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FACTORS CAUSING THE DEVELOPMENT OF WATER EROSION OF SOIL IN VINEYARDS

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Abstract

The water erosion annually causes a great damage to the agricultural lands throughout the world. The struggle against soil erosion is one of the most important government tasks in the system of measures directed to the preservation and transformation of the landscape. The main factors of erosion are: climatic, topographic, geological, soil, biological and the level of human economic activity. The soil erosion in vineyards is one of the priority problems in modern viticulture. The aim of our ongoing research is to study the process of development of the water erosion of the soil in the vineyards. The object of our research is the vineyard soil which is exposed to water erosion. Research methods used in the work: route-field investigation, laboratory study of the water-physical characteristics of the soil. The article describes the main factors leading to the development of water erosion of the soil in vineyards. It is noted that the light structured soil with a small amount of organic substance in it is more exposed to water erosion. It is also ascertained that water erosion can become apparent on slopes even of 1°. The negative influence of the system of vineyard soil maintenance as black steam is shown and scientifically substantiated in the article. Ways to reduce the mechanical loading on the soil and preventing the development of degradation processes of soils in the vineyards are suggested. It is indicated that it is necessary to conduct soil studies to assess the site potential while establishing vineyards; it is necessary to conduct the planning of the site in order to level microeminences and microlowerings to prevent further development of water erosion. The most effective method of combating soil erosion is the use of grass cover, which prevents almost completely the development of erosive processes.

Key words: soil, degradation, watererosion, vineyard.

INTRODUCTION

Erosion (derived from the Latin word erosio – erosion) is the destruction of the earth's crust (rocks and soils) by surface water flows and wind, including the tear and the removal of material debris and their following deposition. The term "water erosion of soil" means the corrupting influence of fluid melted, rain and rainstorm - water on the soil and beddings [1].

The speed of erosion development is divided into normal and accelerated. The normal speed is always observed when there is any pronounced outlet,the soil formation proceeds more slowly and does not lead to noticeable changes of the level and the shape of the earth's surface. The accelerated speed is faster than the process of soil formation, it leads to soil degradation and is accompanied by a marked change of the relief. According to reasons they distinguish natural and anthropogenic erosion. It should be noted that anthropogenic erosion is not always accelerated, and vice versa. Water erosion is divided into raindrop-, sheet-, and linear erosion.

Raindrop erosion is the soil destruction by means of raindrops hitting. Structural elements (clumps) of soil are collapsed by the action of the kinetic energy of raindrops and scattered wide apart. On the slopes the downward displacement of the soil occurs over a great distance. Particles of soil, falling, come to the waterfilm, which promotes their further displacement [2].

Sheet erosion. Sheet (surface) erosion is understood as a uniform wash-out of material off the slopes, leading to their flattening. To some degree of abstraction it is imagined that this process is produced by a continuous moving layer of water, but in fact it is produced by a network of small temporary water flows. Surface erosion leads to the formation of washed and alluvial soils, and on a larger scale — deluvial deposits.

Linear erosion. Unlike the sheet erosion, the linear erosion occurs on small areas of the surface and leads to the dissection of the earth's surface and the formation of various erosion forms (rain channels, gullies, narrows, valleys). This also includes the river erosion, produced by constant streams of water. Washed material usually deposits in the form of debris cones and produces proluvial sediments.

The fight against soil erosion is one of the most important government tasks in the system of measures aimed the preservation, restoration and transformation of the landscape. The solution of this problem is only possible by means of carrying out the complex of interrelated activities, the main ones are: organizational, economic, agronomic, forestry-and-land-reclamation and waterworks. All these activities are directed to the regulation of runoff, protection of soil from flushing, erosion, alluvium, the prevention and cessation of wind erosion, restoration and increase of fertility of eroded soils and their involvement in rational economic use [3].

The **aim** of our work is the investigation of the process of the development of water erosion of soil on vineyards.

Objects and methods of research. The study of technological processes of soil treatment on the vineyards was carried out according to available literature, patents, test reports. While conducting a route-field research we followed the all-Union manual of soil inspection and the development of large scale soil maps. [4].

RESULTS AND DISCUSSION

The main factors of erosion development are: climatic conditions (the quantity and character of precipitation, extreme temperature changes), topographic (rugged relief, the shape and steepness of a slope, depth of local bases of erosion), geological (the diversity of parent rocks with their different resistance to erosion), soil (heterogeneity of the soil cover with different resistance to washout, erosion and blowing-out) and biological (species and quantitative structure of vegetation. It is necessary to add the size and level of human activities.

Great contribution to the science of soil erosion had been made by the founder of Russian soil science V. V. Dokuchaev. His works which were further developed in the works of P. A. Kostychev, G. N. Vysotsky and others, formed the basis of the modern theory of the development of erosion processes and its control [5].

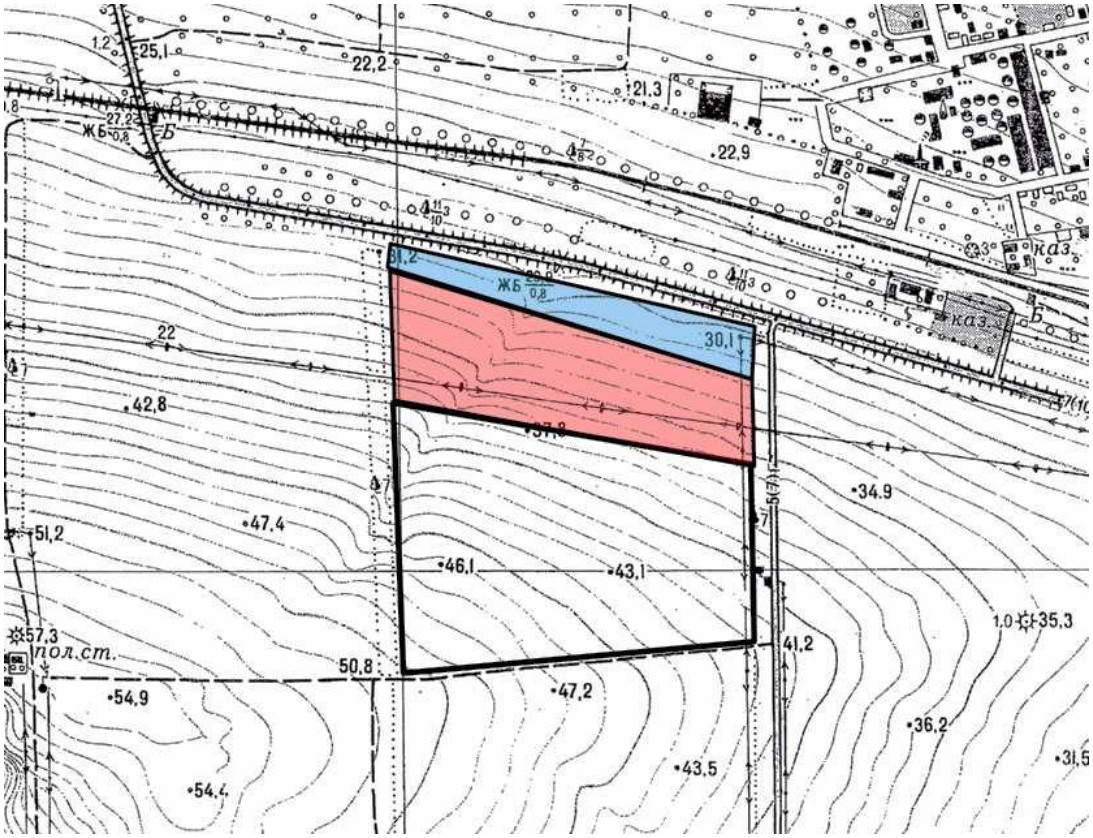
In the book "Our Steppes Now and Then" V. V. Dokuchaev wrote: "a huge part of the steppe (in some places the whole one) has lost its natural cover. Arable lands occupying about 90% of the total area in many places now and having destroyed granular structure which is characteristic structure of black soil and the most favorable for the detention of soil moisture made it an easy possession of the wind and leaves it for washing-away activity of different waters."

During the cultivating of vineyards, one of the key reasons of the development of water erosion is the level of economic activity, namely the system of tillage. Grapes refer to intensive crop with a very high degree of exploitation of soil fertility. Prolonged cultivation of grapes in one place leads to violation of the existing level of soil fertility due to the alienation of part of the vegetable crop production, the removal of plant food by the phytomass of the bush – leaves, shoots,which are moved off during top removal and pruning.

When keeping the soil by the type of black fallow many multiple energy- saturated mechanized operations are foreseen for conducting in every aisle of grape plantings. The aim of these operations is loosening of the top layer of soil, that leads to deterioration of the structure, the destruction and dissipation of structural units of the arable layer of soil with a strong overstraining of the underlying horizons. In the process of compaction of underlying horizons of soil not only the total volume of pores decreases but their size decreases, too, compacted soil is hardly permeable to water, while the sprayed soil arable layer cannot withstand the effects of wind and water flows [6].

The increased mechanical action on the soil is already rendered at the stage of laying a young vineyard. When lifting plantage the upper fertile layer moves downward, and the underlying horizons are transferred to the surface. As a result, the soil which contains very little organic material accurs on the surface, and therefore it is less able to withstand the effects of water flows, what results in progression of water erosion.

The relief of the site is one of the key factors contributing the formation of aboveground runoff and the degree of development of the degradation processes. A small longitudinal decrease (beams) on a relatively flat slope contribute to the concentration of water flows and further development of gullies. Even with good permeability and high water resistance of the soil there may be cases when heavy rainfall of downpour nature leads to the formation of runoff and soil loss. The relief of the studied area presents a gentle slope of the north-eastern exposition slope of 2-3° (Fig. 1).



Conventional signs:

The territory of the studied area

The zone of maximum soil loss

The area of soil overwash

Fig. 1. *Topographic map of the studied area*

In the southern part the site has more gentle slope, in the middle part (shaded in red colour) the nature of the slope becomes steeper, and at the bottom of the slope (the northern part, shaded in blue) the nature of the slope becomes flat again.

According to the above topographic map of 1973 there is one small ravine on the studied site. Nowerdays, this beam has become several times bigger, and the new ones have appeared. During the route-field research calculations of the formed soil depressions have been made and the approximate amount of washed-out soil has been calculated (tab. 1).

According to the data in table 1 it is shown that the bulk of the soil is washed away from intercellular roads, only a small amount of gullies passes across rows. The volume of the washed- away soil is 1247 m3, which corresponds to 1,500 tons of soil.

The dynamic development of the water erosion process on vineyards with horizontal rows is seen by us as follows. A continuous water flow caused by heavy rain makes a small gully, 100 cm wide and 7 cm deep, on the intercellular road. In the rows there are not such washouts as a rule, because the cultivation forms the shaft, and there is microdecrease between rows, which serves as a barrier to the movement of

water flow. Further cultivations fill up a gully in the process of removal of the soil from the aisles into the intercellular road. The following heavy downpour leads to the formation of deeper and wider gully. The process is repeated: the cultivations level the gully, the beam is growing (Fig. 2, 3).

In fact, the intensity of the process of development of water erosion depends on many factors, and their combinations.

To confirm the simulated dynamic development process of water erosion we present photos (Fig. 4, 5).

Table 1. Calculation of the amount of washed-out soil on vineyards located on the slopes of 3-5°C with transverse position of the rows, the field area is 24 hectares (ha)

Location of gully	Width, m	Depth, m	Length, m	Cross sectional area, m^2	Volume, m^3	Square of field, occupied by gullies, m^2
Intercellular gully	7	0,25	102	0,875	89,25	714
	8	0,50	68	2,000	136,00	544
Intercellular gully	6	0,30	68	0,900	61,20	408
	11	0,40	68	2,200	149,60	748
	11	0,45	34	2,475	84,15	374
	7	0,35	68	1,225	83,30	476
	6	0,25	15	0,750	11,25	90
Intercellular gully	2	0,10	68	0,100	6,80	136
	8	0,30	68	1,200	81,60	544
	9	0,36	34	1,620	55,08	306
	9	0,40	34	1,800	61,20	306
	11	0,55	64	3,025	193,60	704
	10	0,50	34	2,500	85,00	340
	10	0,30	12	1,500	18,00	120
Gully across rows	6	0,20	40	0,600	24,00	240
	7	0,35	34	1,225	41,65	238
	6	0,25	34	0,750	25,50	204
Gully across rows	2	0,10	34	0,100	3,40	68
	3	0,25	34	0,375	12,75	102
	4	0,35	34	0,700	23,80	136
Total			997		1247	6798
Per cent of gully square in comparison with total field square						3%

Fig. 2. *The soil Level during the development of water erosion on the transverse profile of intercellular road*

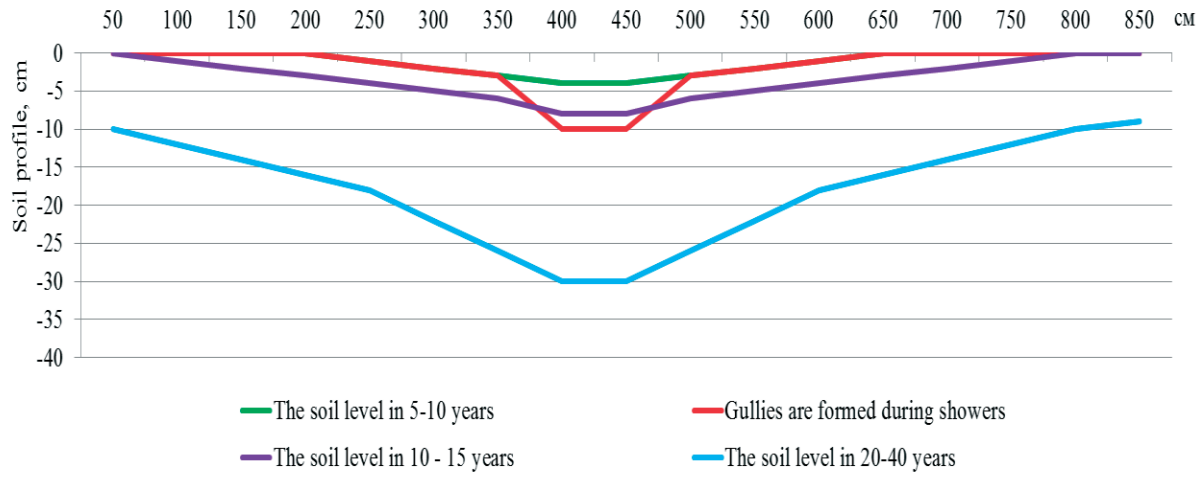


Fig. 3. *Ground level during the development of water erosion on the transverse profile of intercellular roads in the process of cultivation of vineyards within 20-40 years*

Fig. 4. *Development of erosion processes of soil on intercellular roads oin the vineyards, 2-4 year of vegetation*

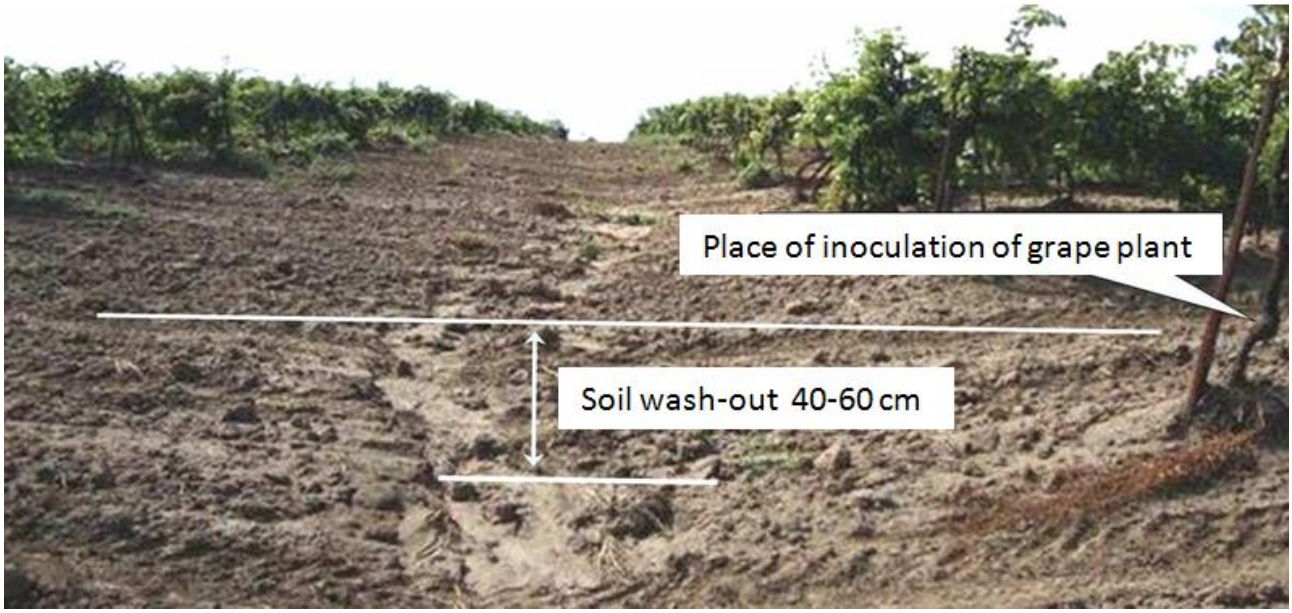


Fig. 5. *Effects of erosion on soil intercellular roads on vineyards in 20-40 years*

During the route-field research it is noted that soils of light granulometric structure with a small amount of organic substance in them are more subject to water erosion. It is also found that water erosion can occur on slopes ranging from 1°. The steeper the slope, the more intensive is the washing-out. One of the solutions of this problem is a joint scientifically proved application of complex measures for prevention of water and wind erosion.

The formation of aboveground aqueous runoff depends on soil permeability. The permeability is connected with the compaction caused by natural shrinkage and because of the numerous passes of agricultural equipment on the same track. Carrying out plowing and cultivations leads to the formation of a plow shoe. In this connection it is useful to use the technique with a low soil specific pressure (catarpillars, wheeled tractors with a special low-pressure tyres).

Direct destruction of soil aggregates and their further washing-out down the slope is connected with water durability of structural units.

Reducing water durability of structural units of the soil is directly connected with the organic substance (humus); mechanical loosening accelerates the process of destruction of organic substances, resulting in a reduction of its quantity. In connection with this information it is necessary to apply organic fertilizers which will provide the reserves of basic elements of food, increase water durability and soil conditioning.

A small longitudinal declivity (beams) on a relatively flat slope contribute to the concentration of water flows and further development of ravines. Even with good permeability and water durability of the soil there may be cases when heavy rains lead to the formation of aboveground runoff and soil loss.

While establishing of vineyards it is necessary to conduct soil studies to assess the site potential and degrees of susceptibility to its development of water erosion; if possible to conduct the planning of the site, in order to neutralize microhights and micro-low-lyings that will prevent further development of water erosion in these places. If all of these listed methods have not brought the expected results and there is water erosion from year to year on the field the most effective method of all invented by the mankind methods of preventing and fighting against soil erosion, is imitation of natural ways to protect the soil. One of these methods is the use of grass cover, which almost completely prevents the development of erosive processes.

The role of plants and animals is in their huge geochemical work. In the system “soil-plant” there is a constant biological cycle of substances, in which plants play an active role. The beginning of soil formation is always connected with the settlement of organisms on the mineral substrate. The soil is inhabited by representatives of all the four kingdoms of nature: plants, animals, fungi, Monera (micro – organisms: bacteria, actinomycetes and blue-green algae) [7].

Vegetation determines the amount, character and containing of the organic debris used as basic material for the formation of humus that accumulates the ash elements and nitrogen in the upper soil horizons. Excreting carbon dioxide and organic acids in the process of growth and development, vegetation contributes to the decomposition of minerals, and participating in the formation of soil structure, it influences actively the water-air structure of soil. Vegetation mechanically strengthens the upper part of the soil profile and thereby prevents its erosion.

Animals dwelling in the soil (worms, burrowing animals, insects, protozoa) are also involved in soil formation. Worms in the process of life let organic debris and soil pass through the digestive tract. It gets soaked with their secretions, takes the form of a cemented lumps and becomes structural. Thus worms improve soil physical characteristics. Burrowing animals (i.e.suslics, moles, etc.) mix the soil, changing its structure and affect the formation of micro-relief of the area. [7].

The experience of European growers shows that on vineyards it is necessary to apply a mixture of herbs. The composition of the mixtures should include both annual and perennial grasses.It is also essential to use winter and perennial plants. They continue to vegetate in the winter time, when the main crop (grapes) is in an anabiosis stage. [8]. The negative feature of the use of herbs on the rows of the vineyard is a strong drying of the soil, which ultimately affects the crop yield of grapes.

Studies show that to prevent water erosion it is enough to sow grass as strips over a row or two rows, which will affect the drying of the soil to the less degree and will be an effective tool in the fight against water erosion. If a strong water deficit exists, it is necessary to sow the grass at least on that part of the area on which the flow of water passes directly and causes soil erosion. According to our calculations, this area varies from 10 to 15 % of the field.

CONCLUSIONS

The development of water erosion is the result of complex influence of factors, the main of which are: climate (the quantity and nature of precipitation, extreme temperature changes), topographical (the crossed relief, the shape and steepness of the slope, the depth of local bases of erosion), geological (the diversity of soil formers with different resistance to erosion), soil (heterogeneity of the soil cover with different resistance to washout, erosion and blowing-out), biological (species and quantitative composition of vegetation The level of the human economic activity must be added to the factors above. In the cultivation of vineyards soil degradation is connected with low water durability of soil aggregates, which in turn is directly related with the content of organic material in the soil, and the reduction of organic material in the soil is connected with the increased mechanical loading, biological removal and the absence of organic fertilizers.

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