an effusion of bases, the emergence of many geological faults and the formation of four platform depressions: Hincesti, Predobrogian, Pontiac and Prut.

In the Neocene, in connection with the evolution of the Carpathian geosynclinal and the Pontiac depression, the immersion process, involved almost the entire territory of Moldova (submerged under the sea). This led to the accumulation of large sectors of marine Neocene sediments, which currently places come to the surface or overlain by Quaternary deposits. Tertiary sediments are saline Sarmatian clays with lenses of sand and loam.

The Quaternary deposits are developed almost everywhere and are loess-like loams, ancient and modern alluvial sediments of different grain size - from clay to sandy loam.

Parental rocks of Moldovan soils are present mainly by Quaternary and partial Neocene origin of surface sediments:

Neocene clay. Come to the surface in the upper and middle slopes of the Central Moldovan Plateau and High Ciuluk Hills, occupying 24 thousand hectares, contain up to 80% of physical clay and more than 35% of silt, on these rocks are formed automorphic solonetzes and vertisoils.

Neocene clay loam. Take 55 thousand hectares on the same plateaus, comprise up to 55% of the physical clay and about 30% of silt, have satisfactory agronomic characteristics.

Quaternary loam clays and their derivatives. Distributed mainly on the North Moldavian Plateau and on the stabilized spaces of the

Central Moldovan Plateau. Occupy 257 thousand ha, contain no more than 64% of the physical clay and 38% of silt, have satisfactory agronomic characteristics, contribute to precipitation water stagnation in the soils and formation of swampy soils on the slopes, as well as the development of linear erosion.

Quaternary loess loamy clays and their derivatives. Occupy 1433 thousand hectares and contain 54-56% of physical clay and 30% of silt. In Moldova this rocks adopted as the standard-parent rocks. Have favorable physical and chemical properties.

Quaternary loess clays and their derivatives. Distributed over an area of 473 thousand hectares, mainly in the south of Moldova, contain 35-37% of physical clay and 20% of silt. Characterized by very favorable physical and chemical properties. However, the soils, formed by those rocks are weak and moderate resistance to water and wind erosion.

Sandy loams and loamy sands of diverse origin. Cover about 50 thousand hectares, contain 19-26% of physical clay and 12% of silt. Very unstable to deflation. Characterized by moderate favorable properties for growing field crops, as are poor in nutrients and have a less favorable water regime. Soils formed on these deposits, especially suitable for the cultivation of high-quality tobacco varieties, planting stone fruit trees, vineyards for special purposes etc. (Leah, 2012).

In conclusion, it should be noted that the parent rocks contribute to the development of the following soil degradation processes:

- *clayey size composition of soils* - conduct to the emergence of excess moisture with stagnant character, formation of the solonetzes on the slopes, the appearance of vertic processes (vertisoils), development of linear erosion;
- *clayey size composition of underlying rocks* - to the accumulation of ground water, forming sliding faces and the appearance of landslides, forming the salinization and alkalization soils in meadows as a result of chemical denudation;
- *saline parent rocks* - to forming solonetzes on the slopes, increased salinity degree of groundwater, salinization and alkalization of soils, as result of chemical denudation;
- *moderate and easy size composition of soils and rocks* - to development of erosion and deflation, aridity and desertification.

2. Relief and soil degradation. The contemporaneous relief of Moldova formed by the interaction of tectonic movements of the earth's crust and denudation processes in continental conditions, extended from the end of the Neocene period. The average altitude of Moldova surface is 147 m, the maximum reached 429.5 m (Balaneshti hill). Elevation of the terrain falls to the north-west to south-east.

At the same time in the Central part of the country, there is a combination of high plains and heights less strongly fragmented.

Within the Moldova limits is identified the following major orographical units: North Moldovan Plateau, North Moldovan low undulating Plain, Central Moldovan Plateau, Dniester Hills, Lower Dniester Plain, South Moldavian hilly plain, Tigheci hills.

North Moldovan Plateau is characterized by smooth topography, which contributes to the weak expression of soil erosion processes. Absolute altitude - 250-300 m. Horizontal fragmentation of valleys - 1.5-2.0 km/km^2, vertical average fragmentation - 50-100 m, in the west, in the fossil reefs chains up to 150 m.

North Moldovan Undulated Plain by the local topography and the expression of the soil erosion like the North Moldovan Plateau, but differs from it in smaller altitudes - 200-250 m.

Central Moldovan Plateau (Codri) is a combination of narrow comb watersheds with deep valleys and wide long slopes which are dissected by erosion and landslides semi-enclosed depressions, called "*hârtopuri*". Horizontal fragmentation of surface is 2.5-4.0 km/km^2 and vertical - 200-300 m. This contributes to the extensive development of landslides, mechanical and chemical denudation, erosion of soil cover. As a result of chemical denudation and salt removal from the Neocene clays, the ground water of floodplains are mineralized and cause salinization and alkalization of hydromorphic soils.

Dniester Hills has a height of 250-300 m, the maximum is 347 m, the vertical dissection - 150-200 m. Western slopes are slow, and eastern - descends sharply to the river Dniester. Soil erosion processes occurs widely.

Plain (terraces) of Lower Dniester is characterized by low horizontal fragmentation of the surface (less than 1 km/km^2) and low absolute altitudes - below 100 m.

South Moldovan undulating plain is characterized mainly by an absolute height in the range of 100-200 m (max. 247 m), the horizontal dissection - 2.0-2.5 km/km^2, vertical - 100-150 m, the soil erosion are widespread, but much weaker that at higher elevations.

Within South Moldavian hilly plains stands ***Tigheci Hills***, elongated in the sub meridional direction. The absolute altitude of the northern part of the upland reaches 300 m, and the southern - 220 m. Erosion appear moderated.

Seven orographical units characterized by specific morphological structure, present in a relatively small area of the country, determines increasing the intensity of contemporary exogenous processes, leading to the destruction of soil cover. Among these exogenous processes should be mentioned the following: erosion and landslide, proluvial-delluvial, crash, colluvial, suffusion and carst. Most strongly manifests erosion and landslide processes, the primary cause of the destruction of soil cover and land degradation.

Relief indicators, which determine the intensity of soil erosion manifestation are: total degree of territory fragmentation, local base of erosion depth, average slope length, slope steepness and forms. In Moldova these parameters are combined in a system so complex that it is impossible to give relief a single integrated assessment. It is necessary that each water catchment area and even slope can be treated separately, taking into account their morphometric characteristics.

According to experimental data, the quantity of eroded soil by erosion increases in proportion to the slope length from 0.5 to 2, on average 1.6. Increasing the slope length with 100 m leads to the increasing the amount of eroded soil by 1.5 times, doubling the slope length from 200 to 400 m increases the volume of eroded soil by 4 times.

Republic of Moldova is characterized by a wide diversity of surface slopes, including inclinations of agricultural land. Experimental data have shown that the amount of soil removed by erosion increases proportionally with the inclination of the slope. Doubling the slope inclination increases the amount of eroded soil by 2.3 times. Increasing the slope angle with 1° (beginning from 2°) increases the eroded index on the surface with maize, the average - 6.6 t/ha, sunflower - 5.7 t/ha, autumn plowing - 4 t/ha, winter wheat - 3.1 t/ha.

Areas with slopes from 0^0 to 2^0 are considered relatively horizontal, the erosion does not occur (up to 1°), or as manifested in a smaller (1-2°) and can be stopped using relatively simple protection processes. Slopes with inclination of 2-6° are already erosion dangerous leading to the formation of weak, medium and even heavily eroded soils. Land with slopes 6-10° shows the high risk and require a complex implementation of special protection measures. The areas of land with slope of more than 10^0 should be taken out of the phyto-intensive works and aforestation alienated or turned into pastures with grazing strictly regulated.

A large influence on the erosion intensity of erosion has slope exposure. Sunny slopes are more susceptible to erosion than shady.

In connection with the general inclination of Moldovan territory from northwest to south and southeast in total the slope which north-facing are the least (21%), the east, south and west exposition are almost equal (26-27%). But the areas are essential differences. For example, in the central part of Moldova slopes with southern exposition predominate (29%).

The depth of the local base level of erosion, both average and maximum is higher in the central area (130-328 m), which indicates an increased risk of manifestation of erosion within that territory. In the northern and southern zones these values are lower, but still significant and should also be taken into consideration the protective measures.

Slope form is essential significance for the erosion manifestation and erosion control measures selection. Danger manifestation of erosion is low for straight slopes that are more prevalent in the North (40%) and about two times less in the South (18%) and Central (23%). Therefore, conditions for minimization of erosion in the last two zones are very complicated. On the other hand, the large number of slopes with concave central area (49%) can contribute to reducing fluid flow and deposition within the slope the material washed away by erosion.

The lowest risk of erosion is characteristic for Plain (terraces) of Lower Dniester, where more than 80% of the territory has a horizontal surface, and 15% - in the slopes 2-6^o. Slopes greater than 10 ° there is no. On the second place is North Moldovan Plateau, where horizontal areas occupy 56% and 31% of the area has slope 2-6°. Close to these parameters ranges the weak undulated Plain of North Moldova - respectively 51 and 39%, and land with slope greater than 10° are only 3%.

Within South Moldovan hilly plains and Tigheci Hills are spread respectively 38 and 43% on the quasi horizontal surfaces.

The greatest erosion danger present territory of Central Moldovan Plateau (Codri), where only 22% of land is occupied by quasi horizontal surfaces and 18% were over 10°. Similar results have the area of Dniester Hills (30 and 14%). In other natural areas quasi horizontal space occupied 25-35%, and with the slope more than 6° - 7-15%. The steep slopes and heights plateaus are mostly covered by forest, which almost completely protects the soil from erosion processes (Monitoring, 2010).

Finally it should be noted that the topography exerts its influence mainly on the forms and intensity of erosion and landslides manifestation - the main factors of land degradation. Therefore, in developing concrete schemes of land use and erosion control measures necessary to consider, first, the quantitative parameters of relief (slope) of specific territories.

3. Climatic conditions and their impact on land degradation and desertification. The Republic of Moldova is characterized by a warm continental climate with short and mild winters (average temperature in January is -3^0, -5^{0}C), with warm and long summers (average temperature in July is +20^{o}C, +22^{o}C) with relatively little rainfall.

Depending on the latitude, altitude and orographic features on the Moldova identified three climatic zones, which are both agropedological climatic zones: North, Central, South. These areas, in turn, depending on local climatic conditions, due to the absolute height and the local topography, climatic divided into subzones. The Northern zone is characterized by moderately warm and moderately humid climate, Central - warm humid and Southern - hot dry. Thermal resources in the Moldova provide a wide range of growing crops, which greatly expanded the movement from north to south. Monthly average soil temperature at the depth of the plow layer is positive or close to 0^0 on the entire territory of Moldova, but in the absence of snow cover or a small thickness, the soil may freeze to a depth of 1 m.

Amount of annual precipitation varies from 500-600 mm in the north and 450-500 mm in the south. Value coefficient of moisture (K - the ratio between the annual rainfall and evaporation from the water surface in the same period), is respectively 0.7-1.0 and 0.5-0.6. In winter falls 18% of the annual amount of precipitation, and in the warm period - 70%. Although the maximum precipitation occurs during the warm season, summer in Moldova is dry. Dry season begins in July and lasts 2-3 months. There are frequent dry winds.

Agriculture of the Moldova must be adapted to arid conditions, which are the negative aspect of climate. The frequency of manifestations of drought in 10 years is: once in the northern, 2-3 times in central and 3-4 times in the southern zone. Drought leads to intensification of desertification processes and reduce their productive capacity.

According to the UN Convention to Combat Desertification standards the territories with a value of $K<0.65$ are prone to desertification. Central and Southern areas of Moldova is characterized by values of this ratio less than 0.65 which indicates the possibility of desertification processes evolution to those territories. Agriculture must also take account of this information.

To estimate the soil erosion hazard assessment are important the data on rainfall character. During the summer, fall long rains of low intensity, which are well moistened the soil and do not cause significant erosion, however, is dominated heavy rains of high intensity (erosion rains). The latter are usually accompanied by hailstorm. Torrential rains condition unnecessary water spills on the slopes, causing soil erosion and surface depth. Large droplets of heavy rains, with considerable speed, shred with their power dynamics the soil structural aggregates, weakening resistance to erosion.

Annual average values of natural flow are not large, from 0.5 l/m^2 in the South-East to 1.5 l/m^2 in the North and Codri zones. Presents a greater interest average leakage rain indicator. On most territory it has a value of about 4.5 mm/10min and reaches 6 mm/10 min and more in the southwest. In general, it can be considered as characteristic typical values within the range 5-6 mm/10 min.

Republic of Moldova, as well as the Carpathians, parts of the Mediterranean Europe and the Balkans refers to the region with extremely heavy temporary rainfall. Within 24 hours, may fall more than 100 mm. These precipitations are particularly dangerous with erosion standpoint. To minimize the effect of erosion is necessary, first, strict adherence to the whole complex of soil conservation measures, and secondly, the construction in high-risk areas (short tributaries of the Prut River), capital waterworks.

To assess the risk of land erosion needed rainfall data that fell within one rain and their intensity. The maximum average value of rain intensity, duration less than one hour is placed within 0.5-2.4 mm/in. Rains with precipitation in 8, 19, 23, 28, 37, 45 mm, respectively, fell for 9, 10, 15, 14, 18 and 58 min cause severe soil erosion. On slopes of up to 5^o the soil loss in row crop cultivation varies from 12-65 t/ha, and on slopes above 5^o can reach 212 t/ha. Under similar conditions, the increase of precipitation amount of 30 to 60 mm (for 15 and 30 min, respectively) leads to an increase in wastewater from 4 to 15 mm or 3.6 times, while further doubling precipitation - only 3.1 times. In the case where the amount of precipitation increases 4 times (from 30 mm to 120 mm) effluents increases from 4 to 45 mm or 11 times.

Also important are the data on the risk of loss periods of heavy rainfall. In Moldova the most dangerous period is the May month, quite dangerous is June, July, August, less dangerous is April and September. In February and early March the torrential rains occurs rarely. In years with a thick snow cover in the case of rapid snowmelt in the spring, locally, once in every 5 years, can manifest process of erosion.

Finally it should be mentioned that the general nature of the arid climate, the frequent repetition of droughts, event planning territory predisposition to desertification processes requires a total adoption of agriculture to drought conditions. The fragmental relief and character of torrential rainfall are causing manifestation of intensive soil erosion.

4. Vegetation cover and soil erosion. The role of vegetation in erosion control multifaceted: more or less important in different cases, it is still always positive. Vegetation cover reduces erosion manifestation or prevents it entirely through the surface (soil cover) and the root part. Superficial part protects the soil from direct destruction of raindrops and an obstacle to formed water rain flow. Root mass connects soil particles, increases aggregates resistance to breakage - washing - slip. Vegetation not only reduces rainfall flow and soil denudation, but also contributes to retaining solid spill originating on either slope located above.

Cultivation of annual and perennial grasses on the slopes is an effective measure to protect the soil from erosion. Along with other measures grasses, forming a dense surface cover and an extensive root system, reduce soil runoff from the slopes to the permissible norms of 5 t/ha. For example, the root mass of alfalfa and sainfoin at age of three reaches in the soil layer 0-40 cm about 100 q/ha, in the upper soil layer (0-10 cm) concentrated about 40-50% of the root mass. The role of perennial grasses in soil protection is determined mainly by the degree of ground cover. In case of intensive rainfall on land sown by herbs there is a slight runoff precipitation with very low water turbidity.

Crops on their soil protection abilities are divided into four groups (Complex Program I, 2004):

1. *Culture with very high soil-protective ability* - perennial cereals and legumes after the first year of use, provide protection for 90-95% of the soil area.
2. *Cultures with high soil-protective ability* - cereals, perennial legumes and cereals after the first year of use, the annual fodder plants with high stand density per unit area, protects 70-90% of the soil area.
3. *Culture with moderate soil-protective ability* - annual legumes, provide protection for 50-70% of the soil area.
4. *Cultures with low soil-protective ability* - row crops of low planting density (corn, sunflower, sugar beet, vegetables) provide protection for 20-50% of the soil area.

Cropping erosion are determined based on the slope characteristics, soil erosion resistance, which depends on their characteristics, reduction degree of leakages of soil by crops.

Erosion resistance depends on the absorption parameters and soil water retention. It was established that the culture with a dense cover reduces the intensity of erosion, the weeding crops contribute to its manifestation.

Under field crops compared with the bare fallow the soil erosion resistance increases as follows: in the weeding crops - 1.5 times, spring grasses - 3.2, autumn grasses - 5 times.

For removal 1 t/ha of cropland soil with winter crops it is need 58.4 m^3/ha of water leakage, spring vegetables - 37.5, weeding crops - 17.8 and clean fallow - 11.6 m^3/ha. Depending on the intensity field crop species absorbing and retaining water runoff and soil denudation is changed considerably. Depending on the field crop species the intensity of the absorption and water retention, runoff and soil denudation is changed considerably.

The field research and the calculations show that the coverage degree of agricultural land by plants increases as their growth and development and achieve the highest index in July and then in August, in September is reduced by 2.2-2.6 times. This indicates that the soil erosion protection should be intensive in the first phase of plant development and less intensive in the later stages.

Proportions of soil denudation during the crop vegetation changes depending on the species, density and development phase of plant.

Soil denudation character while under the compact crops is almost the same - the highest intensity of denudation occurs in May. In June there is an obvious decline - soil denudation is 2-13 times lower compared to its initial value and increases again in July, but not as sharply.

Thus, special attention to the protection of soil from erosion on dense cultures must be exerted in the autumn after sowing, before germination and early spring - before the resumption of vegetation. Under the spring bean crops the protective measures must be made immediately after planting and as the weeding, from May until July. The intensity of soil denudation in weeding crops can be 3-4 times higher than in cultures with compact vegetative cover. With increasing the share of weeding crops in crop rotation decreases sharply the degree of coverage and soil protection. Whether the share weeding crops in crop rotation increases from 20 to 60%, the protection level of soil erosion is reduced by 12-15%, and the need to increase erosion measures increase by 23-25%.

Therefore, in conditions of agriculture on the slopes one should apply special anti-erosion crop rotation, and the structure is dominated by dense and perennial grasses (Complex Program II, 2004).

A special role in protecting the soil against erosion plays landscapes with natural vegetation. In order to maintain the ecological balance between natural and agricultural ecosystems and reducing the erosion risk of territories are required considerable reconstruction and major expansion of landscapes with natural vegetation by increasing the territory of forests, pastures, hayfields, wetlands, etc.

CONCLUSIONS

Natural conditions causing the hazard manifestation and evolution of the processes of soil degradation and land desertification are: geological conformations, solification rocks, topography, climatic conditions, vegetative cover. These conditions with anthropogenic determine the intensity and direction of soil formation, the nature and extent of soil degradation. Based on this research were developed soil protection measures that are implemented on degraded and eroded areas.

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