SOIL EROSION CONTROL IN THE MOLDAVIAN PLATEAU OF EASTERN ROMANIA

ION IONITA AND DUMITRU NISTOR

Abstract: The Moldavian Plateau, located in the Eastern Romania and extending about 27,000 square kilometers, is considered as the broadest and most typical plateau of Romania. The natural vegetation cover was drastically changed by men during the last two centuries. At present, the cropland covers 57 % and forest 15 % respectively. By 1970, the main agricultural feature consisted in the extension of the up and down hill farming, which resulted in the land degradation peak during '60s.

A proper soil erosion control came out between 1970-1990. During this period, proper actions were undertaken to implement conservation practices and tillage. About two thirds of the land with erosion potential were under different conservation systems (contour farming, stripcropping, buffers, terracing, dam structures, etc.). Through the legislation promulgated after 1990, the traditional up and down hill farming is prevailing again and, therefore, soil erosion and reservoir sedimentation represent the most important environmental threat.

Key words: Soil erosion, Conservation practices.

1. Introduction

The territory of Romania, which lies in the South - Eastern Europe, encompasses 237,500 square kilometers. About 43% (6.4 million hectares) of the total Romanian agricultural land is located on slopes and it is subjected to soil erosion and associated processes.

The Moldavian Plateau, located in the Eastern Romania and extending about 27,000 square kilometers is considered as the broadest and most typical plateau of Romania (Bacauanu et al., 1980). Clayey-sandy Miocene-Pliocene deposits with a gentle gradient of 7-8 m/km NW-SE has outcropped from sedimentary substratum as a result of erosion. Shallow intercalations of sarmatian sandstone and limestone can sometimes be identified. This plateau is situated between 32 and 564 m above sea level. The climate is temperate continental with a mean annual temperature of 8-9.8 ^{o}C and precipitation of 460-600 mm. Although men drastically changed the natural vegetation cover, two natural zones have been distinguished: the forested area that occupies the higher parts of the plateau and the area under the combination of the silvosteppe and steppe. Slopes within the plateau are mantled by mollisols and forest soils.

The principal feature of the old traditional agriculture in the study area consists primarily of an up-and-down hill farming system under small plots that speeds the erosion rates.

Since 1960, by improving our basic understanding on soil erosion and best management practices it was possible to improve and implement erosion control practices on about two thirds of the land subjected to soil erosion.

From 1990, the decline in extension of conservation practices is attributed to a particular government policy and the cropping picture of the old traditional agriculture is on the screen again.

2. Materials and Methods

Various studies were conducted to meet different needs for action: describing properties of the eroded soils, understanding fundamental processes of hydrology, improving and implementing best management practices. Research plots were constructed in some locations to determine soil and water losses caused by water erosion. Those plots that were set-up in 1970 at Perieni-Barlad are still in use. Long-term field measurements regarding erosion/deposition rates are of value.

In addition, a lot of information is included in this paper by reviewing of literature.

3. Results

3.1. Study of the soil erosion

According to the 1980 Inventory of the Institute for Geodesy, Photogrammetry, Mapping and Land Planning, the agricultural land from Moldavian Plateau averaged about 77 percent (2.1 million hectares) of the total. The area with erosion potential is 1.260 million hectares that means almost half of the total, and needs treatment of some type. Nationwide, the rate of erosion presents a distinct interest, too. For the entire territory of Romania Motoc M. published a study in 1983. The peak erosion rate is 30-45 t/ha/year and occurred in the Curvature Subcarpathians. Then, the Moldavian Plateau follows with high values of 10-30 t/ha/year. Plateauwide total erosion has been estimated at 25.4 million tons/yr. Most of the sediment comes from agricultural land (21.6 million t/yr.). Some 38% of this latter total results from erosion that is taking place in arable and 33% comes from pasture. The unproductive land is another major sediment source.

Hydrological studies on dispersed overland flow, rillflow, and ephemeral streamflow that cause gully formation have been conducted. By processing long-term data Motoc M. (1960, 1983) elaborated a proper quantitative model to evaluate the soil loss through sheet-rill erosion. It is by the same type as Wischmeier's model. The Hi15 indicator proposed by Stanescu P. et al. (1969), where H is amount of precipitation and i15 the intensity of the rainstorm nucleus on a 15-minute duration was of value in running this model. That index for rainfall aggressiveness is easier to be calculated and has similar performance as the rainfall erosion index proposed by Wischmeier W.H. (1959) for the USA.

Data collected at Perieni Research Station over 25-year period allowed to Motoc M. and Ionita I. (1983) to establish a rainfall and vegetation index for singly storms occurring at short intervals. Field research carried out by Motoc M. and Ouatu O. (1985) on rill development shows the two types of flow patterns: one during rill formation and the other one stable when turbidity is reduced by 8-10 times. Stanescu P. (1979) also elaborated a model for estimating the sediment concentration of overland flow.

Motoc M., Ionita I. and Nistor D., (1998) estimated the erosion and climatic risk at the wheat and maize crops in the Moldavian Plateau related to sheet-rill erosion. Figure 1 illustrates the distribution of soil loss from 1970 to 1994 under the check plot of continuous fallow. Within this erosion cycle, there are obviously two erosion peaks as follows: the first in 1975 and the latter around 1988. Popa N. (2000) has successfully implemented the WEPP (Water Erosion Prediction Project) under the local conditions of the Southern Moldavian Plateau.

As to the concentrated flows and gully development, it is of particular interest research carried out by Ionita I. (1998) in the Moldavian Plateau. Long-term field measurements allowed establishing the patterns of gully evolution and indicating the gully head advance, the areal gully growth, and quantifying material delivered by gullies. The decreasing trend of gullying over the period 1960-1990 is generally as the rainfall pattern but it was subsequently influenced by the increasing effect of conservation practices.

Within approach the concern shifted from descriptive to quantitative models to assess soil loss by gullying (Motoc. M. et al., 1979; Radoane Maria et al., 1995; Ionita I., 1998).

Pujina D. (1997) focussed the attention on landslide processes and the appropriate control methods. Significant contributions on land treatments at basin scale with agricultural use are attributed to Baloiu V. (1980).

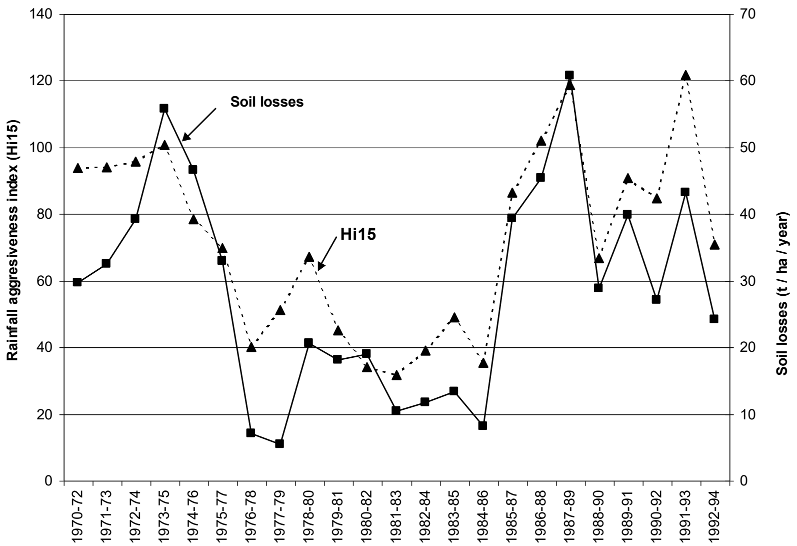

Figure 1 Rainfall aggressiveness and soil losses under continuous fallow for the period 1970-1994 (moving average by three years)

3.2. Implementing conservation practices

The strategy of soil conservation in Romania had in view that the vegetation is generally the most effective means of water erosion control while the constructions are an auxiliary component.

Based on long-term experience gained and research data collecting, the following erosion control practices were recommended: contouring, strip cropping, buffer strip cropping, terracing, using crop residues, establishing permanent vegetation in eroded areas, stabilising gullies with suitable structure, subsurface drainage, land modelling, etc.

The bench terraces, which reduce land slope, were first time constructed at Perieni Research Station by adapting the method used in the United States. The design of a terrace system involves the proper spacing and location of terraces. Most of them were built from the upper side only (Havreliuc A. and Ouatu O., 1971). Later, during 1980s they were constructed from the lower side, especially (Roman I. et al., 1988). The two major types of bench terraces are level terrace and the graded terrace.

In 1954, the Control Research Station for Soil Erosion Control (CRSSEC) was set-up at Perieni, near Barlad City, in the Moldavian Plateau of Eastern Romania. Its major purposes were to enhance the study of erosion processes, to elaborate prescriptions for land planning, to implement conservation tillage and practices and to be fully effective in applying technical training. Through the time, the territory of CRSSEC Perieni of 2,160 ha encompassed three types of small watersheds as representative scale models for soil and water conservation on sloping land. Shifting analysis toward the crop yields over the time, Table 1 is indicating a remarkable increase of yield levels after implementing conservation measures.

Table 1 - Crop yields in Gheltag watershed from Perieni Station

Crop	Crop yields - kg/ha			
	Before land treatment	After implementing conservation practices		
		Strip cropping	Buffer strip cropping	Terraces
Wheat	800-1500	3150-5740	3210-5712	3591-5575
Corn	800-1200	6340-8500	6240-8114	6112-8014
Peas	400- 800		1350-2325	1120-1450

In the implementing of conservation practices the Designing Section for Soil Erosion Control within the Institute for Studies and Designing of Land Reclamations - Bucharest and every county office for land treatments were deeply involved.

4. Discussion

Until 1960, the traditional system on sloping agricultural land in Romania consisted in up-and-down hill farming. Some 85 percent of this land were excessively split in small plots, each of less than one hectare in size. The tillage operations were made by animal traction, by hand and there was no any input of chemical fertiliser. If adding the local natural conditions a high risk of erosion was resulting. Excepting local areas, there was no concern about soil erosion threat and a minimum awareness of conservation practices.

After the Second World War despite some complicating factors, scientists have approached the problem of assessing the erosion impact on soil productivity.

Since 1960, the awareness of soil erosion and adopting conservation practices has been progressively increased because it was the "right thing to do". The area under those small plots was turned into co-operative farms. About 15 percent of the agricultural land, which belonged to proper farmers regarding the ownership size, were changed in state farms. Practising conservation involves changes, all of which have costs. Nationwide, the first important objective was to perform ploughing on or nearly on the contour as one of the oldest and simplest conservation tillage. Then, based on the experience gained by CRSSEC Perieni, in each hilly county was set-up a representative farm under conservation practices.

By the end of 1989 as much 0.9 million hectares, representing 71 percent of the agricultural land with erosion potential in the Moldavian Tableland were adequately protected against erosion. In some regions, the approach of best management practices resulted in appropriate erosion control at county scale such as: Vaslui, Bacau, Galati, Iasi. Annual expenditure in conservation projects was state investment as unreimbursable funding. It should be mentioned that over the period 1960-1975 the main concern was focussed on dam structures within drainage network, especially on gullies. Between 1975-1990, the priority was given to implement proper conservation practices on slopes.

The new landed property law no. 18/1991 includes two provisions which are not of a nature to create conditions for the extension of conservation measures. One of these stipulates that the land reallotment has to be usually done on the old sites. This means in most cases that the plots will be up-and-down the hill led out. The second is referring to the successors' right up to the fourth degree! That enables an increasing rate of land splitting which is higher than that before the Second World War. Moreover, it was just promulgated another law, no.1/2000, which has in view the forestland splitting on a large area for private ownership.

The major effect of the above-mentioned laws is revival of the old traditional agricultural system. So, the up-and-down hill farming is on the screen again. Another problem for the last decade is that the state ceased funding for soil erosion control and this investment does not represent a priority for landowners.

Therefore, it might be concluded that the real activity of soil erosion control in Romania extended over 30-year period, from 1960 to 1990, but mainly between 1970-1990.

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CONSERVATION TILLAGE ON SLOPING LAND

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Abstract. This paper aims to provide a contribution corn farming on slopes by new tillage methods. The basics of these methods is to leave sufficient crop residue on the soil surface to significantly reduce soil erosion and, which involve less energy than conventional tillage.

Over the period 1992-1998 different tillage treatments were considered. During 7-year experiment the influence of soil protecting methods on, soil and water losses, nutrient losses and corn yield was studied, as well.

Partial soil tillage and leaving about 50 percent of wheat stubble (chisel) on the soil surface resulted in decreasing soil losses by 28 percent. Direct corn planting in wheat stubble reduced soil losses up to 68 percent versus conventional farming.

Key words: Conservation tillage, soil and water losses, corn yield.

Introduction

Soil erosion represents on long-term the most severe threat for mankind and the environment. The amount of sediments with a high percent of nutrients, delivered from the agricultural land and carried by rivers in seas and oceans, increased from 9 billion tons/yr before intensive soil cultivation to 24 billions tons/yr (2). Erosion has played, and continuous to play, a major role in gradual impairing the soil productivity and has a strong impact on dam structures, roads, economic objectives and others. Damages from sedimentation tend to be cumulative.

So far as known, of a total agricultural area of 14.96 million hectares in Romania, around 6.37 million hectares (43%) are susceptible to water erosion of varying degree and associated processes. Of this area, nearly 2.6 million hectares are used for cropland (arableland). The average amount of the annual total erosion is 126 million tons of which 106.6 million tons are delivered by agricultural lands. Surface erosion (sheet-rill-erosion) is the main contributor to the total erosion because the annual rate of such induced soil loss is estimated to 61.8 million tons (3).

Material and method

Over the period 1992-1999 the following factors were considered:

Factor A: keeping the soil surface under mulch

a_0 = unprotected (stubble incorporated by ploughing, conventional);

a_1 = partly protected (chisel);

a_2 = protected under wheat stubble (no-till).

Factor B: seedbed preparation

b_0 = by rotary tiller (broadcast tillage);

b_1 = direct planting (strip tillage).

The experimental site lies on mollisols (cambic chernozem), moderately eroded, and the slope is 10-12 percents. Within the cultivated topsoil the nutrient content is as follows: 2.33% organic matter, 0.105% total nitrogen, 0.039% total phosphorus and 80.2 ppm of the same layer is around 23%.

The study was initiated inside a three-year crop rotation of peas-winter wheat-corn. Under plots planted to wheat and peas the conventional tillage was applied. An amount of 75-80 kg phosphorous a.s./ha and 110-120 kg nitrogen a.s./ha has been used by chemical fertiliser. The experiment was set up according to the split-plots method in four repetitions.

Results and discusions

Influence of tillage on water and soil losses

An experimental site consisting in standards runoff plots under different protecting methods entered into operation in Tarina catchement. Six plots are used, all with a tillage history, fully instrumented for measuring runoff and soil loss. The plots are 50 m by 8 m (400 sq.m) and allow mechanical operation of the tillage. Seeding and tillage are perpendicular to the 13 percent slope.

Based on long-term data, illustrated in Table 1, it might be concluded that tillage leaving a protective cover of previous crop residue on the surface represent a new opportunity to control soil erosion (4). Substitution of ploughing (conventional tillage) by chisel planting, without turning over the surface around 50 percent of previous crop residue, resulted in soil losses under the tolerable limit of 6-8 t/ha, annually.

By renunciation to ploughing shifting to a particular drill for direct corn planting in wheat stubble soil losses were reduced by 70-80 percent. Results obtained within this experimental site allowed estimating the runoff ratios for each new treatment under corn as shown in Table 2. Thus, values of the runoff ratios ranged from 0.28 under conventional tillage and 0.16 where no-till was used. These date are of interest to design of the conservation practices, assessing and predicting soil erosion, as well.

Table 1 Influence of tillage on soil losses (1992-1996)

Base tillage	Erosion (t/ha)					
	1992	1993	1994	1995	1996	Average
Continuous fallow	18.2	26.2	-	19.4	23.3	18.4
Unprotected (Plowed, check plot)	4.7	17.1	0.8	8.0	13.8	8.9
Partly protected (chisel)	3.3	24.4	-	0.6	3.7	6.4
Protected in wheat stubble (No-till)	2.7	7.2	-	0.8	2.1	2.6

Influence of the soil-protecting methods on nutrient losses

Within the above mentioned, experimental site the nutrient losses have been determined for the first time in Romania under non-conventional tillage. Also, a great concern was focused to establish the rate of nutrients losses through water and soil, respectively (see Table 3). In average, over the period of study, the organic matter varied between 58.9 kg/ha under no-till plot and 407.0 kg/ha in the check plot-continuous fallow. In comparison with the chisel planting reduces the organic matter loss by over 30 percent and direct corn planting in wheat stubble reduces that value by 75 percent.
Nitrogen losses, in average, ranged from 3.2 to 20.3 kg/ha. In the plot under chiselling the losses were lowered by 50 percent and in no-till plot by 77 percent that of those occurred conventional tillage. About 80-95% of the average nitrogen losses is associated to sediment transport and the rest of minor importance through runoff.

The available phosphorous losses were low, generally, and ranged from 0.9 to 5.2 kg/ha. If compared with the conventional tillage outputs, the no-till treatment resulted in reducing these losses by 80 percent. Of these, over 80 are associated with the sediment transport.

As regards potassium losses the situation is almost similar with that of phosphorous excepting the higher contribution through runoff of 20-40 percent, in the formation of these losses.

Influence of the soil-protecting methods on corn yield

By analysing the average corn yields for the period 1992-1998 it is possible to notice that there were not occurred significant differences between tillage treatments, as shown in Table 4. The highest yield of 5,030 kg/ha was obtained under chisel planting that confirms the existing world results, especially from U.S.A.

Table 2 Influence of tillage on runoff over the period 1992-1996

Tillage	Annual rainfall and runoff (cu.m/ha)												Runoff ratio
	1992		1993		1994		1995		1996		Average		
	Rain*	Runoff	Rain*	Runoff	Rain*	Runoff	Rain*	Runoff	Rain*	Runoff	Rain*	Runoff	
Continuous fallow	563	160.5	1595	369	-	-	788	154.0	1175	476.0	824.2	231.9	0.28
Unprotected (Plowed, Check)	563	197	1595	384	309	32.5	609	115.2	1175	401.7	850.2	226.1	0.26
Partly protected (chisel)	337	52.0	1125	379	-	-	268	17.0	942	120.2	534.3	101.6	0.19
Protected in wheat stubble (No-till)	337	61.0	793	180	-	-	268	22.0	753	78.5	430.2	68.4	0.16

*Rainfall that caused runoff

Table 3 Influence of tillage on the mean nutrient losses for the period 1992-1996

Tillage	Humus Kg/ha	Nitrogen loss			P2O5 loss			K2O loss		
		Total Kg/ha	Water %	Soil %	Total Kg/ha	Water %	Soil %	Total Kg/ha	Water %	Soil %
Continuous fallow	407.0	20.3	4.6	95.4	5.2	10.2	89.8	4.7	20.8	79.2
Unprotected (Plowed, Check)	231.6	13.4	19.1	80.9	4.5	13.7	86.3	3.8	43.3	56.7
Partly protected (chisel)	148.6	6.8	8.7	91.3	1.6	10.5	89.5	1.6	32.2	67.8
Protected in wheat stubble (No-till)	58.9	3.2	10.2	89.8	0.9	15.3	84.7	0.7	38.3	61.7

Table 4 Influence of base tillage on corn yield (1992-1998)

Base tillage	Corn yield (kg/ha)							Average		Differ.	Sig n.
	1992	1993	1994	1995	1996	1997	1998	Kg/ha	%	Kg/ha	
Unprotected (Plowed, Check)	4630	7220	3030	1340	6170	6910	4750	4860	100.0	-	-
Partly protected (chisel)	4490	6780	3030	2430	6530	7270	4700	5030	103.5	+170	-
Protected in wheat stubble (No-till)	4010	6050	2640	3250	6680	7230	4420	4320	88.9	-540	-

LD 5% = 1050 kg/ha

Table 5 Influence of seedbed preparation methods on corn yield (1992-1998)

Seedbed preparation	Corn yield (kg/ha)							Average		Differ.	Sign .
	1992	1993	1994	1995	1996	1997	1998	Kg/ha	%	Kg/ha	
Rotary tiller (broadcast)	4510	7080	3080	2420	7400	7120	4060	5090	100.0	-	-
Planted in stubble (strip)	4240	6290	2720	2260	5520	7150	5190	4770	93.7	-320	-

LD 5% = 630 kg/ha

In most experimental years, there was a tiny difference between the two treatment methods of seedbed preparation. Table 5 illustrates that during the 7-year period an average variation of 320 kg/ha in the favour of the broad tillage occurred but this was not significant. It is of a great interest to underline the protection offered by the undisturbed wheat stubble between corn rows to the sloping land.

Conclusions

- Results obtained during the 7-year experimental period were influenced by the climatic conditions, especially the rainfall, and changes induced by the studied factors, as well.
- Partial processing of the soil and leaving about 50 percent of wheat stubble on the surface (chisel) resulted in reducing soil losses by 28 percent. Direct corn planting in stubble wheat reduced soil loss by 68 percent than in conventional tillage.
- The corresponding runoff ratios are as follows: 0.28 under continuous fallow, 0.26 in conventional tillage, 0.19 under chisel and 0.16 for no-till.
- Conservation tillage systems also reduce nutrient losses. Of these, over 93 percent at organic matter, over 83 percent at phosphorous and over 60 percent at potassium are lost through eroded soil.
- Corn yield was not influenced significantly by the different soil-protecting methods.
- Results obtained during a 7-year period confirm that conservation tillage systems represent a viable and promising alternative for soil conservation and protection of the Romania environment.

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THE QUALITY OF UNDERGROUND WATER AS DRINKING WATER SOURCE UNDER THE IMPACT OF SOIL EROSION

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Abstract

The "Craving for water" of the humanity or the perspective of "water crises" are terms, which appear more and more frequently in prognosis studies of different international and national organisms. The causes of these situations are included in characteristics of waters like natural resources.

In 1995, I.N.M.H. Bucharest appreciated the Romanian water resources, as follows:

- own rivers – 37 billion cm/year;
- underground sources (evaluated) – 11.5 billion cm/year but only 9.0 billion cm/year can be technically and economically used.

Of the underground water sources - 4.0 billion cm/year are provided by surface water- bearing stratum (the depth of exploitable water-bearing is under 50 m), and 5,0 billion cm/year provided by big depth water bearing stratum (the depth of exploitable water bearing more then 50 m).

The areas in our country that lack underground water sources, as shown by the INMH study, are located in central part of Dobrogea, Transilvanian and Moldavian Tableland.

Underground water may be a good source of drinking water, as a result of natural clearing in the soil, especially in the first 90-120 cm from surface of soil.

The pollution sources of underground water could be:

- diffuse, when pollution factors infiltrated and percolated the soil in large areas, measuring several hectares
- concentrated, when pollution factors are punctually infiltrating and percolating through the soil, the affected surface being up to a few hectares in size

Starting with 1997, the Central Research Station for Soil Erosion Control Perieni – Bârlad supervised the water quality, under the impact of soil erosion, in nineteen wells (as sources of drinking water) which are situated the Perieni area along a cross section through a hill. There have been made determinations of the pH, turbidity, nitrogen, phosphorus, sodium, potassium and chlorine.

The results of the analysis that have been carried through in a period of four years led to the following conclusions:

- the content of analysed elements is fluctuating mainly with the location of wells on the hill and only in the wells located on the plateau it is fluctuating with the seasons:
  - a larger content of nitrogen (28 % - 19,2 %) and potassium (18 to 12 times) has been determined, during all seasons, on hill slope and valley area, in comparison with plateau area;
  - the content of analysed elements, from water wells located on the plateau, are framed in the limits of STAS for locale source category, nitrates are excepted because their concentration is higher with 9-299 ppm in spring, 48,9 - 304,2 ppm in summer and with 46,8 - 312,6 ppm in autumn in comparison with maximum values from STAS;
  - in all seasons the wells located on slope and valley areas do not fit the requirements for "local source of drinking water"; the content of analysed elements exceeds

the STAS limits: nitrogen with 71,1 - 854,8 ppm, potassium with 1,4 - 32,8 ppm and chlorine with 46,4 - 114,2 ppm

Keywords: water quality, erosion, sedimentation

Introduction

The "Craving for water" of the humanity or the perspective of a "water crises" are terms, which appear more and more frequently in prognosis studies of different international and national organisms. The causes of this situation derive from the characteristics of water seen as a natural resource*: it is limited regarding the disposable volume aspects; non-uniform distribution in space and time; relatively limited possibilities from the technical and economical point of view of its exploitation;*

In 1995, I.N.M.H. Bucharest appreciated the Romanian water resources as follows:

- own rivers – 37 billions cm/year;
- underground sources (evaluated) – 11.5 billion cm/year but only 9.0 billion cm/year can be technically and economically utilised.

Of the underground water sources - 4.0 billion cm/year are provided by the surface water-bearing stratum (the depth of exploitable water bearing is under 50 m), and 5,0 billion cm/year provided by big depth water- bearing stratum (the depth of exploitable water bearing more then 50 m).

The areas in our country that lack underground water sources, as shown by the I.N.M.H. study, are located in the central part of Dobrogea, Transilvanian and Moldavian Tableland.

Water sources, through their characteristics, are an important factor that should be protected by the human community. The European Community has very strict regulations regarding environment preservation, and it adopted, on the 27th of February 1986, a document that contains direct and clear principles for community actions in this field

The fundamental objectives of this activity are the following:

- preservation, protection and improvement of the quality of environment;
- contributions to persons health care;
- a wary and reasonable insurance of environment resources.

The problem of the quality of water, as an important environment factor, is included in the frame of this activity, covering all this three fundamental objectives of environmental protection, as a constitutive and essential part of it.

Underground water can be a very good source of drinking water, because of the natural cleaning phenomenon that takes place at soil level, especially in the first 0.90 – 1.20 m from soil surface.

The sources of water pollution can be:

- diffuse, when the pollution factor is infiltrating and percolating the soil in large areas measuring from several hectares upward;
- concentrated, then the pollution factors are punctually infiltrating and percolating the soil, the surface affected being up to a few hectares in size.

The sources for diffuse pollution include:

- water from precipitations that fall and wash the soil surface training different polluting elements from warehouse garbage, industrial residues, sterile, a.o.;
- water from precipitations that infiltrates and percolates the farming land, training the different polluting elements from fertilisers, pesticides, a.o;
- used water, chaotically (without channel systems) evacuated from population's households.

In the infiltrating and percolating process of the water from precipitations in soil those elements that are characterised by a high capacity for dissociation and migration through convection can be especially trained. In this category there are especially included some compounds of nitrogen (especially nitrates), calcium and chlorine.

Average concentration in these elements, of percolation's water can reach 80-mg/l nitrogen, 160- mg/l CaO and 80- mg/l chlorine. Apart from these elements, water from percolation can contain, in similar concentrations as therefore mentioned, sulphates and sodium salts. Potassium and magnesium are slowly washed from soil because they are quickly adsorbed and kept in the adsorbent soil complex. Also, the pesticides, the different forms of phosphorus and organic mater are trained in smaller percentage to underground water.

The most toxic of these polluting factors are the nitrates, chlorine's and sodium's ions, grounds on which the quality of phreatic and underground drinking water is appreciated.

Place and research method

For a period of three years, that started in 1997, the Central Research Station for Soil Erosion Control Perieni – Bârlad monitored the quality of underground water under the impact of soil erosion, in nine wells (considered to be sources of drinking water) which are situated in the Perieni area, along a cross section through a hill. The following elements have been determined: pH, turbidity, nitrogen, phosphorus, sodium, potassium and chlorine.

Water samples have been taken on an average two times per month or after especially rainy events that created liquid infiltration that penetrated the wells. Sampling, preparation and conservation of samples for their analysis were made accordingly to the present Romanian standard. The laboratory analysis have been done in the following way: turbidity – filtration, drying and weighting; pH - potentiometer with mixed electrode glass-calomel; nitric nitrogen – colorimetric determined with acid phenol 2÷4 disulfonic; ammonium nitrogen - colorimetric determined with reactive Nessler; sodium and phosphorus – like blue molybdenum colorimetric dosing, potassium - in flame photometry dosing and chlorine - triturated with silver's nitrate.

Results obtained

Between 1996 and 2001 a number of 855 water samples have been taken from the said wells, situated in the village of Perieni.

Tables number 1 show that the statistics of the nitrate anion from the underground water resources taken in study.

Table no. 1.

Statistics for the dynamics of nitrate, in the wells of Perieni

Concentrations, ppm	Number of samplers	% from total samplers
S.T.A.S. 45	48	5,6
45,1 – 90	54	6,4
90,1 – 135	130	15,2
135,1 – 180	100	11,7
180,1 – 225	48	5,6
under 225,1	475	55,5

This statistics show that from the 855 analysed samples, only in 48 cases (5.6 %) concentrations are less then 45 ppm and in 475 cases (55.5%) concentrations are higher then the limits permitted by STAS. The causes that determined the appearance in underground water of these concentrations are linked to the depositing of manure on improvised platforms, placed on hills and on the access roads in the area of underground water sources and from the absence of an evacuation system. In dry years these concentrations become lower, this fact strengthening the conclusion that the main source of pollution of underground water from the first water-layer is the built-up area.

Defining in what concerns the quality of a water source, is also the concentration in chlorides. The statistics concerning chlorides (table number 2) show that from 855 analysed samples in 555 cases concentrations are less then 250 ppm (64.9%), while the outrunning represent 35.1 %. Considering the maximum limit of 400 ppm permitted by Romanian STAS from special conditions the outrunning represent only 4.1% of the cases.

Table no. 2.

Statistics for the dynamics of chlorides in the wells of Perieni

Concentrations, ppm	Number of samplers	% from total samplers
S.T.A.S. 250	555	64,9
251-300	40	4,7
301-350	160	18,7
351-400	65	7,6
under 401	35	4,1

The statistics concerning ammonium cations, show that from 855 analysed samples in 721 cases concentrations are less then 0.5 ppm (84.4%) while the outrunning represents only 15.6% (table number 3).

Table no. 3.

Statistics for the dynamics of ammonium cations, in the wells of Perieni

Concentrations, ppm	Number of samplers	% from total samplers
S.T.A.S. 0,50	721	84,4
0,51 – 1,00	50	5,8
1,01 – 1,50	25	2,9
1,51 – 2,00	20	2,3
under 2,01	39	4,6

The statistics concerning potassium cations show that in 63.7 cases the values are lower then the limit of 12 ppm, while the outrunning represents only 36.3% (table number 4).

Table no. 4.

Potassium cation statistics, from the wells of Perieni

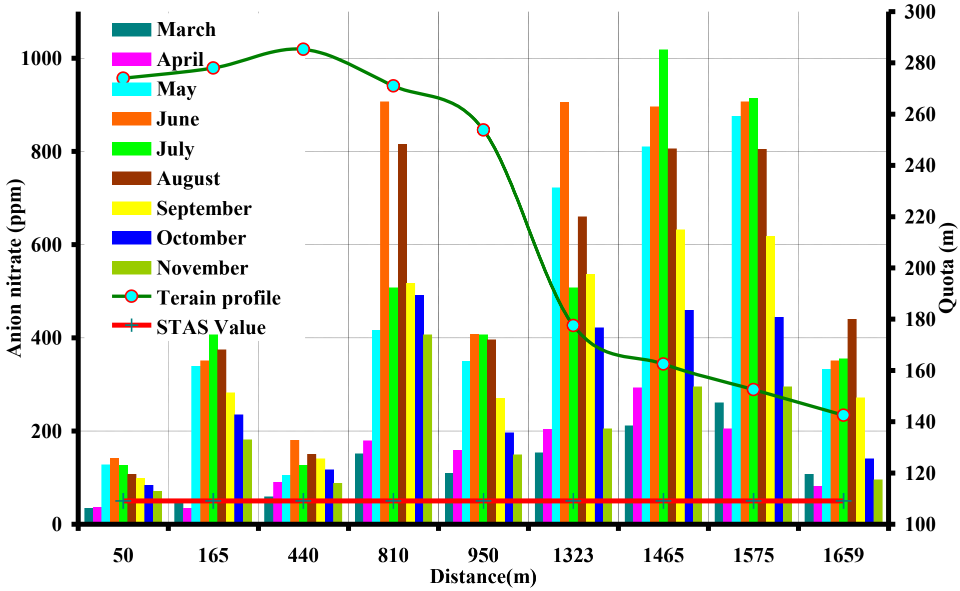
Concentrations, ppm	Number of samplers	% from total samplers
S.T.A.S. 12	545	63,7
12,1 – 24,0	56	6,5
24,1 – 36,0	70	8,3
36,1 – 48,0	80	9,4
48,1 – 60,0	54	6,3
under 60,1	50	5,8

Evolutions of the concentrations of analysed elements are shown in graphic form in images number 1 ÷ 4, where the maximum and minimum values recorded are presented, multiannual average and present standard regulations concerning underground water quality, used as drinking sources by the people from the villages.

Concerning the dynamics of nitrates (figure number 1), we can see that the multiannual average exceed by far the 45 ppm limit permitted by STAS at all the sources taken into study. In the plateau area (sources no. 1, 2 and 3) minimum concentrations are under 45 ppm, while the maximum values are way over this value. In the plateau area the concentrations are smaller followed by a fast growth in the values of nitrates in slope area (4; 5 and 6 sources) and valley area (7; 8 and 9 sources). Smaller concentrations from source no. 9 are justified by the fact that these wells are situated on the left slope which is less populated, while sources no. 1-8 are placed on the right slope where the number of households is bigger. Concerning the concentrations of nitrates, these wells must not be utilised as local sources of drinking water.

Fig. no. 1

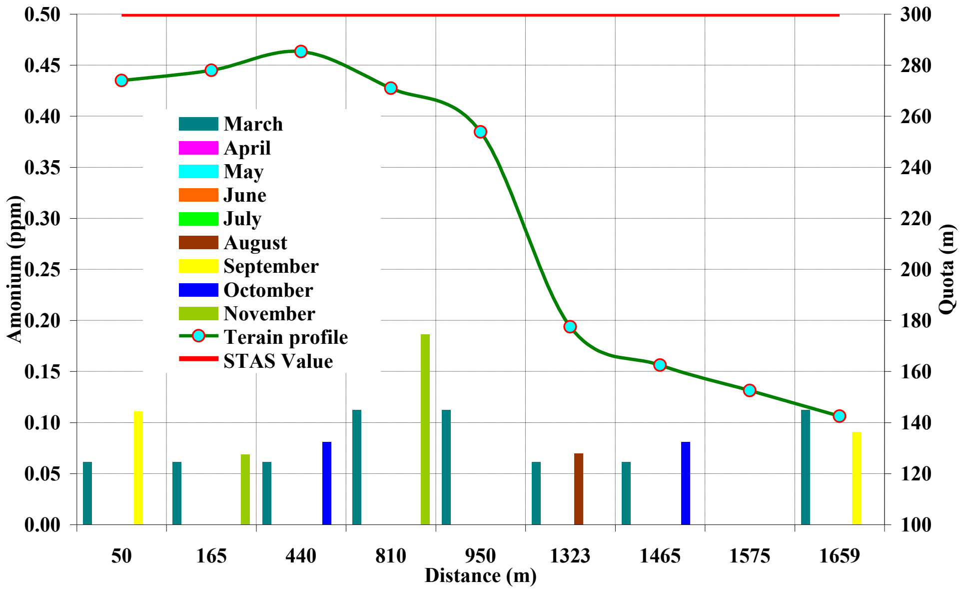
Wells from Perieni - nitrate's monthly fluctuating



The ammonium cation fluctuates from 0 to over 7 ppm maximum values (figure number 2) with multiannual average values oscillating around the values permitted by STAS. Maximum values are recorded when the snow melts slowly, when the ammonium ion from manure stored close to water sources is washed into the wells, process which is increased by the small temperatures in this period (ammonium ion is unstable at temperature and has an volatile trend). Multiannual averages v of ammonium cations are under 0.5 ppm (permitted by STAS) in valley area, while on the plateau and slope these values sink easily under this limit. This process is justified by the fact that the ammonium ion is percolated with difficulty because of its detaining into the soil, and its stability in time is low because of volatility and trend to oxidise.

Fig. no. 2

Wells from Perieni - ammonium cation's monthly fluctuating



Means year's values of phosphates are under limit of 0.5 ppm permitted by present standards and maximum values from spring season represent 18.2% from cases. Growing trend of concentrations is manifest on slope – valley direction (figure number 3).

Values of potassium concentrations are under 12 ppm in sources placed on the slope and valley (figure number 4) like maximum and means years values.

Recorded values on the slope and valley of chlorides outrunning, in some periods, 250 ppm due time the maximum (> 400 ppm) are recorded in four source and she is the most affected like drinking water quality (figure number 5).

Concerning sodium, concentration value outrunning the limit permitted by STAS for normal conditions at water sources placed on slope and valley. Sometime overtaking to the maximum values less than 175 ppm at two sources placed on valley, these values are permitted by standards only by way of exception (figure number 6).

Figure number 3

Wells from Perieni - phosphate's monthly fluctuating

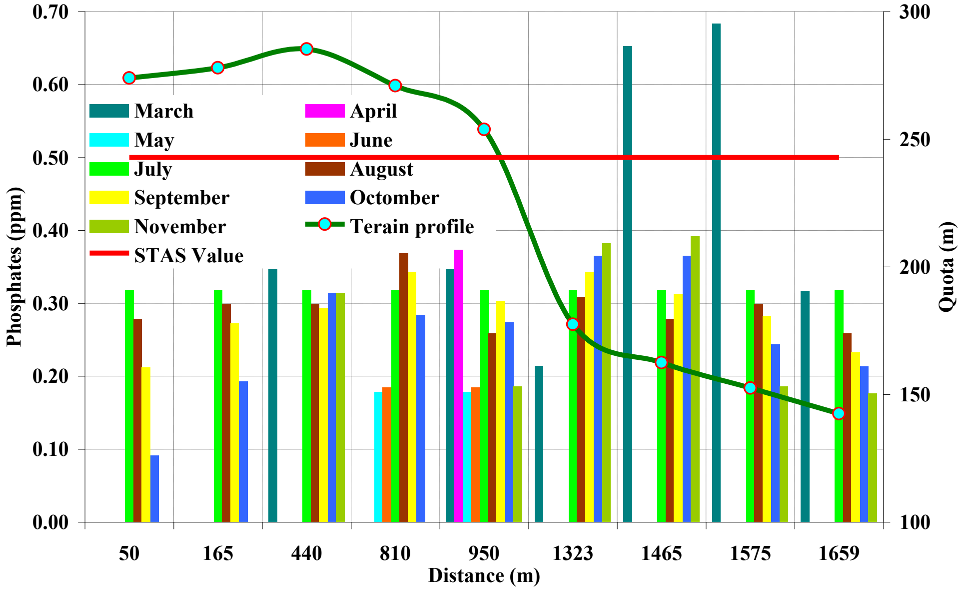


Figure number 4

Wells from Perieni - potassium's monthly fluctuating

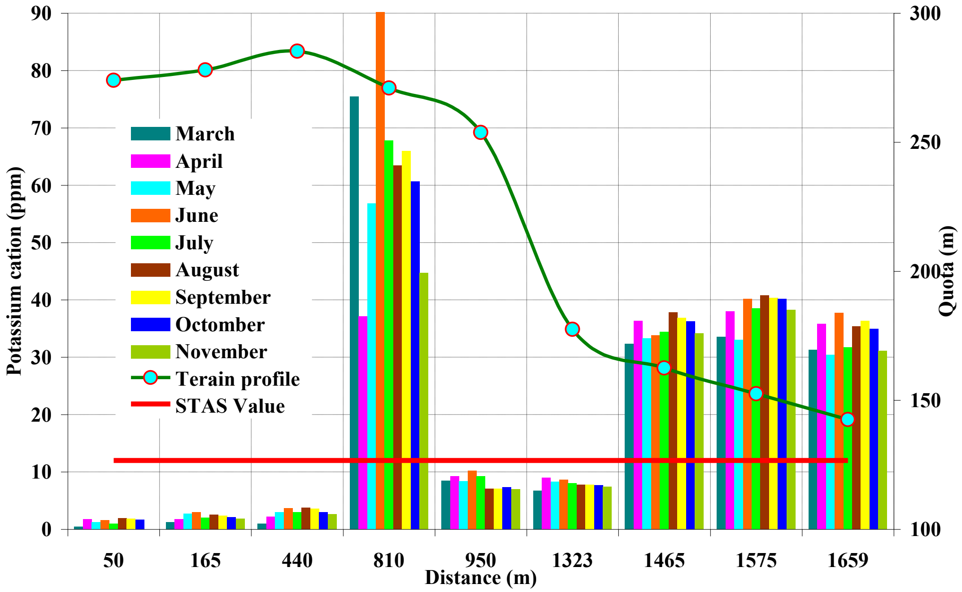


Figure number 5

Wells from Perieni - chloride's monthly fluctuating

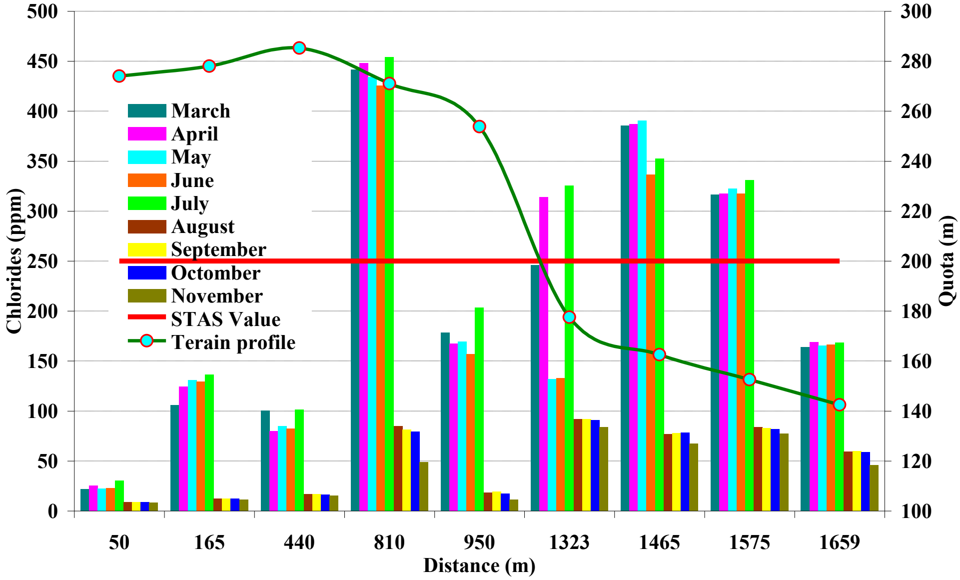
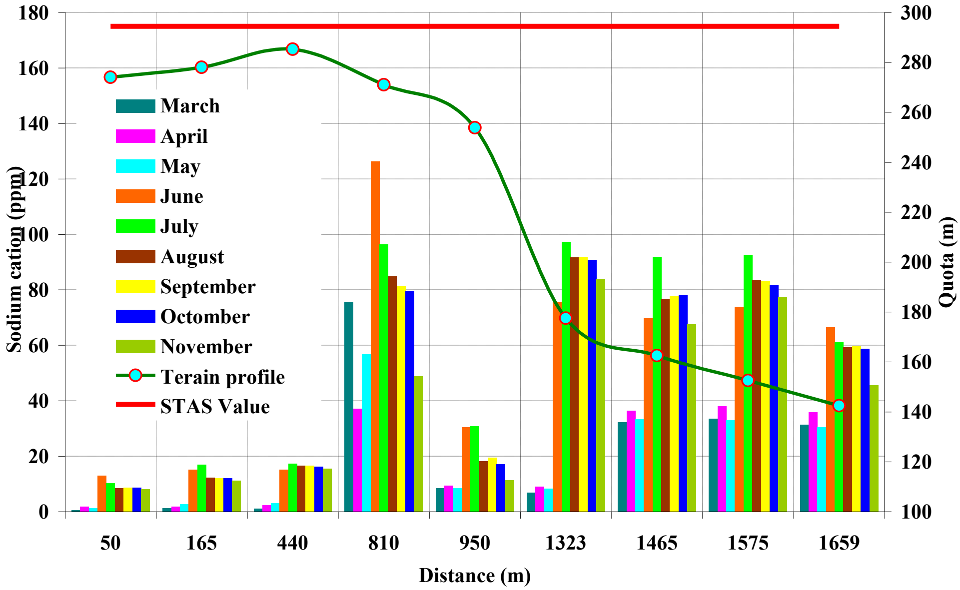


Figure number 6

Wells from Perieni - sodium's monthly fluctuating



The quantities of filterable materials from all studied sources are not affected drinking water quality.

Conclusions

- Mainly, the content of analysed elements is fluctuating with the location of wells on the hill, only for the wells located on the plateau it is fluctuating with the season:
- A larger content of nitrogen (28 % - 19,2 %) and potassium (18 to 12 times), in all seasons, on hillslope and valley area, in comparison with plateau area, has been determinate;
- The content of analysing element, from water wells located on the plateau, are frame in the limits of Romanian standards for locale source.
- Nitrogen are excepted because is larger with 9-299 ppm in spring, 48,9 - 304,2 ppm in summer and with 46,8 - 312,6 ppm in autumn in comparison with maxim values by Romanian standards;
- In all seasons the wells located on slope and valley area are not frame in local source of drinking water; the content of analysing element exceeds the Romanian standards limits: nitrogen with 71,1 - 854,8 ppm; potassium with 1,4 - 32,8 ppm and chlorine with 46,4 - 114,2 ppm
- Regarding monthly fluctuating depth of water from Perieni Wells it come out that only in plateau area there are fluctuations between 0.7 – 2.0 m
- Regarding monthly fluctuating of pH, from same wells, it come out that there are small fluctuations, between 0.2 – 0.3 but under maximum values permitted by Romanian standards
- Statistics, have studied elements from Perieni's wells it come out that:

- Concerning nitrates, only 48 samplers are value under limits permitted by Romanian standards (45 ppm), and from 807 probes 475 are values bigger then 225 ppm.
- Regarding chlorides 555 samplers are value under limits permitted by Romanian standards (250 ppm)
- Regarding ammonium nitrogen 555 samplers are value under limits permitted by Romanian standards (0.5 ppm)
- Regarding potassium 555 samplers are value under limits permitted by Romanian standards (12 ppm)
- Regarding monthly fluctuating of nitrates, with a few exceptions on the plateau area in spring month, are above the limits permitted by Romanian standards
- Regarding monthly fluctuating of phosphate's, in March (after spring's cleaning from courtyard's) there are concentrations that exceeded the limits permitted by Romanian standards in are from base of slope
- In any conditions values of concentrations of sodium are under limits permitted by Romanian standards from underground water, like drinking water source

- Regarding monthly fluctuating of potassium, in wells from Perieni, there are values under limits permitted by Romanian standards in well's area placed on village's plateau and in area from base of slope in all period

- Wells from Perieni - chloride's monthly fluctuating show that there are values under limits permitted by Romanian standards in well's area placed on village's plateau and in are from base of slope from March to July

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THE INFLUENCE OF LONG TERM FERTILIZING ON WINTER WHEAT YIELD AND SOME SOIL AGROCHEMICAL INDEXES

VASILICA NASTASA, EUGEN FILICHE

Abstract: Among the technological elements that have an important contribution on the winter wheat yield there is the level of nutrient supplies, as we ask that slopping lands suffer because of the lack of water and the nutrients absence due to erosion processes. The influence of fertilization and the crop rotation on the winter wheat yield ha materialized yields superior to the unfertilized variant, with differences among the crop rotations. The increasing the wheat yield due of chemical and organic fertilization has varied between 53%-96% in monoculture; 162%-240% in two years crop rotation and between 134%-153% in five years crop rotation, in comparison with unfertilized control. An increase of soil's acidity has been recorded, in comparison with the beginning value, in fertilized variants with high levels, 6.18 in five years crop rotation given the initial situation (6.45). An increase in the pH value by without fertilizing tillage (6.58-6.78, monoculture and five years crop rotation) and organic fertilized variant up to 6.81, in two years crop rotation was determinate.

Concerning the influence of fertilizers on the humus content (on both depths, 0-20cm and 20-40 cm) after 32 years of fertilizing, an improvement of the humus content has been observed given the initial situation, practically a homogeneousness on the soil profile up to 40 cm.

Key words: fertilization, yield, agrochemical indexes.

Introduction

The crop rotation and fertilizing of agricultural crop on the slopping lands are very important measures in order to obtain superior yields and to maintain the soil fertility between acceptable limits.

Neamţu T. şi Gociu Mariana (1992) showed that the crop rotation influence on the yields, without fertilization, ranges between 8.3% (in two years crop rotation) and 73% (in five years crop rotation). Also they came out that the fertilizing levels increased determine decreasing of crop rotation effect. Mihailă and Hera (1994) consider that under the pedoclimatic conditions, the economically optimum rates of fertilizers, regularly applied, assure, in time, a positive balance sheet of humus.

Borza and al. (2000) showed that the long-term fertilization determined a decreased tendency by using nitrogen fertilizers. Also, they considered that a well-controlled and equilibrated mineral fertilization is a sure measure to increase yields and, in the same time, a condition for a positive evolution of soil fertility.

Ciobanu I.V (2000) showed that the periodic manure application contributes to soil phosphate amelioration, not only by returning to the soil of a part of the phosphate up took by yields, but also by the influence of the chemical energy of organic substances and the activity stimulation of micro-organisms.

Material and research methods

The experiments have been performed at CRSSEC Perieni, Colinele Tutovei, Eastern of Romania. They have been placed on moderate eroded chernozem with 12-13% slope. Several variants with crop rotation and different levels of fertilization have been studied. Also, the reaction of wheat crop concerning yield and the soil's modifications for the long time fertilization and crop rotation, have been determined. The evolution of some soil's agrochemical indexes has been observed: pH; humus content; mobile phosphate and mobile potassium. The soil samples have been collected and analyzed according to the standard methods utilized in Romanian laboratories.

The crop rotation variants that have been studied were: monoculture (winter wheat); two years crop rotation (wheat/maize); three years crop rotation (wheat/wheat/maize); five years crop rotation (bean/wheat/maize/sunflower/perennial grass).

The levels of fertilizing that have been studied were: N_0P_0 (control), $N_{32}P_{32}$, $N_{96}P_{96}$, $N_{128}P_{128}$, 50 t/ha manure applied triennial. The yields obtained among 1970 – 2001 were used.

Results and discussions

The influence of fertilizing and the crop rotation on the wheat yields has been materialized by higher yields than the unfertilized control, with differences among those four types of crop rotation.

The average yield (32 years) was between 1325 kg/ha and 2599 kg/ha, in monoculture (table1).

Studying the values of table 1, we can observe an increase of yield due chemical fertilizers application between 53%-96% and an increase of 49%, by organic fertilizers application. The differences of yield are very significantly, with a great degree of repeatability in time.

Table 1 The influence of fertilizers on wheat yield in monoculture

Variants	Average yield (kg/ha)	Relative yield (%)	Difference (kg/ha)	Significance
Unfertilized	1325	100	-	-
N32P32	2030	153	705	***
N96P96	2580	194	1254	***
N128P128	2599	196	1274	***
50 t/ha of manure	1979	149	653	***

LSD 5% = 180 kg/ha LSD 1% = 238 kg/ha LSD 0,1% = 304 kg/ha

Table 2 The influence of fertilizers on wheat yield in wheat/maize crop rotation

Variants	Average yield (kg/ha)	Relative yield (%)	Difference (kg/ha)	Significance
Unfertilized	1381	100	-	-
N32P32	2233	162	852	***
N96P96	3177	230	1796	***
N128P128	3307	240	1926	***
50 t/ha of manure	2228	161	847	***

LSD 5% = 195 kg/ha LSD 1% = 290 kg/ha LSD 0,1% = 350 kg/ha

The application of the two years crop rotation bring about an increase of yield given the monoculture and also varied increases depending on levels of fertilization. Those, if the yield obtained in unfertilized variant was 1381 kg/ha, through chemical fertilizing, this grown up to 2233 kg/ha – 3307 kg/ha, respectively 162% -240%. The yield grown up to 161% in organic fertilization given the unfertilized variant. Though the increase was less than in chemical fertilization, the difference was significance. A considerable increase wasn't obtained through three years crop rotation application, given the two years crop rotation, the yields values being very close, but a very obvious and significant differentiation has been recorded depending on levels of fertilization. Thus, the yield increases have been between 151%-224%, $N_{32}P_{32}$ respectively N128P128, through chemical fertilization given the unfertilized variant. The organic fertilization has determined in this crop rotation variant too, the superior yields in comparison with unfertilized variant of 162%, bigger than the increase obtained by $N_{32}P_{32}$ level.

Table 3 The influence of fertilizers on wheat yield in wheat/wheat/maize crop rotation

Variants	Average yield (kg/ha)	Relative yield (%)	Difference (kg/ha)	Significance
Unfertilized	1396	100	-	-
N32P32	2113	151	717	
N96P96	2975	213	1579	
N128P128	3126	224	1730	
50 t/ha of manure	2267	162	871	

LSD 5% = 195 kg/ha LSD 1% = 280 kg/ha LSD 0,1% = 345 kg/ha

The five years crop rotation has proved to be the most favorable regarding the yields obtained, for all fertilized variants. The reaction of yield through application of this rotation result evidently by the comparing the yields obtained in unfertilized variants (2359 kg/ha. The application of chemical fertilizers has ascertained the increase of yield to 134%-153%, given the unfertilized variant. The differences between the fertilized and unfertilized variants, haven't been so big because the yield has obtained in unfertilized variant was quite big. Also, organic fertilization with manure has ascertained an increase of yield to 134% given the control (table 4).

Table 4 The influence of fertilizers on wheat yield in bean / wheat / maize / sunflower / perennial grass crop rotation

Variants	Average yield (kg/ha)	Relative yield (%)	Difference (kg/ha)	Significance
Unfertilized	2359	100	-	-
N32P32	3155	134	796	***
N96P96	3608	153	1249	***
N128P128	3555	151	1195	***
50 t/ha of manure	3151	134	791	***

LSD 5% = 188 kg/ha LSD1% = 249 kg/ha LSD 0,1% = 317 kg/ha

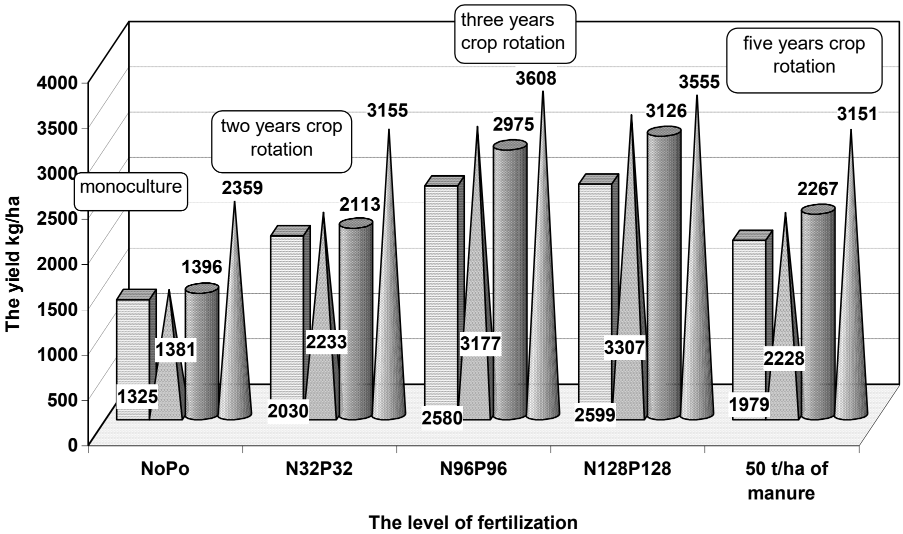

Fig.1. The variation of wheat yield after 32 years of crop rotation and fertilization

The differences that have obtained, among those four types of crop rotation, have been praised in fig. 1. where the influence of interaction between the fertilization and the crop rotation on the yield has shown. We can assert that the crop rotation has a decisive role in materializing of yield, for unfertilized and small levels fertilized variants. The increases of yield has been of 1029 kg/ha in unfertilized variant and of 1125 kg /ha in $N_{32}P_{32}$ variant placed in five years crop rotation, given the same variants from monoculture.

The increase of fertilization level determined a decrease of crop rotation influence on materializing of yield, but not until the "zero limit". The highest yields have obtained in five years rotation in all variants.

The organic fertilized variant is also remark by the yields that have obtained between 1979 kg/ha (monoculture) and 3151 kg/ha (five years crop rotation). The yields that have obtained through organic fertilization were close to those that have obtained trough chemical fertilization with $N_{32}P_{32}$.

The close values of yields that have obtained through high and very high levels of chemical fertilizers application, respectively in $N_{96}P_{96}$ şi $N_{128}P_{128}$ are distinguishing in fig .1, meaning that the $N_{96}P_{96}$ level is the most efficient.

Considerable changes have occurred in the soil profile due to long term crop rotation and fertilization, expressed by the some agrochemical indexes values. The changes that have been recorded following of analyses have performed in 1997 in comparison with the beginning values (in1969), are shown in the next figures (2,3,4,5,6,7,8,9).

The soil acidity has changed, on both depths, following of long term chemical and organic fertilizers application, that is an increase of the soil acidity, in comparison with the initial values, has recorded to the variants with big levels fertilized, 6.18 in five years crop rotation given the initial value 6.45, on 0-20 cm depth. A decrease of soil acidity, expressed through increased values of pH, has been recorded in unfertilized variants, 6.58-6.78, respectively monoculture and five years crop rotation and in manure fertilized variant up to 6.81 in two years crop rotation (fig 2).

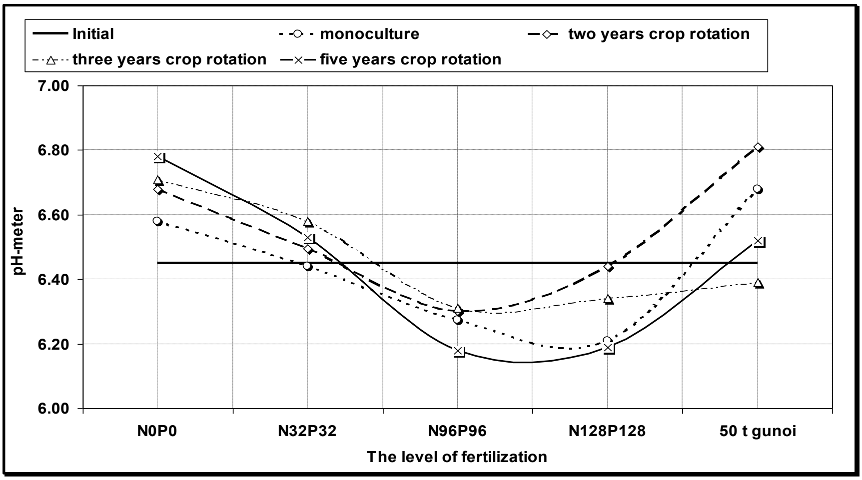

Fig. 2 The variation of pH on 0-20 cm depth

The increases of soil acidity have been recorded on the 20-40 cm depth too in large levels chemical fertilized variants, thus the pH value decreasing up to 6.08 (N_{128} P_{128}), in two years crop rotation, fig. 3.

Concerning the influence of fertilizers on the soil humus content, following of analyses that have been performed on both depths, an improvement of this index has been recorded given the initial situation. Thus, if the humus content has maintained to initial values on the 0-20 cm depth respectively 2.6%with the increases just in monoculture (fig. 4), the humus content has increased on the 20-40 cm depth up to appropriately equal values with 0-20 cm depth values. An improvement of humus content has been observed, practically a homogeneousness on the soil profile up to 40 cm (fig.5)

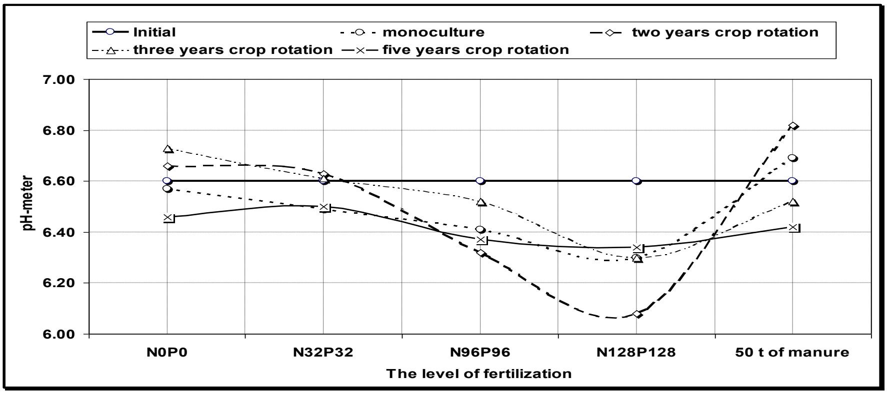

Fig. 3 The variation of pH on 20-40 cm depth

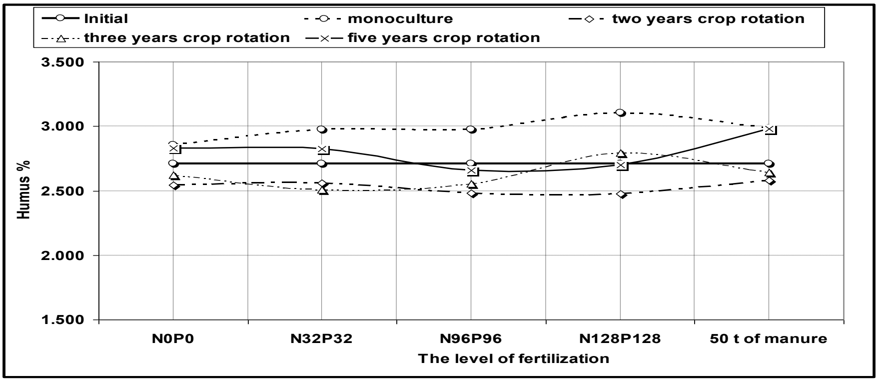

Fig. 4 The variation of humus content on 0 - 20 cm depth

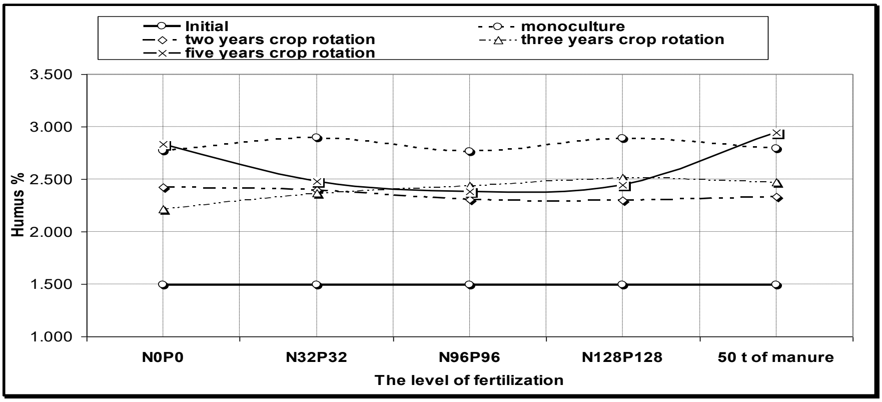

Fig. 5 The variation of humus content on 20 – 40 cm depth

The agrochemical indexes that have suffered the major modifications in comparison with the initial situation have been the mobile phosphorus and potassium. Long term of chemical and organic fertilizers application, has ascertained, concerning the mobile phosphorus, the very big increases which led to the soil's super saturation in this element, directly proportional with the increase of fertilizer's level. The mobile phosphorus values have exceeded 200 ppm P_2O_5, on both depths, at the $N_{96}P_{96}$ and $N_{128}P_{128}$ levels, getting up to over 400 ppm P_2O_5 in five years crop rotation. The increased values of this index have been recorded on the 20-40 cm depth too. The organic fertilization with manure has ascertained the big increases of the phosphorus's content especially on 0-20 cm, between 200-350 ppm P_2O_5, but smaller on the 20-40 depth, respectively 100-200 ppm P2O5 (fig 6,7). The accumulation of phosphorus in the soil is explained through the large adsorption capacity on the soil's colloidal particles.

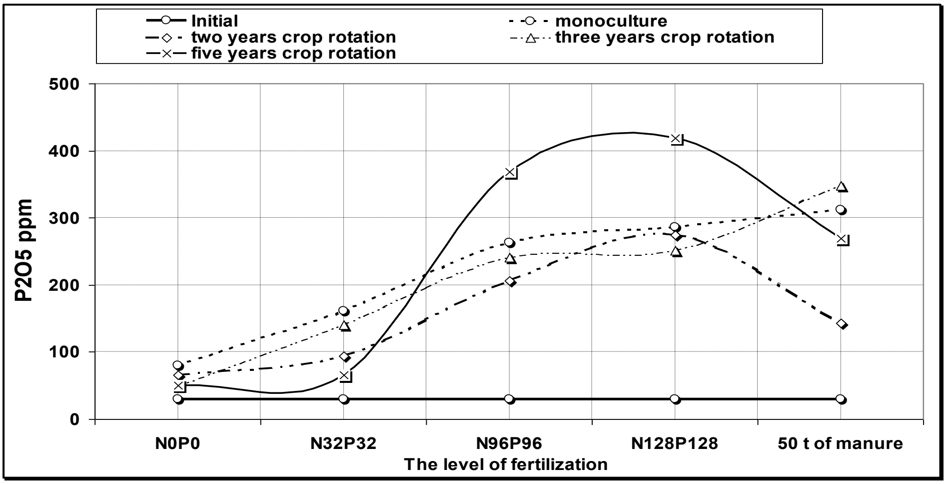

Fig. 6 The variation of P_2O_5 content on 0 – 20 cm depth

The content of potassium expressed by K_2O has modified considerable following of long term fertilization. Thus, the differences among the chemical and organic fertilization have obtained, on both depths in comparison with the initial situation.

As for the content of potassium on the 0-20 cm, if the initial value was by 169.2 pm K_2O, meaning a good potassium supplies, after 32 years of fertilization the potassium content has recorded a decrease to 150-130 ppm K_2O in large levels of fertilization respectively, $N_{96}P_{96}$ and $N_{128}P_{128}$variants. The decrease of potassium content wasn't identical in small level and manure variant of fertilization with the variants fertilized with $N_{96}P_{96}$ and $N_{128}P_{128}$, more, the organic fertilization has determined an increase of potassium to 190.4-230.2 ppm K_2O varying with the crop rotation used. Also, the content of potassium has maintained at close by initial values in the tillage without fertilization.

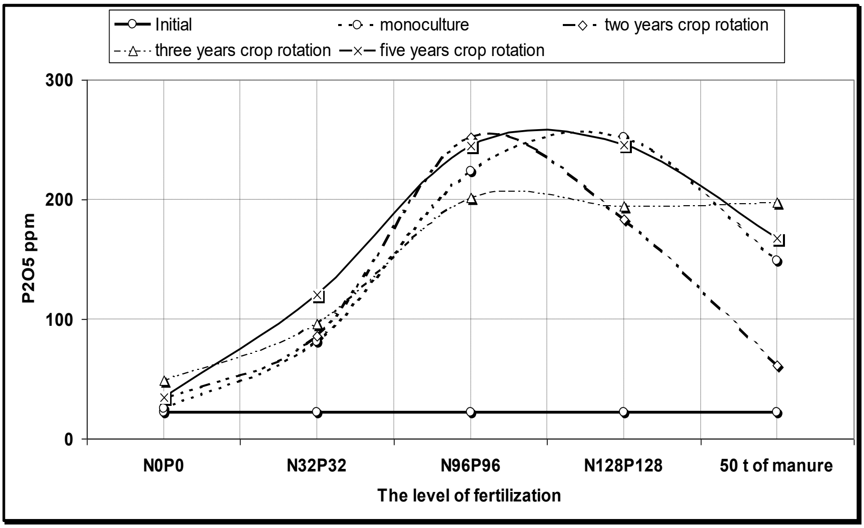

Fig.7.The variation of P_2O_5 content on 20-40 cm depth

Concerning the values of mobile potassium that have obtained on the 20-40 cm depth, these have been close to the values by 0-20 cm depth (fig.8,9).

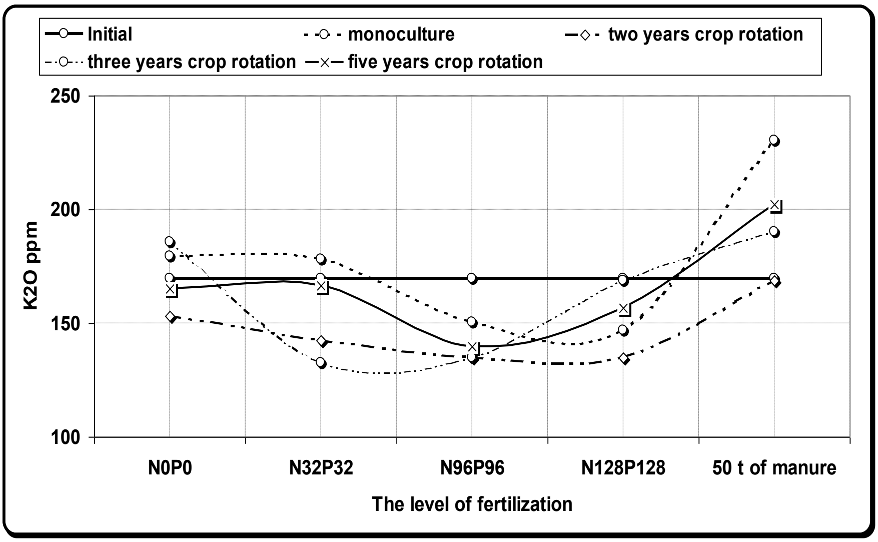

Fig.8. The variation of K_2O content on 0-20 cm depth

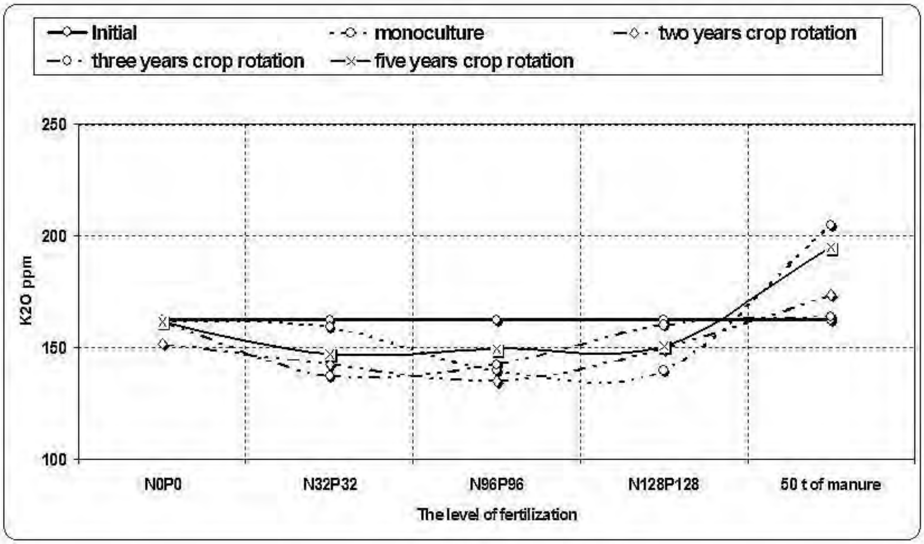

Fig. 9 The variation of K2O content on 20-40 cm depth

Conclusions

- ✓ The yield of wheat has been influenced both the level of fertilization and the type of crop rotation used, thus the highest yields have obtained in five years crop rotation for all levels of fertilization
- ✓ The soil acidity has stressed due to long term fertilizing, especially in the variants that were fertilized with large level of fertilizers, and it has maintained at initial situation as a result of organic fertilization.
- ✓ The chemical fertilization has determined on soil profile accumulations with big amount by mobile phosphorus in $N_{96}P_{96}$ and $N_{128}P_{128}$ variants, and decreasing of mobile potassium content in the same variants.
- ✓ The humus content has maintained approximately by initial level on the 0-20 cm depth, but it has increased with 50% on the20-40cm depth.

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LAND DEGRADATION BY EROSION AND ITS CONTROL IN ROMANIA

DUMITRU NISTOR, DOINA NISTOR

Abstract: About 43% (6.4 million ha) of the 14.963 million hectares of agricultural fields is sloping land with erosion potential. Cropland ranges 2.572 million hectares (26% from arable land). Most of the pastures and vineyards are laying out on sloping land (1).

In terms of sediment yield from Romanian agricultural land estimates amount to 106.6 million tons per year. Cropland, grazing land and unproductive land enter this amount with 81.6%. Sediment derived from surface and gully erosion average 72.6% of this amount (2,3).

The average erosion rate in Romania was estimated at 16.28 t/ha/year.

The total agricultural surface protected by conservation measures till 1990 was about 2.1 million hectares that represents one third from the fields with erosion potential.

Key words: soil erosion, conservation practices, conservation tillage, perspectives.

1. General features

The territory of Romania, which lies in the southeastern Europe, encompasses 237,500 square Kilometers (58.7 million acres). Romania has a variety of landscapes resulting from its wide range of major relief forms which are very well proportioned: 36 % Carpathian Mountains and Subcarpathians, 34 % hills and tablelands, 30 % plains. Within its boundaries live 23.5 millions people.

Average annual precipitation varies from about 360 mm at the lower elevations (Danube Delta) to 1450 mm at the 2000-2543 meters elevation (Retezat, Fagaras, Rodna Mountains).

The mean annual temperature of country is about 10 C.

For the Romanian agriculture the main soil classes are mollisols (chernozems, gray wooden soils) and argiluvisols (reddish-brown soils, brown argoloiluvials, brown-luvic soils and luvisols).

The leading crops are corn, wheat, barley, sunflower, potatoes, drybeans, sugarbeet, rye, flax, soybeans, hay etc. Most of them have the growing months of April through September.

2. Soil erosion and related problems

2.1. Extent and types of water erosion

Romania is the Central and Eastern European Country which presents the most variate forms created by water erosion because of its natural conditions. The wind erosion is only affecting small areas from the southern part.

The critical erosional season is generally streched between May-August as the heavy rainfalls during crop-growing months.

Man's activity had an important role in inducing and intensifying of the erosion processes particularly through the land-use, crops structure on the arable land, crop farming, management of pastures and forests. Data from Table 1 illustrate that among agricultural lands most of the pastures (grazingland) and the vineyards are laying out on sloping lands, especially, with erosion potential. Forests are concentrated on mountain area, mostly.

Although the arable land is located on "gentler" slopes this is a major source for soil losses because the high ratio of the row crops (corn, dry beans, sunflower, potatoes) has determined a high rate of the erosion processes. The non-adequate management of the pastures had an unfavorable influence, too.

Table 1 Use of the sloping lands with erosion potential

Land use	Areas		Mean slope value %
	Over 5% slope millions ha	Percentage from total land, %	
Agricultural, from which :	6.367	42.6	
Arable (Cropland)	2.572	26.0	17.0
Pastureland	3.360	75.0	21.8
Wine plantations	0.169	55.0	16.0
Fruit plantations	0.266	75.0	18.0
Forestland	5.748	87.5	40.4

The rate of erosion presents a distinct interest excepting the state of the erosion. Figure 1 shows division into zones of the total erosion in tones/ha/year.

A special attention was given to the sediment sources by contributions of the major land-uses or of the classical erosion types to the making up of the total erosion (see Tables 2 and 3).

Table 2 Total erosion by land-uses

No	Land-use	Total erosion			
		millions t/year	%		
1	Cropland (Arable land)	28.0	26.2	24.7	22.3
2	Pastures (Grazing land)	45.0	42.2	39.6	35.7
3	Vineyards	1.7	1.6	1.5	1.2
4	Orchards	2.1	2.0	1.8	1.7
5	Unproductive (Abandoned land as gullies)	29.8	28.0	26.4	23.6
	Agricultural land total	106.6	100.0	-	-
	Woodland - total	6.7	-	6.0	5.3
	Total	113.3	-	100.0	-
	Bankrivers and localities erosion	12.7	-	-	10.2
	General total	126.0	-	-	100.0

Table 3 Total erosion by types of water erosion

No	Type of erosion	Total erosion		
		millions t/year	%	
1	Surface erosion	61.8	54.5	49.0
2	Gully erosion	29.8	26.4	23.6
3	Landslides	15.0	13.1	11.9
4	Gully erosion and landslides on woodland	6.7	6.0	5.3
	Total	113.3	100.0	-
	Bankrivers and localities erosion	12.7	-	10.2
	General total	126.0	-	100.0

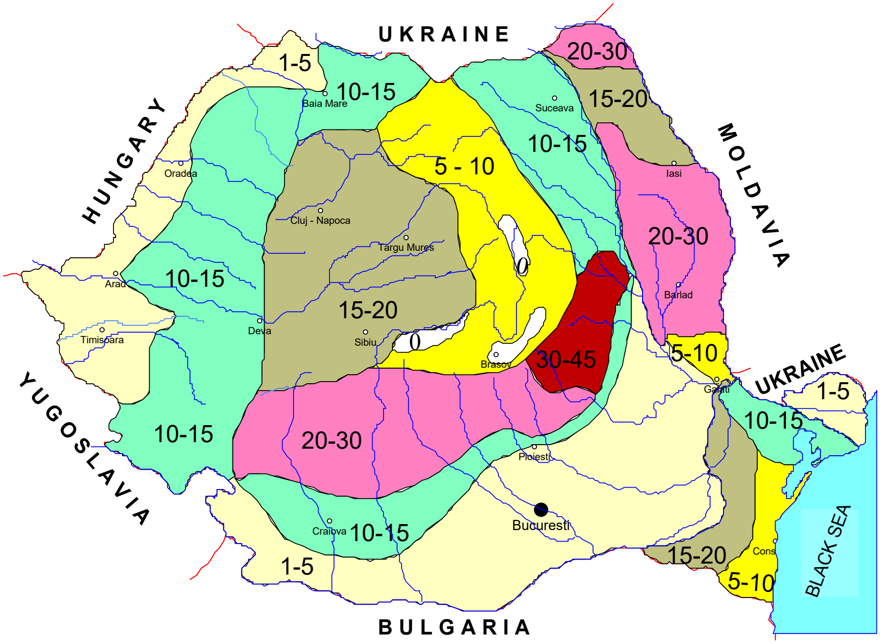

Fig. nr. 1 Total erosion, on agricultural lands - t/ ha/ year
(After M. Motoc, 1983)

These data reflect different input levels to the gross erosion making up. In terms of the physical soil losses from agricultural land estimates run as high as 106.6 million tons per year.

Data in Table 3 show that surface (sheet and rill) and gully erosion are the most important contributing types of erosion.

2. 2. Erosion rates by crops

Longtime field measurements conducted at Perieni Research Station (Moldavian Tableland) on standard runoff plots with loamy-textured mollisols illustrate the influence of crops on soil losses, as reported in Table 4 (After I. Ionita, O. Ouatu and A. Popa).

Table 4 Average annual soil losses at Perieni Station between 1958 – 1984

No	Crop	Soil loss - t/ha/year
1	Corn	14.9
2	Winter wheat	1.7
3	Brome grass	0.5

2.3. Yields of crops

One of the most important damages caused by surface erosion is the steady decline of crop yields. Research conducted in Romania has shown a stratification of yields on crops depending upon the thickness of eroded soil (see Fig. 2).(2)

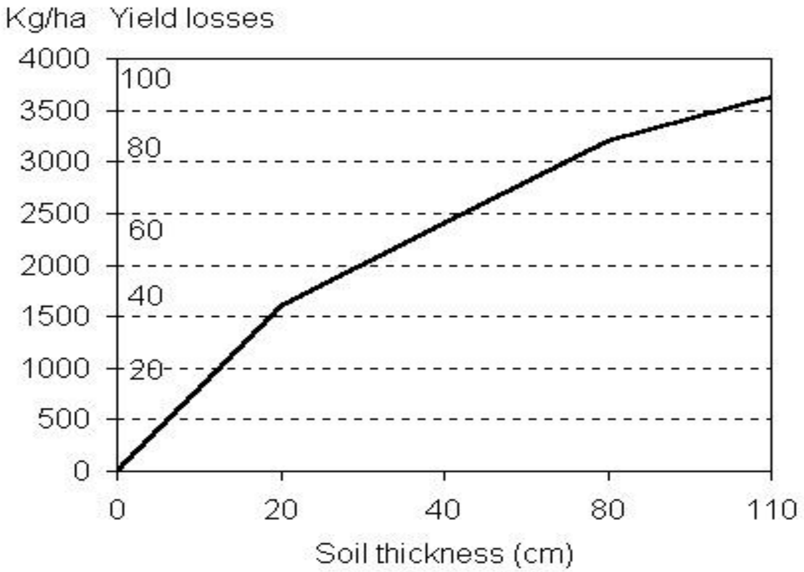

Fig. 2 - Corelation between losses of crop yield and surface erosion

It has been found a rapid increase of crop losses specially when erosion is affecting humus horizon or transitions horizons. Thus for one cm. depth of eroded soil an amount of 60 kilograms grains is lossed if is considered an average yield of 4000 kilograms per hectare for noneroded soils.

For a short time, these losses are large but on long-term they become very high because the crop losses from the previous years are included (totalized).

3. Methods of soil erosion control and land improvement

In Romania existed and are still maintaining the traditional conservation measures on the agricultural fields. Among them are mentioned the following: contouring (the practice of tillage and planting on the contour), stripcropping, buffer stripcropping, agroterracing on cropland, wine and fruit plantation terraces, gully control structures, perennial grasses in the crop rotation system and artificial revegetation of the denuded fields by shrubs and trees.

Unfortunately, these methods have not been generalized. Consequently, in some areas were practiced on large scale methods that enabled increasing of erosion as follows: up-and-down hill plot layout and farming, land clearing for agricultural purposes on hillsides with high risk of erosion.

New methods were implemented besides traditional methods, such as bench terraces on cropland, conservation tillage, terraces by steps concurrently constructed with the field broking for wine and fruit plantations, treatment system of fruit plantations by technological alleys, vegetated and mechanical waterways, interception drainage for wet soils on slopes etc.

The basics of conservation tillage is to leave sufficient crop residue on the soil surface to significantly reduce soil erosion and, which involve less energy than conventional tillage.

Over the period 1992-1998 different tillage treatments were considered.

Based on long-term data, illustrated in Table 5, it might be concluded that tillage leaving a protective cover of previous crop residue on the surface represent a new opportunity to control soil erosion.

Table 5 Influence of tillage on soil losses (1992-1996)

Base tillage	Erosion (t/ha)					
	1992	1993	1994	1995	1996	Average
Continuous fallow	18.2	26.2	-	19.4	23.3	18.4
Unprotected (Plowed, check plot)	4.7	17.1	0.8	8.0	13.8	8.9
Partly protected (chisel)	3.3	24.4	-	0.6	3.7	6.4
Protected in wheat stubble (No-till)	2.7	7.2	-	0.8	2.1	2.6

Within the above mentioned, experimental site the nutrient losses have been determined for the first time in Romania under non-conventional tillage. Also, a great concern was focused to establish the rate of nutrients losses through water and soil, respectively (see Table 6).

The basics of these methods is to leave sufficient crop residue on the soil surface to significantly reduce soil erosion and, which involve less energy than conventional tillage.

Over the period 1998 different tillage treatments were considered.

Table 6 Influence of tillage on the mean nutrientlosses for the period 1992-1996

Tillage		Conti-nuous fallow	Unprotected (Plowed, Check)	Partly protected (chisel)	Protected in wheat stubble (No-till)
Humus Kg / ha		407.0	231.6	148.6	58.9
Nitrogen Loss	Total Kg /ha	20.3	13.4	6.8	3.2
	Water %	4.6	19.1	8.7	10.2
	Soil %	95.4	80.9	91.3	89.8
P_2O_5	Total Kg/ ha	5.2	4.5	1.6	0.9
	Water %	10.2	13.7	10.5	15.3
	Soil %	89.8	86.3	89.5	84.7
K_2O	Total Kg / ha	4.7	3.8	1.6	0.7
	Water %	20.8	43.3	32.2	67.8
	Soil %	79.2	56.7	67.8	61.7

Conservation tillage systems also reduce nutrient losses. Of these, over 93 percent at organic matter, over 83 percent at phosphorous and over 60 percent at potassium are lost through eroded soil. (Table 6)

The total agricultural surface protected by conservation measures is about 2.1 million hectares, that means approximately 30% from the fields with erosion potential.

4. Present day and prospective problems

Romanian Parliament has approved of the landed property law. Through it the land of former agricultural cooperatives is restored to legitimately landowners. This is affecting over 90% of the agricultural land area. The remainder lands belong to agricultural state units that were turned into agricultural societies (companies) with state capital. Now the putting in possession of injured people is taking place with a top limit of 10 hectares per family.

The landed property law includes two provisions which are not of a nature to create conditions for the extension of conservation measures. One of these stipulates that the land reallotment has to be usually done on the old locations. This means, in most cases, the plots will be up-and-down hill disposed. The second is referring to the successors' right up to the fourth degree! This enables an increasing rate of dividing into lots (land chopping) that was very high in past, too. Moreover this means the allotment of about 2 millions people who never had a connection with agriculture.

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SOIL EROSION MODELS USED IN ROMANIA

NELU POPA

Abstract: Based on the results obtained over a period of 10-15 years the first model elaborated in Romania before 1970 is by the same type as Wischmeier's model. Unlike this for rainfall factor, another index ($H\ i_{15}$) was used. This represents the product between the amount of precipitation times the maximum 15 minutes intensity for a given rainstorm. Values of the soil erodibility have been determinated by means of information from runoff plots under natural rain and measurements with the infiltrometer for the main soil types.

During the last decades, erosion experiments have been developed on small watersheds with predominant agricol or forestry land use or forestry land use. Methods of total erosion and sediment delivery estimating and hydrological computing have been elaborated.

A distinct interest is attached to the conceptual models. With that end in view, rill erosion determinations on natural scale polygons have been conducted. For different stages, such as runoff starting, forming of rills established runoff regime some parameters were ascertained.

In the last years, at the Perieni Station, two models were used to predict rainfall erosion losses: Erosion Productivity Impact Calculator (EPIC) and Water Erosion Prediction Project (WEPP).

The main problem we face when starting the model using was the specific Romanian database developing.

Key words: soil erosion, runoff, models.

Intoduction

Soil protection and conservation provide, generally, to go over the three stages:

a. specifying the diagnosis by establishing the values of the soil loss tolerance, assessing the soil risk and analyzing of causes of erosion;
b. conservation planning:
c. Applying of two types of measures: preventive (by general order) and specific (conservation practices).

The diagnosis stage is considered very important since the analyze of priorities in establishing of erozional measures must rely on realistic data. Assessment of the risk of soil erosion can be realized by different methods according to the main purpose:

- simple methods that refer to the expedient field investigations or to the simple mathematics models; they are frequently used to rapidly inform the deciding authorities on local or regional level.

- exigent methods that include performant mathematics models, relatively simple and easy to apply; the best-known model in the world is USLE;
- very exigent methods which are related to informatical high performant programs and are, in fact, process-based models. They require a large amount of input data.

In this paper, only the last two categories which include the best-known models such USLE, and WEPP, were analyzed.

Materials and methods

Situated on the eastern part of Romania, on the contact line between the area with leached chernozems along the Barlad valley and the zone with forestry soils from the hills, the Perieni station has been mainly concerned with the finding out and the actual application in the field of the most efficient methods for reducing soil erosion, with a view to ensuring high and stable yields. The research focussed at first on the study of runoff and erosion on hillsides with various slope gradients and land use. Concomitantly, farm practices were approached in relation to the crop structure and sequence, tillage, use of fertilizers, pasture, etc.

Several research plots were constructed in order to determine soil and water losses under natural rainfalls. Those rectangular plots (25 x 4 m) that were set-up in 1970 are still in use. Long-term field measurements regarding erosion / deposition are of value.

Also, the rill erosion was examined by simulating the microstream runoff with deliveries of 0.6, 1.25 and 2.1 l/s (Motoc and Ouatu, 1977). The determinations were made on 500 m^2 plots (100 x 5 m) cultivated with wheat, and corn or mere fallow, on loamy cambic chernozem. Several aspects were considered:

- the runoff front advance;
- the runoff velocity and sediment concentration in stabilized regime;
- the variation of the sediment discharge in relation to the delivery flow, the sediment concentration and the soil cover 100 m away from the delivery source.

In the last years, two models were studied (Erosion Productivity Impact Calculator - EPIC and Water Erosion Prediction Project - WEPP) having in sight their validation under Romanian natural conditions.

Results and discutions

As a tool for conservation planning, the most used model in the world is Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978).

In Romania, as an alternative to the USLE, an equation by the same type as Wischmeier model (M. Motoc et. al. 1975, 1979) was developed. Unlike this, significance and establishing method of factors are different.

$E_s = K\ S\ L^m\ I^n\ C\ C_s$

where:

Es (to/ha/year) - computed soil loss per unit area and year;

K - erosivity factor (Stanescu et al. 1969) obtained bymultiplying the amount of precipitation by the maximum 15-min. intensity (i_{15} - in mm per min), for a given rainstorm;

S - soil erodibility (S = 1 for loamy cambic chernozem with high erosion;

L^m (m) - field slope length;

I^n (%) - mean slope;

C - cover management factor that shows the influence of crops and tillage (C=1 for corn cultivated year by year);

Cs - support practice factor (Cs=1 for none soil erosion control measures).

There are some changes in comparison with USLE:

- the dimensional factor is no longer erodibility but erosivity;
- the topographic factor (L x i) is no longer the ratio of soil loss per unit area as measured on a standard plot but directly L (m) x i (%).

Starting with 1995, interest has focused on the need to forecast the impacts of climate and changes in land use on erosion processes. Process-based models are indicated for evaluating long-term effects of land management on runoff and erosion.

The Water erosion Prediction project (WEPP) developed by the USDA was the first approached model at Perieni Station. The correctness of prognosis performed by WEPP is directly related to quality and quantity of input data obtained in the specific conditions of Romania.

For an American user, it is relatively easy to have access to computerized climatic or pedologic database while a Romanian user has to approach several stages:

- inventory of all the input data required by the model which include:
    - situation of measured data;
    - situation of missing data.
- performing a comparative study between specific Romanian and American natural conditions to assess the missing data;
- developing step by step of a new database in required format of the model.

A hard work was necessary in order to release a proper simulation of erosion with such a complex process-based model.

The first step in the model evaluation at Perieni was performing the sensitivity of the model response to different input values. The second step was the comparison of simulated data to measured data. So, to be capable to run WEPP hillslope version it was necessary to introduce in the computer memory a climatic data set by analyzing a large number of graphic registration of rainfalls over the period 1989-1993

Running of CLIGEN subroutine of WEPP was possible only by using climatic data provided by some meteo stations from USA which have presented similar characteristics with Barlad meteo station. Thus, recording of mean annual precipitation and temperature, provided by 1079 meteo stations were analyzed and, finally, 12 of them were graphically represented. Among all this, North-Platte Nebraska with 498 mm mean annual precipitation and 9.7°C mean annual temperature, have been retained. Similar values only Dodge City - Kansas, Grand Island - Nebraska and Huron - Sidney were presented.

Measured data from Perieni runoff plots were revealed the following aspects:

- 49 rainfalls generated runoff and erosion, under different crops, ranging between 3.4 mm and 59.7 mm;
- the soil losses varied between 0.008 and 3.4 kg/m^2.

In Table 1, the results of statistical analyze concerning simulated and measured data are being shown.

Table 1 Linear regression of the simulations with WEPP on runoff plots at Perieni Station over the period 1989-1993

Crop	Type of phenome-non	No. of events	Correlation Coefficient R	Linear regression
Fallow	Runoff	49	0,796	Y = -0,125 + 0,744 X
	Erosion	49	0,741	Y = 0,213 + 0,881 X
Corn	Runoff	23	0,899	Y = 0,636 + 0,825 X
	Erosion	23	0,857	Y = -0,074 +0,763 X
Winter wheat	Runoff	19	0,347	Y = -0,232 + 0,079 X
	Erosion	19	0,712	Y = 0,003 + 0,192 X
Bean	Runoff	19	0,993	Y = 0,042 + 0,995 X
	Erosion	19	0,842	Y = 0,244 + 0,711 X
Bromgrass year I	Runoff	15	0,730	Y = 0,072 + 0,600 X
	Erosion	15	0,943	Y = -0,031 + 6.138 X
Bromgrass year II	Runoff	7	0,494	Y = 0,490 + 0,219 X
	Erosion	7	0,546	Y = -0,0003 + 0,379 X
TOTAL	Runoff	177	0,604	Y = 0,258 + 0,479 X
	Erosion	177	0,808	Y = 0,08 + 0,957 X

Figure 1 shows the graphic representation of measured and simulated data corresponding of all 177 registrations under fallow, corn, winter wheat, bean and bromgrass. The linear regression parameters (a = 0.258, b = 0.479 and r = 0.604 where a is the y-intercept value, b is regression slope and r is coefficient of correlation) indicates that the model over-predict runoff for small measured values and under predict runoff for large measured values.

In figure 2, are presented measured versus predicted erosion values for the same events presented above. This case reveals that simulation was more accurately (a = 0.08, b = 0.957 and r = 0.808) that means a uniform distribution of points around the diagonal of the graphic.

Running of WEPP watershed version has required some preliminary operations:

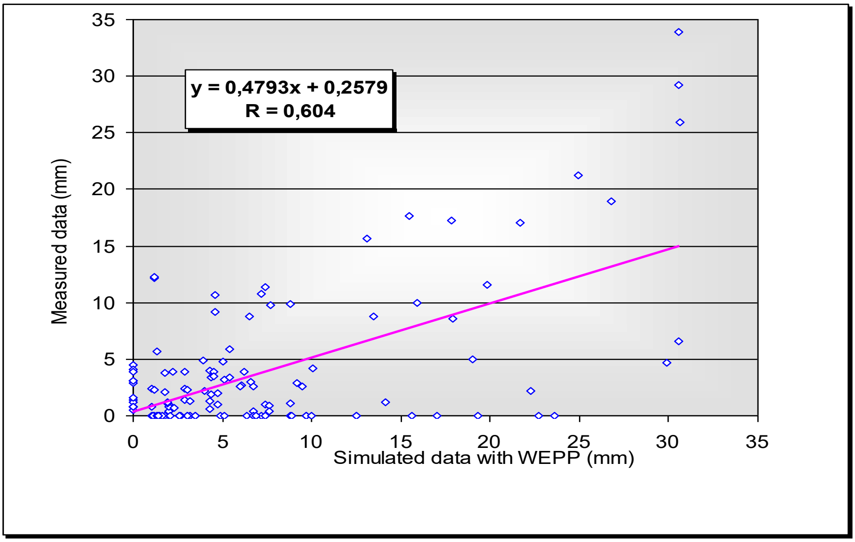

Figure 1 Measured versus simulated data of runoff over the period 1989-1993, at Perieni Station

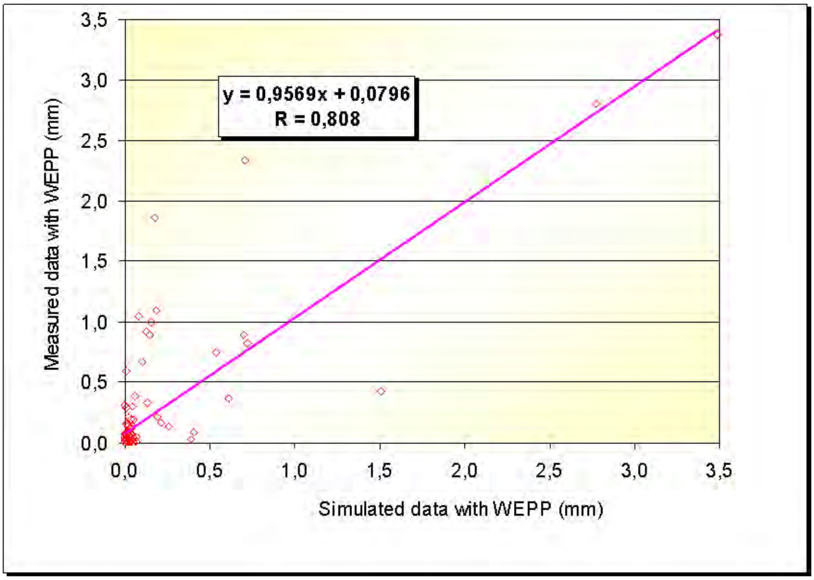

Figure 2 Measured versus simulated data of erosion over the period 1989-1993, at Perieni Station

- establishing of simulation scenarios;
- dividing of watershed into homogenous areas concerning agricol exploitation and conservation practices;
- identifying the channels and the hillslopes which represent the watershed components.

To perfect the volume of work, M. Motoc et al. (1996) have suggested that the simulation scenarios can include only three categories of parameters: crop structure, pattern of conservation practices and fertilizing. The number of scenarios can be reduced having in sight the most used situations met in a specific area.

Table 2 shows the result of simulation with WEPP for 10 years, on a small watershed called Crangul Nou (A = 29 ha), situated in Barlad Tableland, with slope ranging between 5 and 24% (fig. 1).

Table 2 Simulation results with WEPP on Crangul Nou watershed

Scenario	runoff	Snow melt	Erosion	A erod.	Dep.	A dep.	Sedim. yield
	mm	mm	t/ha	ha	t/ha	ha	t/ha
1.1.1. (corn 75%, winter wheat 25%, straight-row farming up and down, no fertilization)	6,39	0,63	26,92	29,0	0	0	26,920
2.1.1. (corn 50%, winter wheat 50%, straight-row farming up and down, no fertilization)	5,87	0,61	19,58	29,0	0	0	19,580
2.3.1. (corn 50%, winter wheat 50%, bench terraces, no fertilization)	3,35	0,31	9,82	27,7	6,81	1,3	9,075
2.3.2.c. (corn 50%, winter wheat 50%, bench terraces, conventional tillage, medium fertilized)	2,68	0,25	7,76	27,7	5,52	1,3	7,165
2.3.2.n. (corn 50%, winter wheat 50%, bench terraces, no tillage, medium fertilized)	1,35	0,14	2,32	27,7	0,83	1,3	2,179
3.3.2.c. (corn 33%, bean 33%, winter wheat 33%, bench terraces, conventional tillage, med.fertilized)	1,78	0,19	6,76	27,7	5,30	1,3	6,219
4.3.2.n. (corn 20%, bean 20%, winter wheat 30%, bromus 30%, bench terraces, minimum tillage, medium fertilized)	0,86	0,07	1,42	27,7	0,51	1,3	1,324

Examination of the simulation data shows the performances of the different support practices for purposes of conservation of water and soil on agricultural lands.

The worst scenario (corn 75%, winter wheat 25%, straight-row farming up and down, no fertilization) is usually met in Romania in the hilly area, after the promulgation in 1991 of a new property law that stipulates that the land reallotment has to be usually done on the old locations. This means, in most cases, that the plots will be up-and-down hill disposed, provision which is not of a nature to create conditions for the extension of conservation measures.

The best scenario (4.3.2.n. - corn 20%, bean 20%, winter wheat 30%, bromus 30%, bench terraces, minimum tillage, medium fertilized) has revealed that soil losses reaches 1.42 t/ha offering a very good protection.

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CHOOSING THE INPUT PARAMETERS OF SOIL EROSION MODELS

NELU POPA, GHEORGHE PURNAVEL, EUGEN FILICHE AND GABRIEL PETROVICI

Abstract: This paper refers to a representative watershed with moderate erosion, 47.9 ha area, situated in Tutova Rolling Hills, eastern Romania. The main conservation practices used are bench terraces and strip cropping.

Analysed scenarios have been focused mainly on identifying the hillslope homogenous units and channels that assure concentrated flow, taking into account the influence of their slope and size on the sediment yields. The study has revealed the channels parameters to which the model is the most sensitive. Also, it was important to know some of the more important aspects of watershed discretisation effects on the model response. Because of the decreased time in data preparation and computer run-time for lower levels of discretisation, users may be tempted to choose a coarse level. It is important to evaluate the sensitivity of result as compared to the amount of details in the input data and to estimate the level of discretisation, which is appropriate.

Two series of tests were designated to evaluate the response of the model to increasing levels of discretisation. The purpose of the first test was to determine the effect of the number of channels and hillslopes used with the same watershed geometry and size. The second test concerned an area drained by a channel network of increasing complexity.

The third series of tests was designated to evaluate the sensitivity of the model response to changes in the channel parameters on watershed.

Keywords: soil erosion, conservation practices, erosion models

Introduction

The users of soil erosion models are often in trouble when they have to prepare an input data set. The problems arise mostly when the input data must be selected from a multitude of possible variants, all seaming at a first look to lead to a correct solution.

All soil erosion models make use of relief parameters, which are very different from site to site. These input parameters refer, generally, to slope length and declivity. But there are some important questions that a user faces when trying to model a watershed: “How many hillslope profiles should be represented for an area?”. “How can be determined the slope length according to restrictions of the model?”. “When model is based on rill and interrill erosion equations, what channels should be choosen?”. “What is the assigned direction of flow on the hillslopes?”. “Which way the hillslopes feed the channels?”, etc. (Baffaut C. et.al, 1997).

The objectives of this study were:

- to identify, by analysing some scenarios, the hillslope homogenous units and channels that assure the concentrated flow taking into account the influence of the declivity and length on the sediment yields.
- to reveal the channels parameters to which the model is most sensitive.
- to know some of the more important aspects of watershed discretisation effects on the model response.

Slope length is the factor that involves most judgements, and the way it is determined by users varies greatly.

Slope length is defined as the horizontal distance from the origin of overland flow to the point where either the slope gradient decreases enough that deposition begins, or runoff becomes concentrate in a defined channel (Wischmeier and Smith, 1978).

The major slope length situations that users can find in the field are as follow:

A - If undisturbed forest soil above does not yield surface runoff, the top of slope starts with the edge of undisturbed forest soil and extends down slope to a windrow if runoff is concentrated by windrow.

B- From the point of origin of runoff to a windrow if runoff is concentrated by windrow.

C- From windrow to the flow concentration point.

D- From the point of runoff origin to a road that concentrates runoff.

E- From the road to a flood plain where deposition would occur.

F- On nose of hill, from the point of runoff origin to a flood plain where deposition would occur.

G- From the point of runoff origin to a slight depression where runoff would concentrate.

On this basis, it is important to reveal that simulation models, as the Universal Soil Loss Equation, calculate only the average annual erosion expected on a field slope, and do not estimate sediment yields. On a watershed, sediment yields include erosion from slope channels and mass wasting minus the sediment that is deposited after it is eroded, but before it reaches the point of interest.

In running process-based models like WEPP, a great influence has the relief parameters.

Methods

The study was made on 47.9 ha situated in the upper Tarina Valley – Tutova Rolling Hills, Romania.

Analysed scenarios have been focused mainly on identifying the hillslope homogenous units and channels that assure the concentrated flow, taking into account the influence of their declivity and area on the volume discharge and on the soil loss.

Two series of tests were designated to evaluate the response of the model to increase of level discretisation. The purpose of the first test was to determine the effect of the number of channels and hillslopes used with the same watershed geometry and size.

Figure 1 shows that the area was divided into seven hillslopes which are drained by three channels.

Figure 2 shows the test 1.b. where it can be observed an increased number of channels (6 channels and 13 hillslopes), with the same dimensions of the studied area.

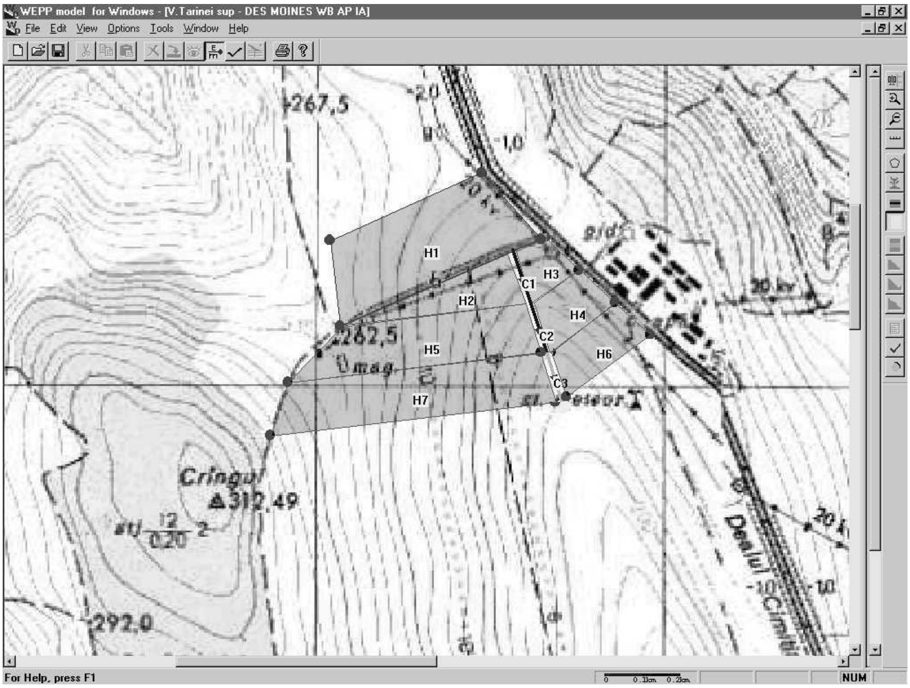

Figure 1 Tarina Valley – Tutova Rolling Hill,
Simulating erosion with WEPP, discretization – test 1.a

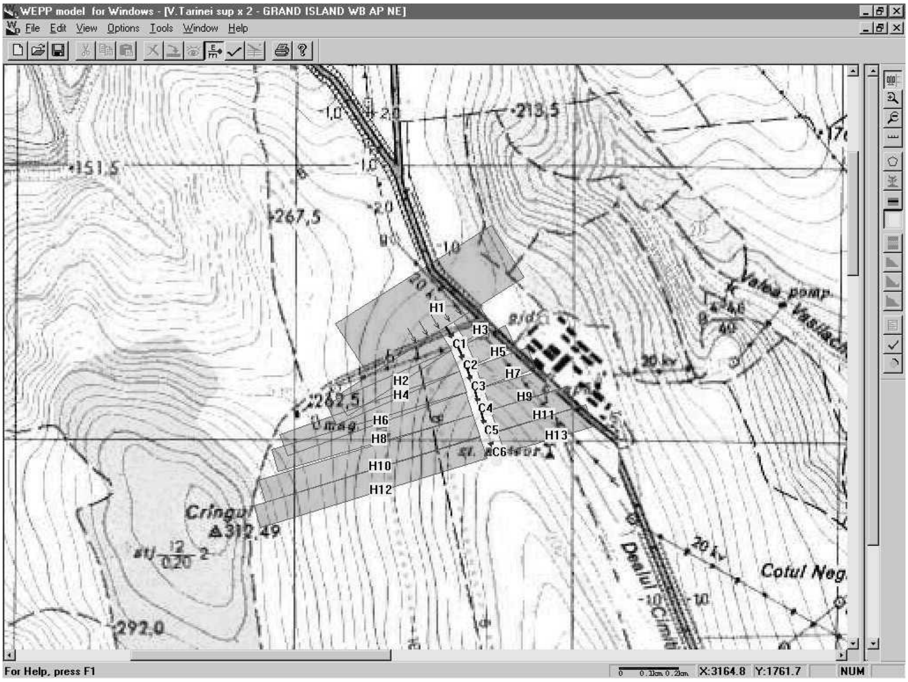

Figure 2 Tarina Valley – Tutova Rolling Hill,
Simulating erosion with WEPP, discretization – test 1.b

The second series of tests concerned an area drained by a channel network of increasing complexity. At first level Test 2.a. is identical with test 1.a. The area was divided into 19 different hillslopes drained by 17 channels (test 2.b.).

Slope declivity of all hillslope varied between 5 and 12 percent and the channel elements were triangular with a uniform 5% slope.

The soil surface was covered by maize. Conventional tillage (mouldboard plough) was used.

In Table 1, some results of discretisation tests on upper Tarina Valley are shown. It can be observed that simulation corresponding to test 1 indicates a low level of increasing runoff volume and soil loss as the number of channels and hillslopes increases.

Test 2 revealed a significant decrease of runoff and soil loss as the complexity of the channel network increases. This phenomenon was observed mainly for short and intense rain events. The correct number of elements and length of channels and hillslopes can be indicated by field observations.

Table 1 Results of discretization test of WEPP on upper Tarina Valley
Contributing area: 47.9 ha

Test No.	No. of channels	No. of hillslopes	Runoff volume (m^3/y)	Soil loss (to/y)
1.a.(2.a.)	3	7	15914.0	1216.4
1.b.	6	13	15923.0	1221.3
1.c	12	25	15954.0	1226.5
2.b.	17	19	12356.0	934.2

For example, field observations on Tarina Valley, particularly during heavy rains, indicated the most appropriate pattern of channels and hillslopes. Otherwise, the problem is difficult to solve, especially in this case, due to the influence of shelter belts.

Another example where the field observations contributed to find out the right network of channels, was the upper Crang Watershed – Tutova Rolling Hills (30 ha). After important rain events, especially in spring or in late autumn, when the soil is properly unprotected by crops, photos of rills offered useful information about the position and relative dimensions of the channels.

Often some input data are missing and may be estimated. According to such situation in Romania , the WEPP and EPIC models may be run with different amount of estimation. For instance, at Perieni Station it has been approach several stages:

- inventory of all input data required by the model which includes:
- identification of measured data;
- estimation of missing data.
- performing a comparative study between specific Romanian and American natural conditions to assess the missing data;
- developing step by step of a new database according to the format required by the model.

Tables 2 and 3 show analysed data of weather, relief, crop, soil and farm machinery.

Table 2. WEPP input data.

Crt. No.	Input data	Measured data	Assimilated data	Total
1	Climate	19	1	20
2	Relief	5	0	5
3	Vegetation	13	8	21
4	Soil	14	4	18
5	Tillage	4	7	11
	TOTAL	55	20	75
		73%	27%	100%

Table 3 EPIC input data.

Crt. No.	Input data	Measured data	Assimilated data	Total
1	General	16	2	8
2	Climate	9	11	20
3	Soil, relief	25	2	27
4	Vegetation	13	11	24
5	Fertilizers, irrigation, drainage, etc.	6	5	11
6	Tillage	4	7	11
	TOTAL	53	38	91
		58%	42%	100%

It may be noticed that the total percentage of missing data at Perieni Station was 27% for WEPP and 42% for EPIC.

Running of Climate Generation subroutine of models was possible only by using data provided by some meteorological stations in U.S.A., which have presented similar characteristics with Barlad meteo station in Romania. Thus, data concerning mean annual precipitation and temperature from some one thousand meteo stations were analysed. Finally, twelve of them have been considered. Among these, North Platte – Nebraska, with 498 mm annual precipitation and 9.7^{0}C average annual temperature, has been taken into account. Similar values only Dodge City – Kansas, Grand Island – Nebraska and Huron – South Dakota presented.

Conclusions

- Determination of the slope length factor of the Universal Soil Loss Equation involves most judgement of users.
- Due to the decreased time in data preparation and computer run-time for lower levels of discretisation, a user of erosion models may be tempted to choose a coarse level. It is important to evaluate the sensitivity of the results as compared to the amount of details in the data and to estimate the level of discretisation, which is appropriate;
- Field observations are very useful in providing the correct information concerning the number and dimension of channels and hillslopes;
- The missing input data must be carefully assimilated from the model database. A comparative study with local conditions is indicated.

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THE DEGRADATION OF CUIBUL VULTURILOR RESERVOIR UNDER THE IMPACT OF SOIL EROSION PROCESSES

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Abstract

The problem of soil erosion, sedimentation and water quality degradation of dam storage is alarming in the whole world, not only in our local area. It requires the development of a new global strategy, starting with the study of watershed processes and finishing with the approach to the issue of reclamation, exploitation and conservation of agricultural lands, rivers and reservoirs.

Soil erosion has a great impact on reservoirs, owing to sedimentation and the degradation of water quality.

The sedimentation process cannot be stopped, only diminuated, and has negative consequences on normal exploitation of reservoirs. In the studied reservoir, these processes are due to the deposit of sediments from the Tutova River (the main water supply of the reservoir) and of those from hill slopes and watersheds located in the vicinity of the reservoir.

The degradation of water quality is mainly due to a decrease in water depth and to the natural or artificial addition of fertilisers.

As regards the sedimentation of the Cuibul Vulturilor reservoir we noticed that:

In 1992 the useful volume of water was 6,400,000 $m^{3,}$ compared to the 9,500,000m^3 forecast in 1978;

The sedimentation volume, in 1982, was 3,100,000 m3, compared to the 140,000m^3 forecast in 1978;

In 14 years the rate of sedimentation in the reservoir was 32.63 %, with a 2.33% average annual ratio.

The annual sedimentation ratio is 221,430 $m^{3,}$ in comparison with 10,000 m^3, which was anticipated in 1977 by I.C.P.G.A. Bucharest;

The thickness of the deposited sediment throughout the length of reservoir has maximal values close to dam (1.9-2.1 m), thinning out to the end of the reservoir (0.9-1.2 m) in the middle area and (0.2-0.4 m) at the far end;

As regards the degradation of the water quality in Cuibul Vulturilor reservoir we noticed:

The main fertiliser elements used in this area are the nitrogen, phosphorus and potassium compounds.

In June, when the level of precipitation is maximal, the concentration value of the studied elements is also maximal;

The largest concentration value of the studied elements is recorded at the lateral water inlets;

As a result of the dilution process, at the intake points the water quality is not affected;

Keywords: soil erosion, sedimentation, water quality.

Introduction

The problem of soil erosion, sedimentation and water quality degradation of dam storage is alarming in the whole world, not only in our local area. It requires the development of a new global strategy, starting with the study of watershed processes and finishing with the approach to the issue of reclamation, exploitation and conservation of agricultural lands, rivers and reservoirs.

The data published in F.A.O., I.U.P.R.O., U.N.E.S.C.O. reports, International Association of Soil and Water Conservation Report and other synthesis papers showed that:

Yearly, about 25.4 billion tons of soil is eroded, from hill slopes where the maximal limit is surpassed. Walling and Webb (1983) say that every year, the rivers of the world carry about 15 billion tons of suspensions and about 4 billion tons dissolution's to seas and oceans (Hadley, 1985). As the area of the watershed grows larger, rivers manage to evacuate less than 1% of the total soil eroded; the rest is found in local storage (alluvial plains and storage dam reservoirs);

The opposite of erosion is sedimentation, without which no fertile alluvial plain would exist. A great part of sedimentation is achieved today in rivers, through dam storage. The water table of dam's reservoir storage covers more than 1% of the Earth surfaces. Reservoirs have larger possibilities, due to their volume, which is 5 or 6 times larger than the multi-annual discharge of the world rivers (1250 K.^{3}/s); therefore they retain a larger quantity of sediments.

The Cuibul Vulturilor reservoir, located in Eastern Romania (in the watershed of the Tutova River, flowing through the Tutova Hills, at 34.5 km from the source), provides part of the water necessary for the population of the city of Bârlad. The reservoir was formed along with the erection of an earth dam (17m in height and 843 m long at crest) with a central weir and a diversion dam on the Right Bank. In 1978 it was taken into exploitation, with the following planned characteristics (from Normal Retention Level): available water volume – 9,500,000 m^3, deadstorage capacity – 300,000 m^3, annual sedimentation ratio – 10,000 m^3.

In 1978, with the help of synthesis hydrological data offered by the National Institute of Meteorology and Hydrology, the National Research and Project Institute for Water Management – Bucharest, a study was made regarding the sedimentation of this reservoir. It that (in the Tutova control section of the Tutova river – annual mean value): the affluent flow is – 0.86 m^3/s: the alluvial discharge is 0.6 kg/s (i.e. 19.000 to/year) – which corresponds to a specific rate of 0.28 to/ha and year.

There are two-deposit area at 3 – 5 km and 7 – 9 km from the dam, whose thickness after 50 years could reach an average value of 1 to 1.5 m's.

The average volume of these deposits area could reach 1.000.000 m^3, fifty percent of which would be situated under the permanent water area. This study shows that the deadstorage capacity of the reservoir - 300.000 m^3, will be reached in 30 years of exploitation.

Soil erosion has a great impact on reservoirs through the processes of sedimentation and degradation of the water quality.

The sedimentation process cannot be stopped, only diminuated, and has negative consequences on normal exploitation of reservoirs. In the studied reservoir, these processes are due to the deposit of sediments from the Tutova River (the main water supply of the reservoir) and of those from hill slopes and watersheds located in the vicinity of the reservoir.

The degradation of water quality is mainly due to a decrease in water depth and to the natural or artificial addition of fertilisers.

Research method

The sedimentation of this reservoir, at N.N.R. (normal retention level – semi-permanent average exploitation level) under the impact of the erosion process was set by bathymetric and topographic measurements of 11 transverse profiles, in 1992. These profiles were remade first after 4 then after another 3 years (only some of the profiles, seen as typical for the description of the sedimentation process). In order to achieve these measurements and to re-make them at various intervals (3 or 4 years) transverse profiles were materialised, which cover the whole water table of the reservoir, spaced off by 300 to 500 metres. (Figure number 2). Along the length of these profiles bathymetric measurements were made every 30m (by means of a cable with fixed spaced floats) on a floating platform mechanically powered. These were followed by topographic measurements on both banks, in order to provide a reliability of 1.0 $^0/_{00}$. The first measurements were made in 1992, which were resumed in 1996 and 1999.

The degree of degradation (pollution) of the water quality under the influence of the loss of nutrients due to the erosion process, was established by monitoring the concentration of these elements at the intake points of the Cuibul Vulturilor reservoir (rivers: Tutova, Iaura, Roşcani and Cârjăoani – the last three with non-permanent regime) and at the water intake points. Between 1996 and 1999 a number of 204 samplings were taken from the frontal intake point (Tutova River), 306 samplings from the lateral intake points (rivers Iaura, Roşcani and Cârjăoani) and 102 samplings from the main intake area. Water samples were taken manually or with an ISCO (Automatic Water Sampler), during normal discharge flow and during or after hydrologic events, from February to October. The prelevation, preparation and conservation of samples for were made according to the current Romanian standards.

In this case the principal elements studied were: nitrogen, under the form of nitrates colorimetrically determined with acid phenol 2÷4 disulfonic; ammonium nitrogen - colorimetrically determined with reactive Nessler; phosphorus – like blue molybdenum colorimetric dosing, and potassium - in flame photometry dosing.

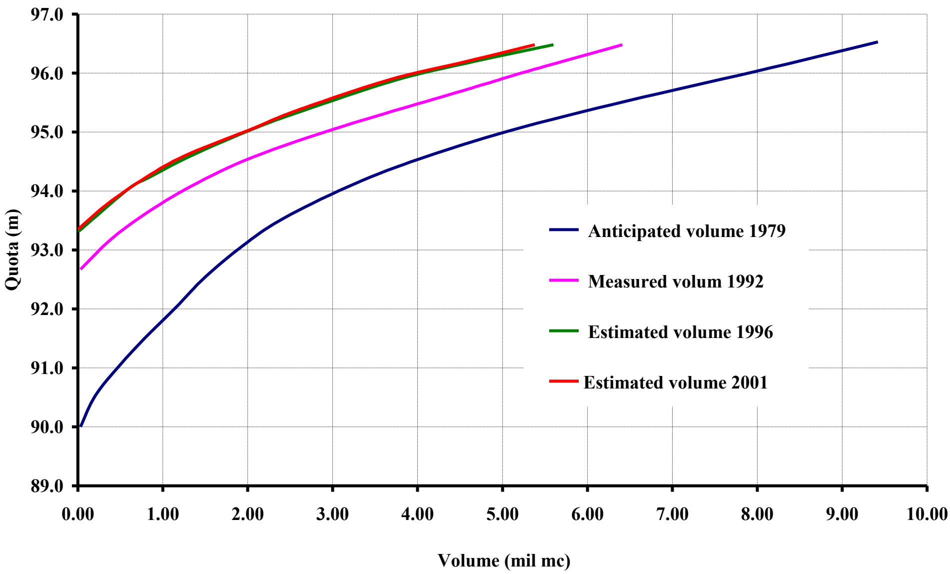
Results obtained

Reservoir sedimentation

By processing data from 1992, we could restore the curve showing the capacity of the reservoir (Fig. 1), establishing the amount of sedimentation; we could also estimate the average annual sedimentation ratio; the water volume at N.L.R. was 6,400,000 m^3 and the sedimentation volume 3.100.000 m^3. In this situation, the amount of sedimentation after 14 years is about 32.6 % and the annual sedimentation ratio for this reservoir is 0.29 mil. m^3, which means 1.8 % of the initial water volume at N.L.R.

Figure number 1

Cuibul Vulturilor reservoir capacity curve at N.L.R.

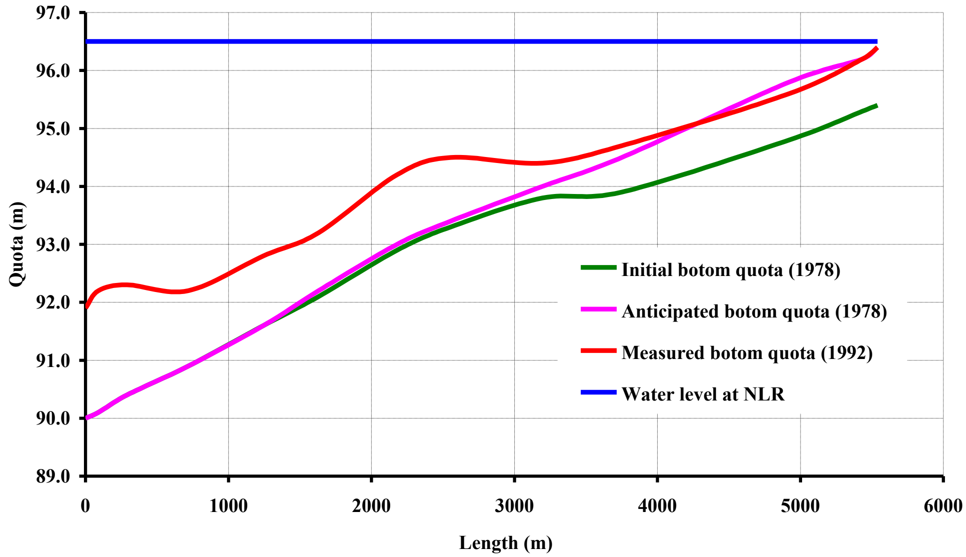


The longitudinal profile of the reservoir shows how the sediments are deposited along the length of the reservoir (Fig. 2). We observed that the thickness of the deposited sediment throughout the length of reservoir has maximal values close to the dam (1.9-2.1 m), thinning out to the end of reservoir (0.9-1.2 m) in the middle area and (0.2-0.4 m) at the far end.

The restoration of bathymetric and topographic profiles from 1992, on the same alignments, in 1996 and 1999, permitted, by comparing them, to differentiate the thickness of deposited sediment at different areas of the reservoir. The initial profile from 1978 was realised with the help of topographical plans (scale 1/5000). Two profiles were analysed comparatively (Figure number 3 and figure number 4), which were considered typical for the description of the sedimentation process. This analysis outlines the thickness and the distribution of sediments:

Figure number 2

Cuibul Vulturilor Reservoir – longitudinal profile



The profile P1, situated in the area of direct influence of watershed Cârjăoani (with a valley gully as the predominant form of erosion):

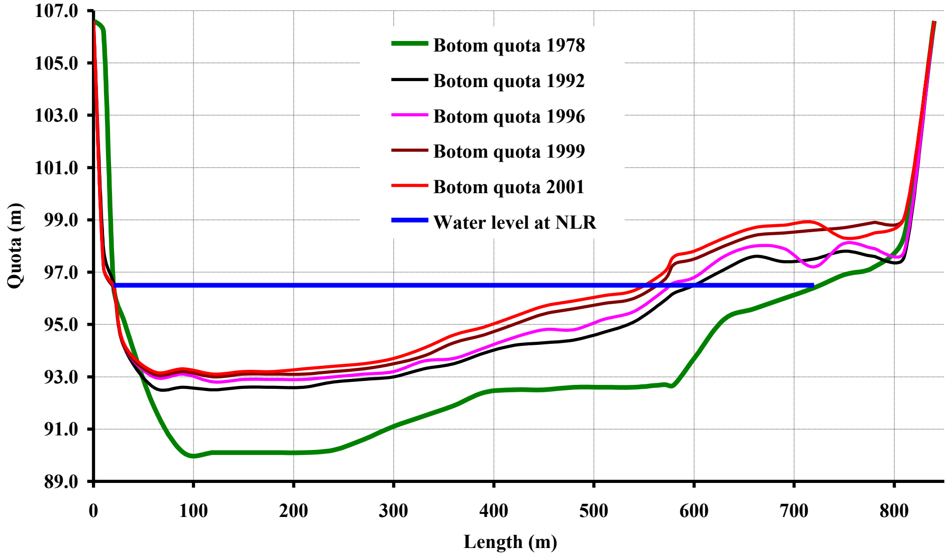
In 1992, after fourteen years of exploitation, the deposits are unevenly distributed throughout the length of the profile, with a thickness of 2.5 m on the left bank, 1.8 m in the central area and 3.5 m on the Right Bank. The average annual ratio of sedimentation was 0.16 – 0.13 – 0.25 m. throughout the length of the profile.

In four years, from 1992 to 1996, the deposits were relatively evenly distributed throughout the length of the profile: 0.4-m on the left bank, 0.3 m in the central area and 0.6 m on the right bank. On the left bank there are relatively larger values because there appeared a hill gully during the thaw of early 1996. The average annual ratio of sedimentation was 0.10 – 0.08 – 0.15 m throughout the length of profile;

In three years, from 1996 to 1999, the deposits were clearly unevenly distributed throughout the length of the profile: 0.1-m on the left bank, 0.2 m in the central area and 0.7 m on the right bank. The average annual ratio of sedimentation was 0.03 – 0.06 – 0.23 m's throughout the length of the profile.

Figure number 3

Cuibul Vulturilor Reservoir – P1Cross profile



Profile P4, situated in an area without the direct influence of a watershed area, only with the influence of a nearby hill:

In 1992, after fourteen years of exploitation, the deposits were evenly distributed throughout the length of the profile, with a thickness of 1.2 m on the left bank, 1.4 m in the central area and 1.5 m on the Right Bank. The average annual ratio of sedimentation was 0.09 – 0.10 – 0.11 m. throughout the length of the profile;

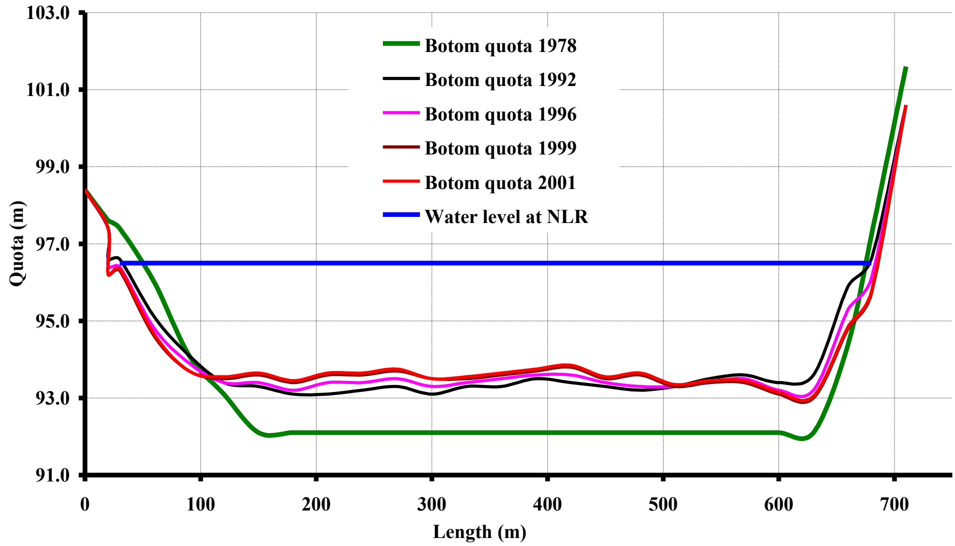
In four years, from 1992 to 1996, the deposits were fairly evenly distributed throughout the length of the profile: 0.13-m on the left bank, 0.16 m in the central area and 0.12 m on the right bank. The thickness of the sediment grows to the centre of the profile and fingers out to both banks, as the result of the lower charges of hill stream flows. The average annual ratio of sedimentation was 0.03 – 0.04 – 0.03 m throughout the length of profile;

In three years, from 1996 to 1999, the deposits were thicker to the centre of the profile and to both banks, as a result of the lower charges of hill stream flows. The thickness of the sediment throughout the length of the profile is 0.10 m on the left bank, 0.20 m in the central area and 0.10 m on the Right Bank. The average annual ratio of sedimentation was 0.03 – 0.06

– 0.03 m throughout the length of the profile.

Figure number 4

Cuibul Vulturilor Reservoir – P4 Cross profile



Degradation (pollution) of water quality

As regards the dynamic nitrogen, under the form of nitric nitrogen (Figure number 5) we noticed an increase in the average monthly values in April and October; a process accountable by the fact that in this period the vegetation is less developed, therefore the soil is less protected from erosion. The increase in concentration of June is due to the fact that rainfalls are at their highest and wash away nitric nitrogen. Maximal values of 37.2 PPM (Table 1) do not exceed the limit of 45 PPM permitted by STAS for this category, while the minimum values are characteristic for a normal discharge flow.

Nitrogen, under the form of ammonium nitrogen, being trapped in the adsorbent soil complex, is hard to wash, compared to nitric ion nitrogen. The increase recorded during the spring season and in September (Figure number 6) is due more to ammonium nitrogen, which comes from manure washing, containing 0.32 – 5.82 % nitrogen - 1/3 under ammonium form (Davidescu D. and V., 1978). The data in Table 2 show that although the maximal monthly value at intakes exceeds the value permitted by Romanian standards – 1 PPM for first use category in plug area with an annual average value of 0.47 PPM, allow us to set the reservoir in this category.

Figure number 5

Dynamic nitrogen, under nitric nitrogen form on frontal and laterally input and form plug area during 1996 - 2001

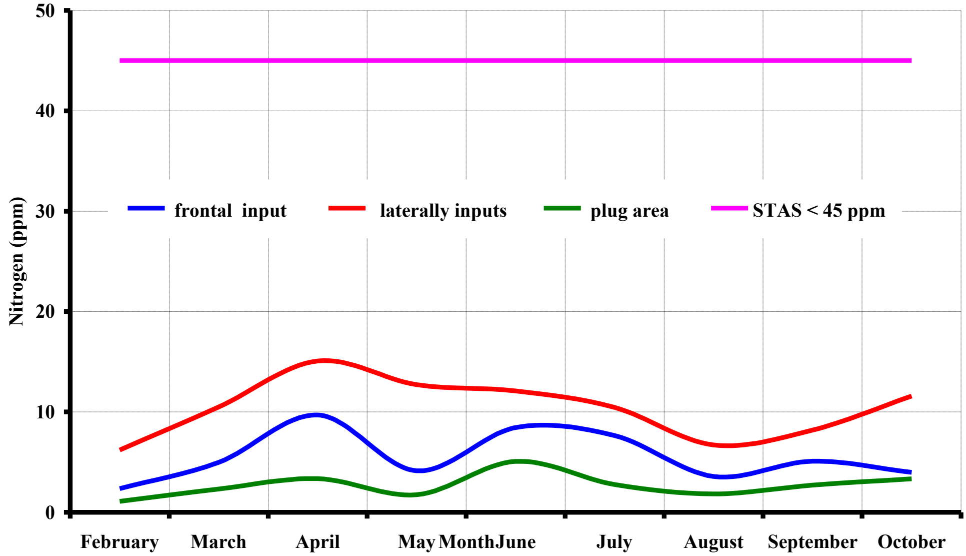


Figure number 6

Nitrogen, under ammonium nitrogen form, on frontal and laterally entrance and form plug area during 1996 – 2001

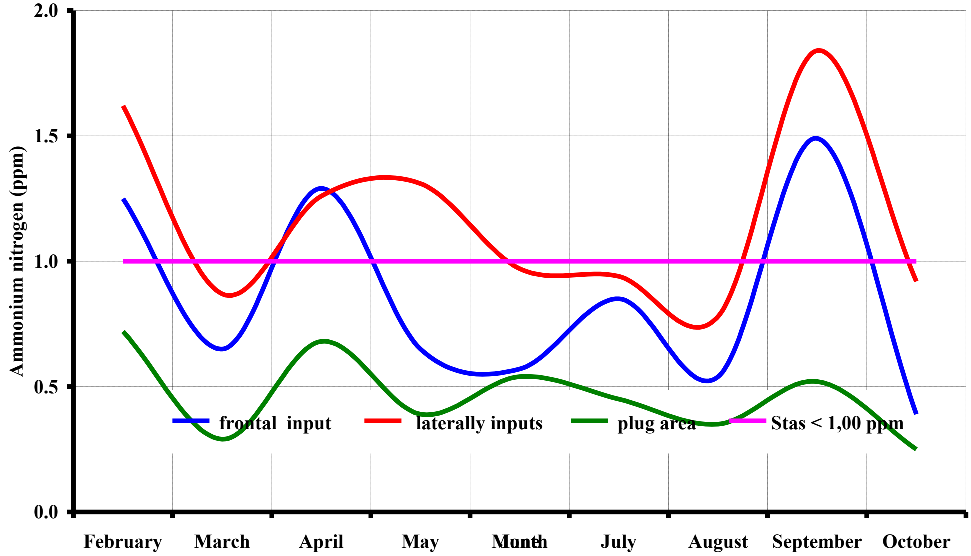


Table 1 shows the average annual value of nitrogen as an element under nitric and ammonium nitrogen form – the sum of which is considered to form the mineral nitrogen. In fact the nitrogen lost from agricultural lands, by water leaks, amounts to 5 – 20 % and that lost due to soil erosion amounts to 80 – 95 % of the total loss of nitrogen. Part of the soil eroded (with organic nitrogen) is found in the reservoir. In conclusion we can tell that the washed out nitrogen greatly contributes to the acceleration of the eutrophyc process of the reservoir, a process characteristic reservoirs with total nitrogen content larger than 1.5 PPM (Cojocaru I., 1995).

Table no.1

Average year value of studied elements, on frontal and laterally inputs and form plug area of Cuibul Vulturilor reservoir, during 1996 – 2001

Value	Laterally input	Frontal input	Plug area
AMMONIUM NITRATE			
Minim	3.76	2.13	1.10
Maxim	37.2	20.37	5.07
Year average	10.39	5.54	2.69
AMMONIUM CATION			
Minim	0.30	0.23	0.18
Maxim	5.10	3.60	1.18
Year average	1.00	0.85	0,47
AMMONIUM MINERAL			
Nitric ammonium	10.39	5.54	2.69
Ammonium nitrogen	1.00	0.85	0.47
Ammonium mineral	11.39	6.39	3.16
PHOSPHORUS ANION			
Minim	0.24	0.20	0.20
Maxim	2.02	0.86	0.31
Year average	0.55	0.38	0.24
POTASSIUM CATION			
Minim	5.2	4.0	4.7
Maxim	56.6	23.6	12.0
Year average	11.7	10.7	8.3

From the dynamics of phosphorus anion (Figure number 7), we find that the evolution of this anion is similar to that of the nitrogenous anion, with concentrations increasing in the spring season, when the soil is less protected from erosion, and in June, a month with a high level of rainfall. The loss of phosphorus is lower than that of nitrogen because it is fixed in the soil and it is less likely to migrate (Buckman and Brady, 1961). Although at the reservoir intake points the value is higher than 0.5 PPM – the value allowed by Romanian standards for first use category (Table 1), in the plug area the quality of the water is not affected. The contribution of mobile phosphorus (under the form of phosphorus anion in water) to the total phosphorus share in reservoir is from 0.08 to 0.18 PPM in the eutrophization process (total phosphorus higher than 0.15 PPM).

Figure number 7

Phosphorous dynamic's, under phosphorus anion form, on frontal and laterally entrance and form plug area during 1996 – 2001

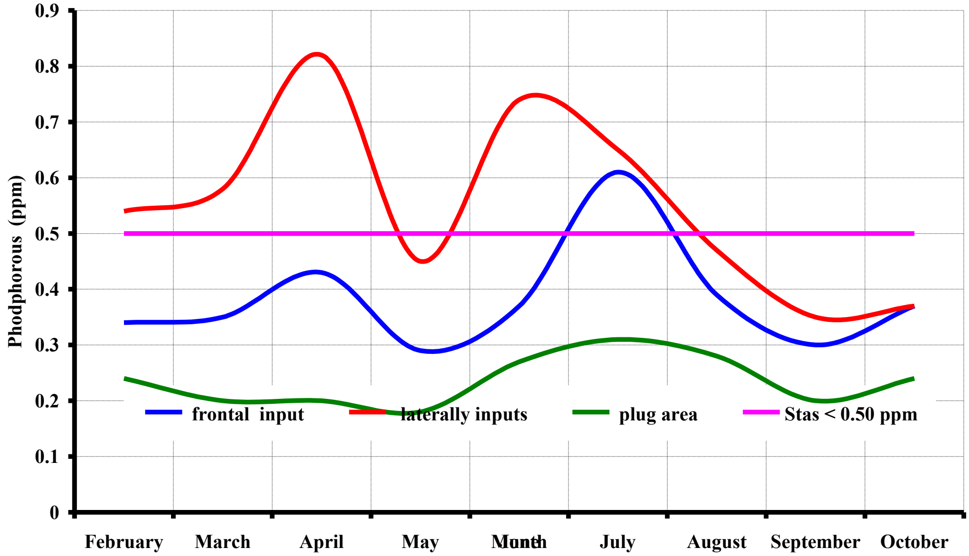
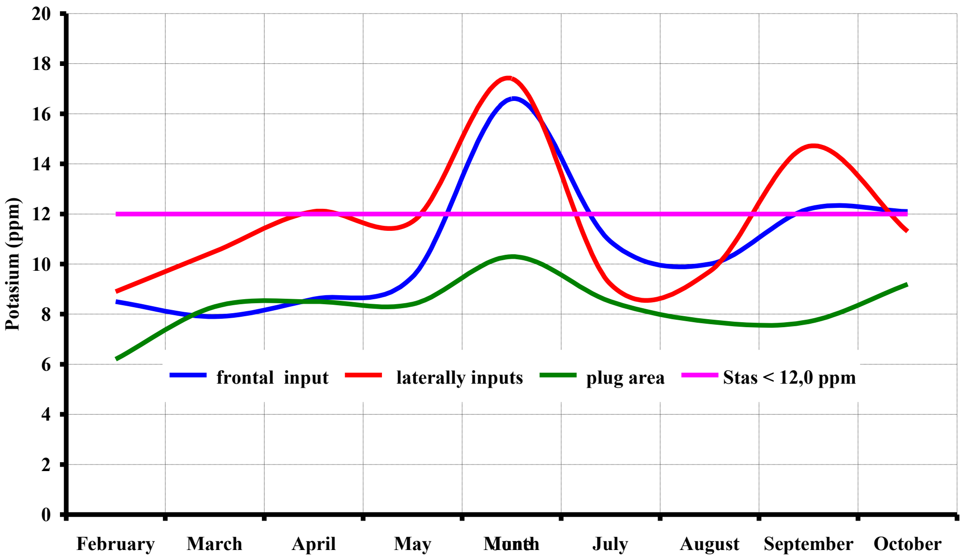


Figure number 8

Potassium dynamics, on frontal and laterally and form plug area during 1996 – 2001



Conclusions

As concerns the sedimentation process of Cuibul Vulturilor reservoir we can conclude:

In 1992 the useful volume of water was 6,400,000-m3, compared to 9,500,000 m^3 as it was forecast in 1978;

The sedimentation volume, in 1982, was 3,100,000-m3 compared to 140,000 m^3 as anticipated in 1978;

In 14 years, the rate of sedimentation of the reservoir was 32.63 %, with a 2.33% average annual ratio.

The annual sedimentation ratio is 221,430 m^3, in comparison with 10,000 m^3, as estimated by I.C.P.G.A. Bucharest in 1977;

The thickness of the deposited sediment throughout the length of the reservoir has maximal values close to dam (1.9-2.1 m), thinning out to the end of reservoir (0.9-1.2 m) in the middle area and (0.2-0.4 m) at the far end;

We noticed a variable ratio of sedimentation: in the direct intake area of micro-watersheds, it is 4 or 5 times higher than the value recorder in the areas influenced by the hill slopes directly adjacent to the water-table.

The same was noticed about the granulometry of the sediment: it is finer at the far end of the reservoir and rougher close to the dam.

As concerns the degradation of the water quality degradation of *Cuibul Vulturilor* reservoir, we can conclude:

The main fertiliser elements used in this area are: nitrogen, phosphorus and potassium;

In June, when the level of precipitation is highest, the concentration of the studied elements is also at its highest;

The highest concentration of the studied elements is recorded at the lateral intakes;

As a result of the dilution process, in the direct intake area the water quality is not affected;

In sprig and the beginning of autumn, when the soil is insufficiently protected against erosion, the contents in fertiliser elements increase in the supply sources of the reservoir;

The highest concentrations are recorded in the nitrogen and potassium because these are not strongly retained by the adsorbent complex of the soil.

Fertilisers used on agricultural land are not a source of degradation of the quality of surface water.

From a chemical viewpoint, the reservoir sediment is slightly alkaline (7.1-8.4), the content of humus is very small to small (0.3 – 1.9 %) and poor in total nitrogen (0.02 – 0.10 %), which leads to insignificant influence in the degradation process of the reservoir water.

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THE INFLUENCE OF CROP ROTATION AND FERTILIZERS CONCERNING GLUTEN CONTENT ON THE SLOPING LAND

NĂSTASĂ V., ELENA NĂSTASĂ

Abstract: Generally on arable sloping land, obtaining high yields consecutively with soil erosion prevention are desired. Concerning yields, especially wheat yield one of the most important quality index is gluten content. Having in view that the rate of fertilizers and the crop rotation are two factors which have a grate influence on gluten content a series of experiments were carried out at CRSSEC Perieni in order to quantify the link between these variables. It has been studied the variation of gluten content by application of different rates and types of fertilizers. The rates of fertilizers have been increasing from 32 kg/ha to 128 kg/ha nitrogen and phosphorus. Also has been studied the influence of different types of crop rotation on gluten content. A strong correlation has been observed between the amount of fertilizers applied and gluten content, and also between crop rotations and gluten content. Statistically analyze of results has shown the existence of significant difference between different rates of fertilizers.

The gluten content had variable values from 15.5% to 23.9% in monoculture, from 16.3% to 27.4 % in two years crop rotation, 17.5% - 27.3% in three years crop rotation and 15.3%- 23.8% in five years crop rotation.

Key words: fertilization, crop rotation, gluten, sloping land.

Introduction

This kind of researches were effected in different conditions in our country. So in 1967 O. Bunescu and C. Coronea did a series of analyses relating to preliminary influences of fertilizers on the chemical composition of wheat after five years of cultivation in monoculture and in rotation with corn and bean. Te authors establish that the previous plant strongly influence the wheat chemical composition, especially the content of total nitrogen and protein. The highest total nitrogen and protein content was registered after bean followed by the wheat cultivated after corn and the lowest in monoculture. The researches on brown – red forest soil from Saftica undertaken by D Dinca and co- workers (1971) underline that after 12 years of experiments, there is a tendency of increase in the content of protein, P2O5 and starch exclusive of the crop rotation. The fertilizers application has determine increases of protein content, especially in monoculture noticing the positive influence of manure. Cr. Hera and co-workers (1979) researching the influence of some technological factors on the content of protein and its quality, establish that one of the main factor is represented by the previous crop. At SCA Turda , Maria Stefanescu (1997) experimented the long term fertilization with nitrogen and phosphorus influence of the wheat quality yield and established a rise in the protein quantity up to 3% compared to the unfertilized variant, following the administration of 40-160 kg/ha nitrogen.

Material and method

The experiments have developed at C.R.S.S.E.C. Perieni on a 112-14 % slope on a moderate chernosem soil. It has been followed the influence fertilization rates (nitrogen and phosphorus) applied at the winter wheat crop and the crop rotation on gluten content. The experimented factors were: 1. the fertilization level with five options: unfertilized- control, N32P32, N96P96, N128P128, manure 50t/ha once every three years; 2. the crop rotation with four options: monoculture, two years crop rotation (wheat-corn), three years crop rotation (wheat-wheat-corn) and five years crop rotation (bean-wheat-corn-sun flower –grass). The gluten content was determine in according with national methods, by using the wheat yields in the last five years. The interpretation of the results was made also in according with national methodologies.

Results and discusions

Tight connection was observed between the level of fertilizers and the gluten content, as well as between the crop rotation type and the gluten content. The differences between variants were statistically analyzed and the following dates were obtained.

In which concerns the influence of fertilization rates on the gluten content an increase of gluten content was established in the same time with the increase of rate of fertilization. So in monoculture was established a rise of gluten content, but at the application of a superior dose of N32P32, practically the gluten content was unchanged compared to the unfertilized variant, 15.5%. Important increases between 33-54% were registered in the fertilized variants with high rates of chemical fertilizers (table no 1).In organic fertilized variant establish a progress of 9.7% compared to the control.

In the two years crop rotation in which wheat is preceded by corn the gluten content raised compared to the monoculture in all fertilized variants. If in unfertilized variant the gluten content raised at level of 16.3% in N32P32 variant established a insignificant rise. But the application of

N96P96 and N128P128 doses determined the accumulation of a gluten quantity raised with 48%-68%.compared to unfertilized variant.

In three years crop rotation when wheat is cultivated after wheat the gluten content is between 17.5 % in control variant and 27.3% in N18P128 variant. With the organic fertilized variant exception the others got obtain significant increases (12%-56%).

In three years crop rotation when the wheat is preceded by corn the gluten content has recorded higher values than the variant which had as previous crop wheat excepted the unfertilized variant. This is the reason of the big differences between the fertilized variants and the control variant. Thus, if in control variant the gluten content was by 16.4% in fertilized variants it's values has increased up to 20.3% in N32P32 variant, with 23.7% more than control, 27.5% in N96P96, 29.2% in N128P129 and 20.3% in organic fertilized variant. (table 1).

The gluten content reached maximum values (32.0%and 32.8%) in the five years crop rotation in the chemical fertilized variants with N96P96 and N128P128 rates. It must be mentioned also that all fertilized variants determined very important increases of the gluten content.

Table 1 The significance of the differences of the gluten content depending on fertilization rates and type of crop rotation

Variant		Gluten content	Difference		Significance
		%	%	%	
Monoculture	N_0P_0	15.5	100.0	0.0	-
	$N_{32}P_{32}$	15.5	100.0	0.0	-
	$N_{96}P_{96}$	20.7	133.3	5.2	* * *
	$N_{128}P_{128}$	23.9	154.0	8.4	* * *
	50 t manure	17.0	109.7	1.5	*
Two years crop rotation	N_0P_0	16.3	100.0	0.0	-
	$N_{32}P_{32}$	16.8	103.1	0.5	-
	$N_{96}P_{96}$	24.2	148.0	7.8	* * *
	$N_{128}P_{128}$	27.4	168.0	11.1	* * *
	50 t manure	18.0	110.2	1.7	* *

Variant		Gluten content	Difference		Significance
		%	%	%	
Three years crop rotation (W/W)	N_0P_0	17.5	100.0	0.0	-
	$N_{32}P_{32}$	19.6	112.2	2.1	* * *
	$N_{96}P_{96}$	26.0	148.6	8.5	* * *
	$N_{128}P_{128}$	27.3	156.2	9.8	* * *
	50 t manure	18.3	104.8	0.8	-
Three years crop rotation (W/C)	N_0P_0	16.4	100.0	0.0	-
	$N_{32}P_{32}$	20.3	123.7	3.9	* * *
	$N_{96}P_{96}$	27.5	167.3	11.1	* * *
	$N_{128}P_{128}$	29.2	177.5	12.7	* * *
	50 t manure	21.0	127.8	4.6	* * *
Five years crop rotation	N_0P_0	15.3	100.0	0.0	-
	$N_{32}P_{32}$	18.0	117.4	2.7	* * *
	$N_{96}P_{96}$	32.0	208.7	16.7	* * *
	$N_{128}P_{128}$	32.8	214.1	17.5	* * *
	50 t manure	19.7	128.3	4.3	* * *

LSD 5% =1,16% LSD 1% = 1,56 % LSD 0,1% = 2,05 %

In which concerns the crop rotation in the determination of the gluten level were made averages on the five fertilizers rates from every crop rotation type. The results from the table 2 shows an increase of gluten content from the monoculture to the five years crop rotation.

The lowest content was registered in monoculture(18.5%) followed by the two years crop rotation(20.6%), three years crop rotation (21.8% and 22.9%) and the five years crop rotation (23.6%). Comparative with the values obtained in monoculture gluten content has increased with 11.1% in two years crop rotation, with 17.9% in three years crop rotation when wheat follow after wheat, 23.2% in the same rotation but wheat follow after corn and 27.3% in the five years crop rotation where the winter wheat follow after bean crop.

Table 2 The gluten content depending on the crop rotation

Variant	Gluten content			Significance
	%	Differences		
		%	%	
Monoculture	18.5	100.0	0.0	-
Two years crop rotation	20.6	111.1	2.0	*
Three years crop rotation	21.8	117.6	3.3	**
Three years crop rotation	22.9	123.7	4.4	***
Five years crop rotation	23.6	127.3	5.1	***

LSD 5% = 1,50 LSD 1% = 2,18 LSD 0,1% =3,26

The averages values of the gluten content on the fertilizers levels have registered a very important rise only in chemical fertilized variants with N96P96 and N128P128 (table 3)

Table 3 The significance of gluten content differences depending on fertilization level (average on five years)

Varianta	Gluten content			Significance
	%	Differences		
		%	%	
N_0P_0	16	100	0.0	-
$N_{32}P_{32}$	18	111	2.0	-
$N_{96}P_{96}$	26	161	10.0	***
$N_{128}P_{128}$	28	173	12.0	***
50 t/ha manure	19	116	3.0	-

LSD 5% = 2,86 LSD 1% = 3,84 LSD 0,1% = 5,06

The gluten value content in the unfertilized variant was of 16%. The application of a small rate of chemical fertilizers and organic fertilizers too have determine an insignificant rise with 11% and 16% more than the control variant. The significant rises were register only in chemical fertilized variants with high rates of fertilization with 61% and 73% higher than the control

In fig.1 are showed the regression equations. Analyzing of these equation we‘ll observe that between fertilization level and gluten content there is a positive and significant correlation. Regression coefficient values were by 0.992 in monoculture, 0.985 in two years crop rotation 0.987 in three years crop rotation (W/W), 0.997 in three years crop rotation (W/C)and 0.956 in five years crop rotation.

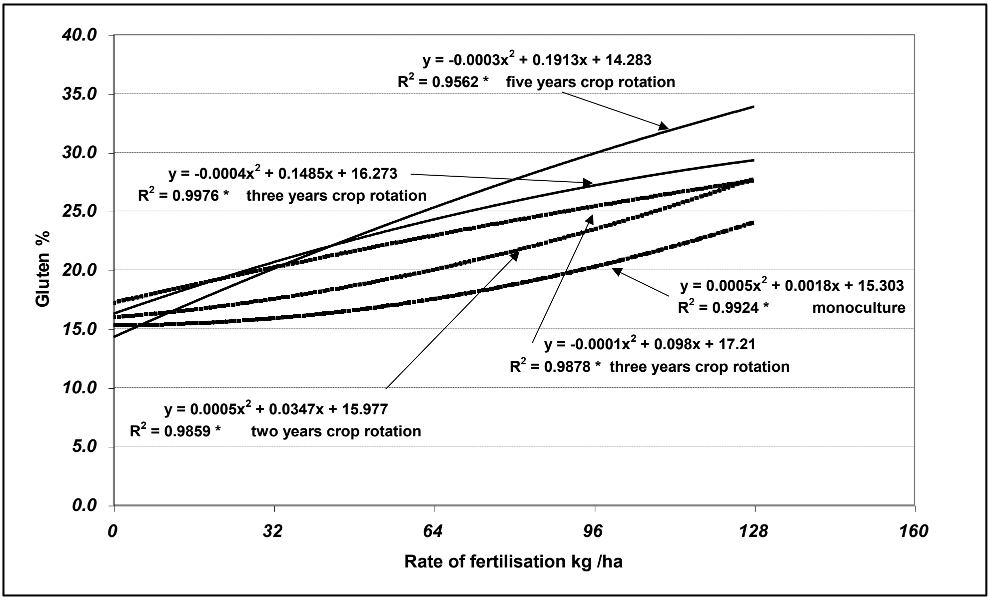

Fig. 1 The correlations between the rate of fertilization and the gluten content

Conclusions

1. Concerning the influence of fertilization level of gluten content was establish a rise in all crop rotation variants when fertilizers quantity applied has increased ;

2. The application of a small doses of chemical fertilizers and manure have determine a insignificant rise with 11% and 16% than the control. Significant rises were established only in chemical fertilized variants with high levels of fertilizers, respectively with 61% and 73% more than control variant;

3. The crop rotation establish a significant rise of gluten content. The lowest content was establish in monoculture (18.5%) follow two years crop rotation (20.6%), three years crop rotation and the highest content was registered in five years crop rotation (23.6%).

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THE INFLUENCE OF SOIL COMPACTION ON SOIL EROSION, NUTRIENTS LOSSES AND CORN PRODUCTION

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Abstract: Over the period 1999 – 2004, on the background of an on going runoff plots experiment, different compaction treatments including extra wheel-by-wheel multiple tractor passes, were applied. During the 6-years experiment, the influence of soil compaction expressed by bulk density, resistance to penetration and total porosity on soil and water losses, nutrient losses, and corn yield was studied.

The effects of excessive soil compaction induced by up to 15 wheel-by-wheel passes of a 2.7 tons tractor to a depth of 0.25-0.30 m, even though unlikely to occur in our area, are easily annihilated by the loosening effect of freezing and thawing during winter and by normal operations.

Excessive compaction treatments applied before planting in spring do not result in any limitations of root growth during early stages of plant development. The threshold value of 2.5 MPa of resistance to penetration is overtaken during the second half of July, due to natural decline of soil moisture content.

Tillage pans are rarely noticed as sparsely distributed spots and the contour strip cropping system of soil conservation masks their occasional role in soil erosion.

Apparently, additional traffic compaction, limited to maximum of 15 tractor passes in our experiments, has a somehow beneficial effect on soil erosion, so that runoff increased by 40 %, but soil and nutrient losses were not so high. In other words, the water in the runoff becomes cleaner with moderate compaction.

During the three initial years 1999, 2000 and 2001, a slight decrease in corn yield with increase of soil compaction was observed. During the following years, that relationship was no longer obvious. The overall level of corn production was relatively low after 2000, if compared with yields in the previous decade, because of some other critical factors responsible for yield and time, not discussed.

Key words: Soil compaction, cone penetration resistance, soil and nutrient losses, corn yield.

Introduction

In Romania, as far as known, of a total agricultural area of 14.96 million hectares, around 6.37 million hectares (43%) are susceptible to water erosion of varying degree and associated processes. Of this area, nearly 2.6 million hectares are used for cropland (arable land). The average amount of the annual total erosion is 126 million tons of which 106.6 million tons are delivered by agricultural lands. Surface erosion (sheet-rill-erosion) is the main contributor to total erosion because the annual rate of such induced soil loss is estimated at 61.8 million tons (Motoc, 1983).

Some 2/3 of the arable land in Romania is estimated to be affected by compaction (Canarache et al., 1984). During the last 15 years, the most usual tractor was U-650, which has 65 HP and a mass of approximately 3.7 tons. The harvesting equipment only rarely carried loads greater than 10 tons. Only very few of the newly appeared farmers can afford heavier and more powerful field equipment. After 1991, the application of Law 18, which refers to reallotment of the original landowners, resulted in an increased rate of fragmentation of the agricultural land: 48 million individual plots on an area of 9 million ha (60% of the total agricultural land), 4.2 million agricultural estates with an average of 2.2 ha each, and containing 5-16 small parcels, sometimes sparsely distributed. As a consequence of this structure of land property, small individual landowners are encouraged to buy even less powerful tractors, conversely to the trend in western countries. The problems of soil compaction being close related to the nature and intensity of traffic will depend on how the size of land property and possibilities of farmers to buy powerful equipment will evolve.

Compaction from wheel traffic has often been found to influence adversely all stages of crop growth, responses being particularly marked in the early phases of establishment. However, in some situations crop responses to compaction are beneficial and this is particularly true in the case of certain loose sandy soils (Soane et al., 1982).

Reduced permeability in wheel ruts has been observed to lead to water erosion problems in Britain (Reed, 1979, cf. Soane et al., 1982), in Norway (Gaheen and Njøs, 1978, cf. Soane et al., 1982) and in Schleswig-Holstein, Germany (Fleige and Horn, 2000).

From a wide range of soil properties measured usually in compaction studies (Soane et al., 1980/1981), resistance to penetration is used on an ever wider scale as a complex parameter that describes the soil physical status. It was used initially in soil management, civil engineering and soil dynamics, to estimate resistance to ploughing or cutting and in studies on soil compaction or soil tillage. Later on, resistance to penetration was widely used in research related to root growth (Canarache, 1990). Together with vane-shear strength tests, resistance to penetration tests were sometimes used in soil detachability studies (Poesen, 1986, Torri, 1987).

The aim of this paper is to provide a contribution to a better knowledge of relationships between soil compaction by excessive traffic from wheeled vehicles and soil and nutrients losses by water erosion on sloping agricultural land.

Materials and Methods

The experimental site is located on mollisols (Cambic Chernozem), developed on top of sandy loams (Table 1), moderately to highly eroded, and has a slope of 10-12%.

Table 1 Cambic Chernozem, moderately to highly eroded in Tarina Valley, Perieni. Data extracted from a 1992 survey carried out by the regional soil authority

Hori-zon	Depth	Color (moist)	Particle size distribution			Bulk density ($Mg \cdot m^{-3}$)	Humus (%)	pH
			Sand	Silt	Clay			
Am	0-30	10YR 3/1	75.3	9.0	15.7	1.34	2.33	6.9
A/B	30-62	10YR 4/4	73.8	9.9	16.3	1.46	1.54	7.3
Bv	62-93	10YR 6/4	73.5	11.0	15.5	1.51	0.0	7.9
C	93-110	2.5YR 8/4	64.4	16.0	19.6	1.63	0.0	8.0

The experimental layout consisted of seven parallel plots of 400 m^2 each, 50 m long and 8 m wide, previously instrumented for runoff plots experiments (Figure 1 and 2). Each plot was divided in two, both by length and by width for two different reasons: 1) longitudinally each plot was split in two in order to have replicas of some variables like yield, soil moisture content, bulk density, excepting compaction treatment, 2) laterally, only half of each plot (4 m wide and 25+25 m long) was used for experimental tests, the other half (4 m wide and 50 m long) being used as buffer zone. After the application of compaction treatments and sowing, tin walls delimited the downhill half of each 50 m long plot, and runoff was collected only from these areas. Originally, when the site was used only for runoff experiments, treatments were randomized among the plots available. The splitting in two of each plot along the slope did not solved the problem of statistical coverage, because there was no room to leave also a buffer zone in between, and consequently to apply accurately the compaction treatments in a random manner (compaction treatments were applied on the up and down hill direction, while all other operations were performed following the contour lines). In autumn, all plots were primarily tilled by chisel, to a depth of 18 – 20 cm. Annually, complex fertilization was applied over all plots at the rate of 120 kg of Nitrogen and 80 kg of Phosphorus. The seedbed preparation was made by rotary tiller, and seeding was done by common row crops planter. During the last 5 years, the same Turda 200 corn hybrid was cultivated (no crop rotation). Usually, the sowing was done within the period of April 20 - May 10, and harvesting within the period September 20 – October 10 of each year, according to circumstances. The first and the second plot in the northern side of the experimental field (right hand side in figure 1) were used as control (no additional compaction treatments).

Figure 1 Runoff plots in Tarina Valley, Perieni

The first plot was maintained free of weeds, as continuous fallow (control 1) and the second was cultivated with corn, but did not receive any additional compaction (control 2). Every year, in spring, the other plots received 3, 5, 10, and 15 compaction treatments respectively. Compaction was done by up and down hill wheel-by-wheel passes of U-650 tractor (the most usual tractor in Romania), which has a weight of 3620 kg, inflation pressure in the rear wheels was 170 – 200 kPa (depending on the operation) and tyre diameter of 38 cm. All tillage was done following the contour lines, as one could see on the background.

Figure 2 Runoff collecting device and storage tanks

Soil and nutrient losses by water erosion have been determined on each experimental plot on a regular basis, and runoff samples have been taken in order to be chemically analyzed. Organic matter, total nitrogen, phosphorus, and potassium losses have been also determined. In order to perform al these sampling operations, the downhill side of the tin contained plots was V-shaped, and all the amounts of runoff occurring after rain storm events was directed through a 10 ¾ inch plastic pipe to 7 individual 2000 l storage tanks. In this particular experiment, the boxes did not have any subsequent dividers. When runoff occurred and was accumulated in, the storage tanks both water and sediment were homogenized and subsequently divided into 200 l amounts (when larger than 200 l). From each 200 l quantity of collected material 0.5 l samples were extracted, filtered through paper, dried on ambient temperature or in ovens at maximum 35^{o}C, and eventually chemically analyzed. All water and sediment samples were summarized and compared with the total amount of material collected and the recorded precipitation.

Although certain morphometric measurements were performed on a regular basis during corn growth, finally the yield was evaluated by weighting the grain production.

In order to characterize the state of compaction during the corn growth, at certain stages of plant development (vegetative, 5-6 leaves, early tassel, silking, blister, beginning dent) cone resistance to penetration tests (CRP) were performed on a geostatistically optimized network of testing points and bulk density and soil moisture content were determined simultaneously. There was an intention of making the CRP tests at the end/beginning of each month. During the summer months, periods with excessive soil moisture after rain events were avoided, by delaying the CRP tests with 2-3 days.

Depending on actual water content, a Dutch penetrograph or penetrometer was used (the penetrograph can only measure efforts up to 5 MPa and the penetrometer up to 10 MPa). Generally speaking, only cones No. 1 and No. 2, having 60^{o} and 1 cm^2 and 2 cm^2 base area, respectively, have been used, because, practically the power of the operator is a limiting factor when it comes to maintaining a constant piercing speed of 2 cm/sec. CRP tests were performed to a depth of 80 cm by penetrograph and of 100 cm by penetrometer. Readings were done continuously or from five to 5 cm, respectively.

Bulk density and soil moisture content were determined by the core sampling method, by means of a Dutch kit of 100 cm^3 cylinders (5 cm diameter), during the very same day, in 22 sampling points/plot, at the same depths where resistance to penetration readings were made. Total porosity was calculated by the classical formula (Canarache, 1990) which, for particle density 2.65 g·cm^{-3}, is

$$TP = 100(1 - BD/2.65)$$

where TP = total porosity, and BD = bulk density.

The choice of optimum distance between testing / sampling points

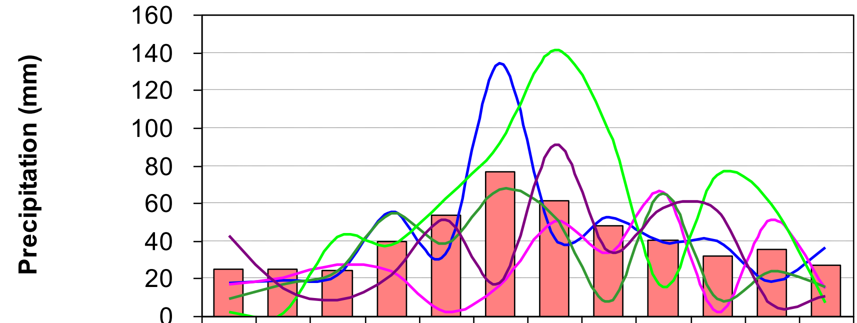
In order to solve the problem of space variability in a convenient manner so that the measurements in a certain plot with wheel traffic to be representative and objective, we have applied the geostatistical method of informational entropy to optimize the distance between sampling points on each direction. It is assumed that as long as on the studied territory the contour strip cropping system of soil conservation is applied, the traffic distribution has a certain pattern with strips, which are very often compacted by wheeling (both by wide and narrow wheels), some strips only occasionally, and others are never trampled. The initial distance between sampling points was equal to the width of the rear tractor tyres (38 cm). This distance was gradually increased up to a point where the amount of information acquired, had a significant decline. Finally, we have established that a 2.5 m network would provide representative, statistically assured averages of resistance to penetration, within each plot. Due to the higher variability across the contour lines and the lower variability along the wheel ruts, it was decided that 11 sampling points in the slope direction (25 m length) each doubled across the plot (4 m wide) would provide statistical coverage. In this way, each plot is characterized by averages calculated from readings in 22 sampling points.

Results

Annual precipitation varied from 323 mm to 632 mm (in comparison with the multi-year average of 490.9 mm) and the annual mean temperature between 9.7 ^{o}C and 11.2 ^{o}C, versus the multi-year average of 9.7 ^{o}C. Figure 3 illustrates the monthly precipitation distribution and the multi-year monthly average. The years of 2000 and 2001 were remarkably dry so that in 2000 no runoff occurred (Table 2).

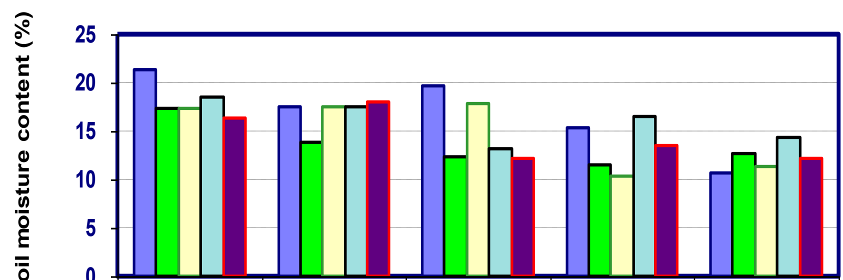
Figure 4 illustrates the evolution of soil moisture content at the time of compaction tests (usually the beginning/end of each month), during the vegetation period of corn, and in the years 1999 – 2003. One can see that always in the beginning of May the moisture content is slightly above field capacity (16.3 – 21.3 %) and at the end of vegetation period (beginning from the second half of July) ends up close to or under the wilting point.

Measurements of resistance to penetration in May and June (Figure 5) show that there are no limitations of root growth at this stage, due to initial compaction treatments. The lower threshold value of 2.5 MPa (Table 6 at the end of this article) is overtaken only beginning from the second half of July.



	JAN	FEB	MAR	APR	MAY	JUN	IUL	AUG	SEP	OCT	NOV	DEC
AVG 1941-2004	25,1	24,9	24,1	40,1	53,9	77,1	61,8	48,4	40,3	31,9	35,8	27,5
1999	17,8	18,8	21,4	55,1	32,8	134,0	41,1	52,2	39,2	39,5	18,0	36,4
2000	16,5	20,5	27,4	23,9	1,9	15,9	50,3	33,2	65,7	2,4	50,8	14,7
2001	9,4	16,7	24,1	54,2	38,2	66,9	52,4	7,8	64,9	9,0	23,8	15,5
2002	2,0	1,4	41,8	37,7	62,2	91,5	140,9	98,1	15,5	74,7	59,3	7,0
2003	42,3	14,5	8,3	21,9	51,3	17,3	90,8	34,2	57,3	56,2	6,2	10,7

Figure 3 Precipitation distribution during the study period (1999-2003) and multi-year average



	MAY	JUNE	JULY	AUGUST	SEPTEMBER
1999	21,3	17,5	19,7	15,3	10,7
2000	17,3	13,9	12,3	11,5	12,7
2001	17,3	17,6	17,9	10,3	11,3
2002	18,4	17,4	13,1	16,5	14,4
2003	16,3	18,0	12,1	13,5	12,2

Figure 4 Evolution of soil moisture content during corn vegetation period (average values at the time of compaction tests)

The result of the variable but inexorable decline of moisture content is that soil shrinkage (densification) takes place by drying and the frictional component of shearing resistance becomes more and more important, resulting in a remarkable increase of resistance to penetration, by 321 % in average terms or 500 to more than 1000 % in point measurements (Fig. 5).

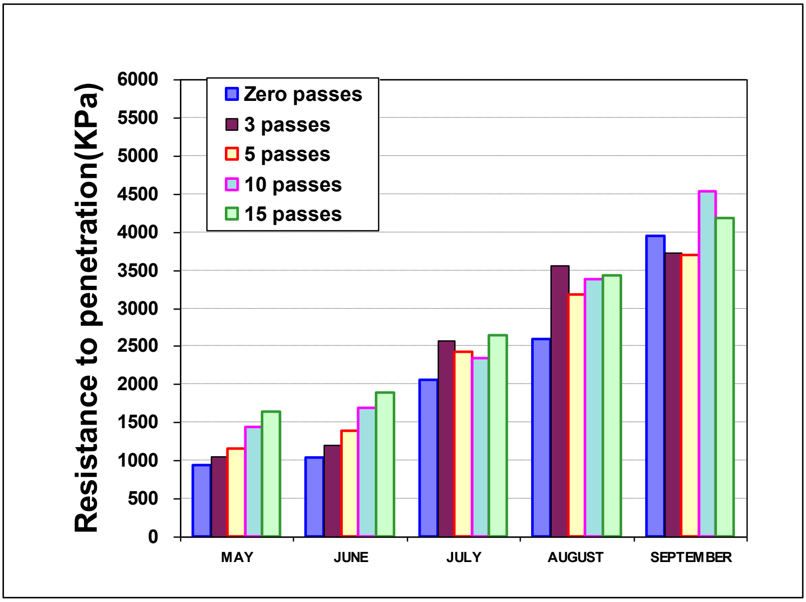


Figure 5 Resistance to penetration between 0-30 cm, during 1999 – 2003, at natural moisture (water content at the time of penetration tests)

During this process, bulk density increases by 20 % if no additional compaction is applied. In other variants, where a different number of tractor passes is applied, bulk density increases by only 12 – 16 % (Figure 6).

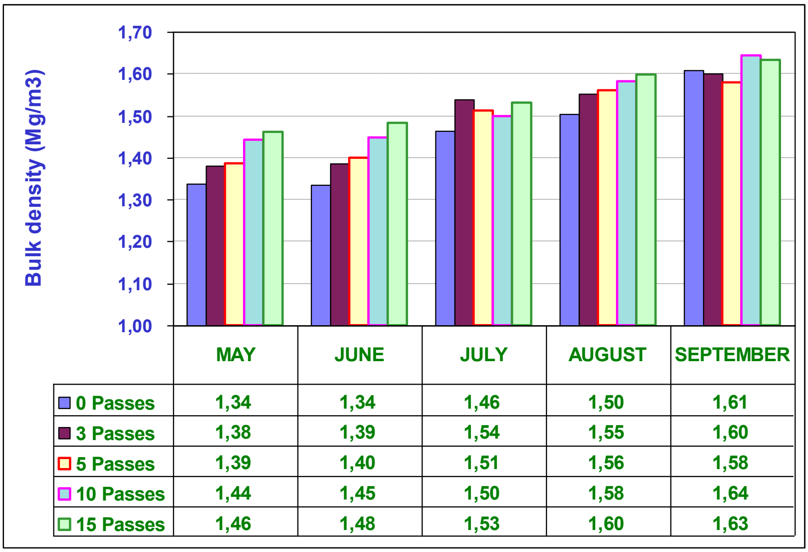


Figure 6 Evolution of bulk density during the vegetation period of corn (averages at the time of penetration tests)

Generally speaking, the influence of compaction treatments was noticed on penetration diagrams with continuous readings to a depth of 25-30 cm, although only rarely the passage is sharp (normally there is a gradual increase of CRP values). That means tillage pans are only rarely noticed as sparsely distributed spots. That is why in average calculations only values to a depth of 30 cm are considered (Figure 5).

Total porosity has a similar (likewise) but converse evolution, decreasing by 3 – 9 % because of compaction and by 14 – 21 % because of drying process.

The influence of compaction on soil and nutrient losses

Soil and nutrient losses have been measured within the fully instrumented experimental site after all occasional rain events capable of producing runoff. As mentioned before, some years within the study period, 2000, 2001 and 2003, were severely dry, with precipitation of 323.2 mm, 383.9 mm and 411.0 mm, respectively. Only in 1999 and 2002, because of slightly larger rainfall during June, July and August (only in 2002), the multi-year precipitation was exceeded. That is why, in some years (2000) no runoff occurred (Table 2). During the other years, the amount of precipitation which provoqued runoff, totalized 5120 m^3/ha. Apparently,

Table 2 Influence of compaction on runoff, during corn growth, in the years 1999 – 2003

Variant / No. of passes	Runoff (m^3/ha) - annual average					Average runoff / year (m^3/ha)	Runoff ratio
	1999	2000	2001	2002	2003		
Black Fallow (Control 1)	716	-	252	393	270	326	0.31
Conventional (Control 2)	463	-	80	153	126	164	0.16
3 Passes	450	-	81	183	85	160	0.15
5 Passes	277	-	0	210	41	106	0.10
10 Passes	250	-	94	150	78	114	0.11
15 Passes	677	-	73	243	191	237	0.23

there is no clear correlation between degree of compaction (number of passes) and soil erosion. However, only in the variant compacted by 15 passes, the runoff increased by 40 % (the runoff ratio varied from 0.16 to 0.23) in comparison with the traditionally cultivated variant (Control 2).

In all plots with additional compaction, soil losses associated with runoff events, drop under the tolerable limits of this type of soil, which are 6 – 8 t/ha/yr. (Motoc et al., 1975) (Table 3).

Table 3 Influence of compaction on soil losses during corn growth, in the years 1999 - 2003

Variant / No. of passes	Soil losses (t/ha) during the years:					Annual average (t/ha)
	1999	2000	2001	2002	2003	
Black Fallow (Control 1)	47.8	-	16.5	18.1	21.2	20.6
Conventional (Control 2)	18.9	-	3.2	9.4	3.0	6.9
3 Passes	27.1	-	1.5	8.8	1.8	7.8
5 Passes	17.1	-	0.0	13.2	0.9	6.2
10 Passes	15.7	-	3.1	8.2	0.9	5.6
15 Passes	23.6	-	1.3	11.9	3.2	8.0

Table 4 illustrates the summarized nutrient losses through water and sediment, during corn growth, in the years 1999 – 2003, when all experimental sites received complex fertilization (including the black fallow). In average, the loss of organic matter varied between 133.9 kg·ha^{-1} under "10 passes" plot and 498.3 kg·ha^{-1} in the plot maintained as continuous fallow (Control 1). There was no visible correlation between number of passes and loss of humus.

Table 4 Summarized annual nutrient losses depending on soil compaction, during corn growth, in the years 1999 - 2003

Variant / No. of passes	Humus (kg/ha)	Nitrogen			Phosphorus			Potassium		
		Total kg/ha	Wa-ter (%)	Sedi ment (%)	Total kg/ha	Water (%)	Sedi ment (%)	Total kg/h a	Water (%)	Sedi ment (%)
Black Fallow Control 1	498.3	25.7	3.7	96.3	2.8	7.1	92.9	5.8	20.1	79.9
Conven-tional Control 2	160.8	8.7	5.2	94.8	1.0	10.1	89.9	5.8	28.8	71.2
3 Passes	177.7	9.2	4.8	95.2	1.0	9.5	90.5	2.1	26.8	73.2
5 Passes	157.3	8.6	6.1	93.9	1.1	10.1	89.9	2.1	25.0	75.0
10 Passes	133.9	7.5	5.1	94.9	0.9	8.9	91.1	1.8	27.0	73.0
15 Passes	194.1	12.1	11.5	88.5	1.5	12.6	87.4	3.3	37.5	62.5

Nitrogen losses, in average, ranged from 7.5 to 25.7 kg/ha. The available phosphorous losses were low, generally, and ranged from 0.9 to 2.8 kg/ha. As regards potassium losses the situation is almost similar with that of phosphorous.

Incidence of compaction on corn yield

Plant observations were made throughout the corn vegetation period on a regular basis. Early signs of compaction like sparse crop emergence, uneven plant stands and reduced plant height, were noticed even form the initial phases of plant development, especially in 10 or 15 passes variant. By analyzing the average corn yields for the period 1999 - 2003 it is possible to notice that during 1999 – 2001, a slight decrease in corn yield with increase of soil compaction was observed, as shown in Table 5. Before 2000, in normal years, on such a soil, the corn yield was as high as 10,000-12,000 $kg \cdot ha^{-1}$. During the following years, that relationship was no longer obvious. Table 5 illustrates that the 5-year average of corn yield decreased due to compaction by 18% only within the 15 passes variant.

Table 5 Incidence of compaction on corn yield

Variant / No. of passess	Grain yield (kg/ha)					5-year average
	1999	2000	2001	2002	2003	
Black Fallow (Control 1)	-	-	-	-	-	-
Conventional (Control 2)	2482	1216	2920	3296	2496	2482
3 Passes	2262	904	2520	3544	2480	2342
5 Passes	2158	680	1744	3720	2888	2238
10 Passes	2054	632	1976	3208	2480	2070
15 Passes	1976	240	896	3408	3160	1936

Discussion

Usually, soil compaction is associated with water erosion in several ways, depending on type of compaction involved. Among various forms of soil compaction, some of them are kinds of local soil densification: tillage pans, and/or diffuse densification induced by wheeled vehicles to a certain depth under the wheels (ruts). In order to define more physically based the influence of soil characteristics on rainfed superficial soil erosion, one of the components of soil erodibility, namely soil detachability, is proposed (Torri, 1987). Three main soil characteristics are relevant in defining soil detachability: texture, aggregate stability, and soil shear strength. Usually, soil shear strength is more difficult to measure *in situ* with its main components cohesion and angle of friction because of difficulty to apply a normal load. Therefore, shear-vane tests can only provide the cohesion component of soil shear strength, in undrained, unconsolidated circumstances and with negligible angle of friction (ø ≈ 0). Cohesion of soft clays, soft silts, mud, for which the angle of internal friction is negligible, can be calculated by the formula:

$$c \cong \frac{R_p}{14} \text{ [daN/cm}^2\text{]}$$

where c = cohesion, R_p = resistance to penetration (Paunescu et al., 1982).

Having the close relationship between soil detachability and shearing resistance and resistance to penetration, the latter was preferred in assessment of soil erosion circumstances, as being more easily measured in the field. It is a common thing in the literature on the subject to state that both resistance to penetration and shear resistance tests must be performed at soil water contents close to those acting during the erosion process, which means close to saturation or beyond field capacity (Poesen, 1986).

The state of soil compaction as expressed by resistance to penetration tests is related to root growth the way it is presented in Table 6.

Table 6 Suggested limits for classes of soil resistance to penetration and limitations of root growth (Canarache, 1990)

Resistance to penetration class	Limits (MPa)	Limitations for root growth
Very low	≤ 1.0	No limitation
Low	1.1 – 2.5	No limitation
Medium	2.6 – 5.0	Some limitations
High	5.1 – 10.0	Some limitations
Very high	10.1 – 15.0	No root growth possible
Extremely high	> 15.0	No root growth possible

Changes in bulk density *per se* have limited use as an absolute indication of compaction and may be slight or poorly correlated to root growth responses (Trouse, 1966 cf. Soane et al., 1981). However, according to *Handbook of Soil Science* from 1999, bulk densities can be used to establish classes of restrictive circumstances for root growth (Table 7).

Crop growth often reflects the root system and soil environment. Early signs of compaction in the upper 5 cm of soil can be seen as plants erminate and emerge. The plant must push up through the compacted surface soil or grow laterally until it finds a crack. If the seedling does not reach sunlight it will die. Also, if food reserves in the seed are used up before the plant establishes a good root system the seedling may not emerge or it may emerge and then die. This will result in an uneven stand. Compaction also

Table 7 Approximate bulk densities that restrict root penetration (from Handbook of Soil Science, 1999)

Texture	Critical Bulk Density for Soil Resistance ($Mg \cdot m^{-3}$)	
	High	**Low**
Sandy	1.85	1.60
Coarse-loamy	1.80	1.40
Fine-loamy	1.70	1.40
Coarse-fine silty	1.80	1.30
Clayey	Depends on both clay percent and structure	

influences plant height. Corn is most sensitive because it is one of the taller crops. By the end of the growing season corn may be 15 cm to 120 cm shorter on compacted soil than on noncompacted soil (Jones et al., 1997).

Compaction can prevent normal root development, especially if the compacted zone is within 15 cm to 20 cm of the soil surface.

The last major plant symptom of soil compaction is reduced yield. When other critical factors have been eliminated as possible causes of yield reductions, compaction may be considered as a likely cause. Compaction can cause yield reduction of 0 to 60% (Jones et al., 1997).

All the signs mentioned above influenced us in deciding to perform penetration tests at instantaneous soil moisture contents so that they reflect the efforts made by plant roots to push up through the compacted surface soil.

In years when soil moisture is plentiful, the impact on crop growth may not be obvious. In years of moisture shortage, plants on compacted soil stress more easily, and reduced growth and yields are noticeable (Frisby et al., 1993).

Some of the most important conclusions of our previous compaction studies in the years 1992 – 1997 (Nistor Doina et al., 2000), being focused on the influence of various soil protecting methods, on soil physical properties and crop yields were:

1) Within the No-tillage variant of soil protection (sowing by direct drilling in wheat stubble), which may be assumed as being close enough to the abandoned soil, bulk density was greater than the unprotected, ploughed variant, which is considered as a conventional, by maximum 3.9 %.

2) Penetration resistance increases gradually, from the unprotected variant to the No-till variant, by 23 % when chisel was the basic tillage and by 67 % in the latter variant.

Conclusions

1. The effects of excessive soil compaction induced by up to 15 wheel-by-wheel passes of a 2.7 tons tractor to a depth of 0.25-0.30 m, even though unlikely to occur in our area, are easily annihilated by the loosening effect of freezing and thawing during winter and by normal operations.

2. Excessive compaction treatments applied before planting in spring do not result in any limitations of root growth during early stages of plant development. The threshold value of 2.5 MPa of resistance to penetration is overtaken during the second half of July, due to natural decline of soil moisture content. Bulk densities show that an increase of this soil characteristic to only 1.46 $Mg{\cdot}m^{-3}$ from 1.34 $Mg{\cdot}m^{-3}$ is far from threshold values in the literature mentioned as restrictive to the development of root system.

3. Tillage pans are rarely noticed as sparsely distributed spots and the contour strip cropping system of soil conservation masks their occasional role in soil erosion.

4. Apparently, additional traffic compaction, limited to maximum of 15 tractor passes in our experiments, has a somehow beneficial effect on soil erosion, so that runoff increased by 40 %, but soil and nutrient losses were not so high. In other words, the water in the runoff becomes cleaner with moderate compaction.

5. During the three initial years 1999, 2000 and 2001, a slight decrease in corn yield with increase of soil compaction was observed. During the following years, that relationship was no longer obvious. The overall level of corn production was relatively low after 2000, if compared with yields in the previous decade, because of some other critical factors responsible for yield and time, not discussed here (e. g. precipitation did not come at the right time for this crop).

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HILL LAKE SEDIMENTATION'S, FROM BÂRLAD WATERSHED, UNDER IMPACT OF SOIL EROSION PROCESSES

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Abstract

The problem of soil erosion, sedimentation and water quality degradation of dam storage is alarming in the whole world, not only in our local area. It requires the development of a new global strategy, starting with the study of watershed processes and finishing with the approach to the issue of reclamation, exploitation and conservation of agricultural lands, rivers and reservoirs.

An relative recently analyse, by M. Motoc (1984), it come out that on Romanian lands total erosion is of 126.0 million to/year and from these 44.6 million to/year there are sediment effluence (0.35 effluence coefficient). Provide area point of view, 84.5% (106.8 millions to/year) is from agricultural area and 15.5% of erosion provide from forestry area and bank rivers. Generating processes point of view about 49.0%-61.8 million to/year provides from sheet erosion and about 23.6%-29.8 millions to/year provides from gully erosion.

Sheet erosion and gully erosion has a different weight (49.0–23.6 %) in total erosion. The effluence coefficients on these category are also different (0.26% for sheet erosion and 0.46% for gully erosion), but their contribution at sediment effluence are very near – 16.1 millions to/year (36.2%) sheet erosion and 13.8 millions to/year gully erosion;

Autonomous Administration Romanian's Water consider that on the whole Romania, during last 15 years, in reservoirs placed on inner rivers, it was fall about 200,000 millions m^3 sediments (13.4 millions m^3/ year that means 27% from total years average sediments carry).

In the studied reservoirs, these processes are due to the deposit of sediments from the main water supply of the reservoir and of those that are due from erosion from hill slopes and watersheds located in the vicinity of the reservoir.

Keywords: soil erosion, reservoirs, sedimentation.

Introduction

Autonomous Administration Romanian's Water considers that on the whole Romania, during 15 years, in reservoirs placed on inner rivers lakes, it was fall about 200,000 millions m^3 sediments (13.4 millions m^3/ year that means 27% from total years average sediments carry).

The problem of soil erosion, sedimentation and water quality degradation of dam storage is ominously in the world not only in the local area. It requires development of a new global strategy starting with the study of watershed processes and finishing with the draft of land reclamation, exploitation and conservation measures of agricultural lands, of rivers and reservoirs.

Ichim Ionita (1993,1996) considers the fact that only a concept named “sediment systems” can offer an adequate frame for elaborating such strategy who can ensure an adequate frame for elaboration an efficiently strategy. This strategy must assure better processes understanding a pragmatically approach of erosion reducing and reservoir sedimentation. In decision processes from reduce sediments transport, when are interested in reservoir protection, it must accord inters through "sedimentation processes" and “sediments storage" who in sediment system must be looking distinctly but, at time and space scale god define and in connection.

M. Motoc (1984) realise a general view (table 1) concerning provides area reference to lands use and the processes like sediments sources offer total erosion, effluence coefficients and sediment effluence give by sources and processes on Romanian lands.

Table 1

Erosion and sediments effluence differentiation in Romania
(after M. Motoc 1984)

Land use	Total erosion mil. to/year	Total erosion %	Effluence coefficient	Sediment effluence mil. to/year	Sediment effluence %
Land use category (provide area)					
Arable	28,0	22,3	0,28	7,9	17,7
Pastures	45,0	35,7	0,27	12,3	27,6
Orchards	2,1	1,7	0,29	0,6	1,4
Vineyards	1,7	1,2	0,28	0,5	1,1
Gully erosion (unproductive)	29,8	23,6	0,46	13,8	31,0
TOTAL agriculture area	106,8	84,5	0,32	34,2	78,8
Forestry area (gully erosion and landslides)	6,8	5,4	0,40	2,7	5,9
Bank erosion on rivers	12,6	10,0	0,54	6,8	15,3
Total	126,0	100,0	0,35	44,6	100,0
Erosion forms (generating processes)					
Sheet erosion	61,8	49,0	0,26	16,1	36,2
Gully erosion	29,8	23,6	0,46	13,8	31,0
Landslides	15,0	12,0	0,35	5,2	11,6
Gully erosion and landslides on forestry area	6,8	5,4	0,40	2,7	5,9
Bank and riverbeds erosion on rivers	12,6	10,0	0,50	6,8	15,3
Total	126,0	100,0	0,35	44,6	100,0

Analysing the present date (table 1) it comes out that: on Romanian lands total erosion is of 126.0 millions. To/year and from these 44.6 millions to/year there are sediment effluence (0.35 effluence coefficient); provide area point of view: 84.5% (106.8 mil. to/year) are from agriculture area and 15.5% provide from forestry area and bank rivers; generating processes point of view: about 49.0%-61.8 mil. To/year provide from surface erosion;

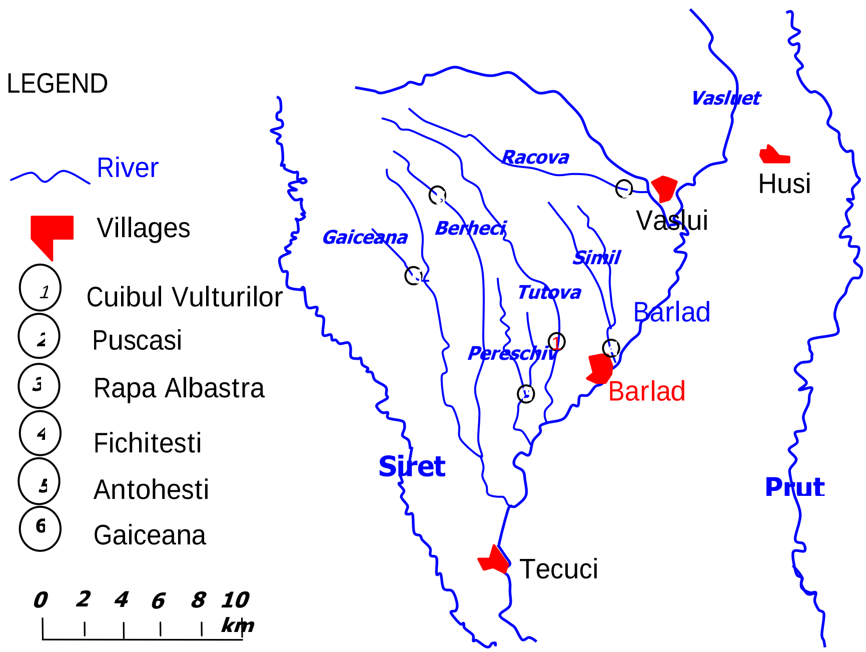
about 23.6%-29.8 mil. To/year from gully erosion; sheet erosion and gully erosion has a different weight (49.0–23.6%) in total erosion; effluence coefficients on these category are also different (0.26% for sheet erosion and 0.46% for gully erosion), but their contribution at sediment effluence are very near–16.1 million to/year (36.2%) sheet erosion and 13.8 million to/year gully erosion. Following only effluence coefficients, the bigger are for gully erosion (0.46) and for bank and riverbeds erosion (0.54), these tow kind of process erosion take part with 46.3% (20.6 to/year) to total sediment effluence.

Research location

Researches are made in the drainage area of Bârlad river where are realised and exploited, since 1960, 47 reservoirs (about 4.2 % from Romanian hill lakes) from earth dam with 2 to 18 meters height and 100 to 1,000 meters longer at the crowing.

Figure 1

Reservoir studded from Barlad river watershed



These reservoirs, at the beginning, totals at NLR (normal level retention): 2,425 hectares water surface; 244.3 mil. m^3. (about 7% from maximum utilisable volume created from Romanian hill lakes water volume) for different utilisations (water supply–52.8 mil. m^3; irrigation's–

9.57 mil. m^3; fish breeding–18.73 mil. m^3; pleasure–140 mil. m^3 and other utilisation's–3.23 mil. m^3). Bârlad watershed's reservoir also totals 70.98 millions. m^3 for high flood attenuated and 88.83 millions m^3 for flood forestalls.

Concerning sedimentation process it was made systematically determinations on six reservoir: Puşcaşi – Racova watershed; Cuibul Vulturilor – Tutova watershed; Râpa Albastră - Simila watershed; Fichiteşti - Pereschiv watershed; Antoheşti - Berheci watershed and Găiceana - Ghilăveşti watershed (figure 1). The determinations and the examinations are start since 1992 and there are continue at present.

Research method

It was catalogued the natural conditions and prevalence dominates erosion's form from watersheds and the effect of these erosion forms, equipped and unequipped, through determinations and examinations on the sedimentation reservoir. At the same time it was establish sedimentation rank and it was also estimate average year ratio of sedimentation. Thus it was praised the different contribution from proceeding area and generating process to reservoir's sedimentation, the different give than the erosion forms and from the way of erosion equipment or the absence of these. All this to establish a specifically draft frames to decrease more possible the sedimentation process.

Measurements (estimations) from runoff and erosion in excessive influence area

These measurements were effectuated at different events (brusque snow thawing, rain events with height quantity or a long standing) that produced runoff and erosion. The measurements were consisting in: following and registration of variable level in reservoir and the registration of water volumes that enter in this, at different events; drawing and analysing water probes entering in reservoir direct from excessive influence area, at different events and rebuild the flood discharge and speedy measurements concerning surface erosion through streaming and gutters.

The rate and modes sedimentation of studied reservoir determination

The sedimentation of these reservoir, at NLR (normal level retention-semi permanent average exploitation level), was set by bathymetric and topographic measurements on a different number of transverse profiles. These profiles were remade first after 4 then after another 3 years (only some of the profiles, seen as typical for the description of the sedimentation process). In order to achieve these measurements and to re-make them at various intervals (3 or 4 years) transverse profiles were materialised, which cover the whole water table of the reservoir, spaced off 100 to 500m. Along the length of these profiles bathymetric measurements were made every 30m (by means of a cable with fixed spaced floats) on a floating platform mechanically powered. These were followed by topographic measurements on both banks, in order to provide a reliability of 1.0 $^0/_{00}$.

Following the behaviour of land reclamation works from the excessive influence area

These were made using the estimated and measurement erosion date as well as using the topography measurement made in the mentioned area. Concerning surface erosion it was follow tow area types: land without reclamation works and wrong cultivate concerning erosion and land with reclamation works and adequate cultivate concerning erosion. Concerning gully erosion (from slope or valley) it was follow three types: natural fixed form; active form without erosion control works and active form with erosion control works.

Results obtained

Specifically area's natural conditions reflected in general sedimentation system review it was manifested by the help of tow major elements:

The positioning in a temperate continental climate's: the torrential rain frequency is more than 20% and the aggressiveness rain factor is K_a= 0.13. The Bârlad watershed rivers are operating through: an unstable winter regime and the attenuation of big spring water (about 40% from cases); the winter leakage volume are like in summer (represent 16-22% and respectively 21-22% from yearly leakage volume; the autumn leakage is only 15% from yearly leakage volume; the most yearly discharge flow is produced in only 50% from case in summer.

The control factors regime of sediment production: the leaking coefficients are very high C_s = 0.39-0.42 (slope of 16-38%); the prevalent silting facieses are favour a high density of gully erosion forms (0.8-1.0 kilometres/square kilometre and depth more then 15-20 metres) and area soils moulded in common on feeble bed rooks (gray; brown podsol and podsols; leached chernozems), have an very high erodabillity factor S = 0.8-0.9;

Results obtained, for hill lake from Bârlad watershed (table 2) making the evident distinguish value of the annual rate and rhythm of sedimentation (reported at the initial water volume at NLR) varying with watershed and their emplacement into these:

- The reservoirs Antoheşti and Găiceana, who was placed in superior and middle part of Berheci watershed have an sedimentation rate of 40.91 % and 41.46%, with an sedimentation average annual rhythm of 4.09 % and 4.15 %;
- Cuibul Vulturilor reservoir placed in lower Tutova watershed is deposited in 32.63% and she realise an sedimentation average annual rhythm of 2.33%;
- Râpa Albastră reservoir from lower Simila watershed have an sedimentation rate of 21.13% with an sedimentation average annual rhythm of 2.33%; Fichiteşti reservoir from lower Perschiv watershed are the most affected by sedimentation, her sedimentation rate are 52.6% with an sedimentation average annual rhythm of 3.3%.

The analyse of sedimentation trend, best describe from polynomial relation of degree tow, from Tutova Hills reservoir considering some proper morphologic parameters permit few assessments concerning the conditions from placing and realising of new reservoir on area.Sedimentation annual mean rata is decreasing through reducing of the watershed area until one limit then this limit is growing again. The same trend are relying on the initial area of water at NLR, these are explained by fact that the small watershed are the same with excessive influence area. Relying on excessive influence area regarding sediments transport and the initial water volume the trend is decreasing at the same time with these tow parameters. The lower value of sedimentation annual mean rata are realise when: the watershed area is between 30,000 and 40,000 hectares; the surface of excessive influence area regarding sediments transport is < 4,000 hectares; the initial water volume at NLR is > 6,000,000 m^3 and the surface of water at NLR is between 200 and 260 hectares.

Concerning the distribution of sediments it were analysed comparatively the longitudinal profile (Figure 2) and two cross profiles (Figure 3 and 4), which were considered typical for the description of the sedimentation process. This analysis outlines the thickness and the distribution of sediments.The thickness of the deposited sediment throughout the length of reservoir has maximal values close to dam, thinning out to the end of the reservoir.On the small reservoir (depth of water between 2 to 4 meters) with the watershed identifying with excessive influence area regarding sediments transports the results remark a relative uniform distribution of sediment deposits on longitudinal and cross profiles.

On bigger reservoir, where the excessive influence area regarding sediments transport is between 2 and 10 % from watershed area, but these are order of same thousand hectares (comparatively with all watershed of

Table 2

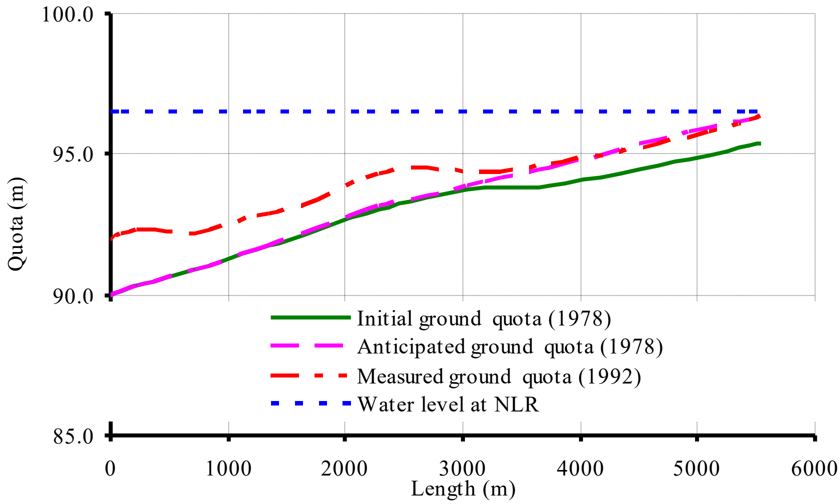
Initial and present characteristics of few reservoirs from Barlad watershed

Specifications	M. U.	Reservoirs name					
		Puşcaşi	Cuibul Vulturilor	Râpa Albastră	Fichiteşti	Antoheşti	Găiceana
Initials characteristics							
Year of exploitations coming		1973	1978	1979	1977	1984	1984
Watershed		Racova	Tutova	Simila	Perschiv	Berheci	Berheci
River		Racova	Tutova	Simila	Perschiv	Berheci	Ghilăveşti
Dam's type		Earth's dam					
Dam's height*	m	17	17	18	14	6	7
Crossing's longer*	m	890	843	810	700	350	320
Watershed area	ha	29600	54200	25300	16300	3963	4665
Water surface	ha	224	345	230	180	25	28
Water volume at NLR	m^3	17000000	9500000	10600000	5500000	220000	410000
Anticipation sediment volume	m^3	600000	300000	200000	200000	40000	40000
Sedimentation's average year ratio	m^3	15000	6000	4000	4000	4000	4000
Present characteristics							
Determination year		1998	1992	1993	1993	1995	1995
Exploitation years		26	14	14	16	10	10
Initial water volume at NLR (V_i)	m^3	17200000	9500000	10600000	5500000	220000	410000
Waters volume at determination time	m^3	6300000	6400000	8360000	2610000	130000	240000
Sediments volume at time	m^3	10900000	3100000	2240000	2890000	90000	170000
Sedimentation rate	% of Vi	63.37	32.63	21.13	52.54	40.91	41.46
Sedimentation average annual rata	m^3/an	419231	221430	160000	180625	9000	17000
Sediment effluence	m^3/ha	14.16	4.08	6.32	11.08	2.27	3.64
Sedimentation average annual rhythm	% of Vi	2.44	2.33	1.51	3.28	4.09	4.15

and topographic profiles from 1992, on the same alignments, in 1996 and 1999, permitted, by comparing them, to differentiate the thickness of deposited sediment at different areas of the reservoir. The initial profile from 1978 was realised with the help of topographical plans (scale 1/5,000).

Figure 2

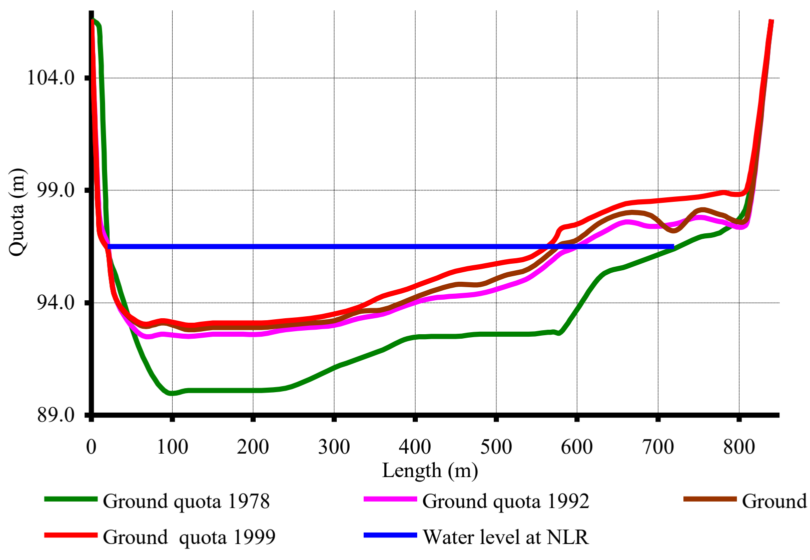
Longitudinal profile



- The profile P1, situated in the area of direct influence of watershed Cârjăoani (with a valley gully as the predominant form of erosion):

Figure 3

Cross profile P1



- After fourteen years of exploitation, the deposits are unevenly with a thickness of 2.5 m on the left bank, 1.8 m in the central area and 3.5 m on the right bank. In this case the average annual ratio of sedimentation was 0.16 – 0.13 – 0.25 m. throughout the length of the profile.

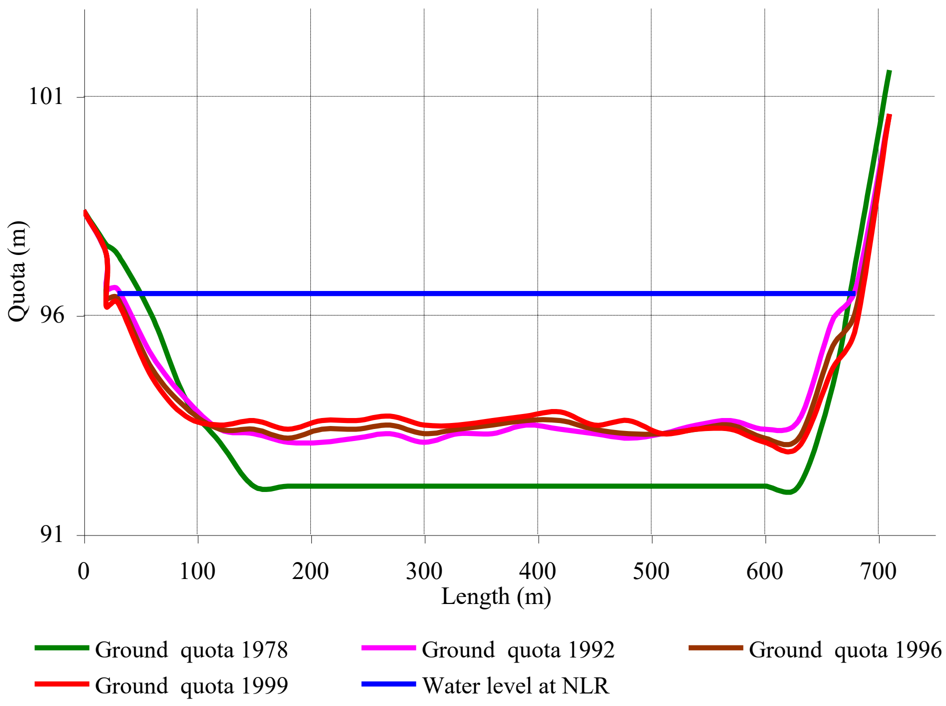
- In four years the deposits were relatively evenly distributed 0.4-m on the left bank, 0.3-m in the central area and 0.6-m on the right bank. The average annual ratio of sedimentation was 0.10 – 0.08 - 0.15 m throughout the length of profile;

- In three years the deposits were clearly unevenly distributed 0.1-m on the left bank, 0.2 m in the central area and 0.7 m on the right bank. The average annual ratio of sedimentation was 0.03 – 0.06 - 0.23 m's throughout the length of the profile.

The profile P4, situated in an area without the direct influence of a watershed area, only with the influence of a nearby hill:

Figure 3

Cross profile P4



- After fourteen years of exploitation the deposits were evenly distributed with a thickness of 1.2 m on the left bank, 1.4 m in the central area and 1.5 m on the right bank. The average annual ratio of sedimentation was 0.09 – 0.10 – 0.11 m. throughout the length of the profile;

- In four years the deposits were fairly evenly distributed 0.13-m on the left bank, 0.16 m in the central area and 0.12 m on the right bank. The thickness of the sediment grows to the centre of the profile and fingers out to both banks, as the result of the lower charges of hill stream flows. The average annual ratio of sedimentation was 0.03 – 0.04 – 0.03 m throughout the length of profile;

- In three years the deposits were thicker to the centre of the profile and to both banks, as a result of the lower charges of hill stream flows. The thickness of the sediment was 0.10 m on the left bank, 0.20 m in the central area and 0.10 m on the right bank. The average annual ratio of sedimentation was 0.03 – 0.06 – 0.03 m throughout the length of the profile.

Erosion from excessive influence area regarding sediments transport

In the area regarding sediments transport of reservoir, there are all erosion forms less then landslides. On the agricultural land with same slope sheet erosion was between 10 to 12 to/hectares on equipped lands and was between 30 to 35 to/hectares on unequipped lands. Sheet erosion on the unequipped area is about three times large then sheet erosion of equipped area.

During the fast snowmelt from february-march 1996 (in the same area) it was making on the left bank upstream of dam, a slope gully (about 235–250 meters length, 4-10 meters depth). From this slope gully, in reservoir, it was enter 5,400 m^3 sediments (estimated).

Concerning the gully erosion in the third lower part of equipped slope gully every year it appear under washing processes materialised through 3–4 rapids from 0.5–1.5 meters. As result of these rapids where eroded about 80–120 m^3/rapid of material who are going to the reservoir like sediments. On the valley gully, equipped with crossing sedimentation control works, the alluvial deposits usually are at the level of the weir but scouring phenomenon is appearing on the intervals of sedimentation control works. These scouring phenomenon produce about 2,400-m^3/km length that is going to the reservoir like sediments.

The alluvial effluence from excessive influence area

At the same events was determinate the sediment effluence, from excessive influence area regarding sediments transport into the reservoir, (table 4).

From the date presented in table 4 it coming out that the bigger sediment effluence provide from the micro watersheds who are directly coming into the reservoir (7.93–9.87 to/hectares from the direct slopes and 1.8–30.5 to/ha from these kind of micro watersheds.

Table 4

The sediment effluence and the sediment volume coming into the Cuibul Vulturilor reservoir, from the excessive influence area, annual mean of the events from 1996 – 2000

Location /micro watersheds	Area (ha)	Effluence sediments (to/ha)		Sediment's input into the reservoir (m^3)	
		Event		Event	
		Snowmelt	Long term rains	Snowmelt	Long term rains
Left hill side	372	8,89	9,87	4.639	5.158
Roşcani watershed	742	25,36	30,52	26.432	31.797
Pogana village area	146	1,22	1,44	249	293
Iaura-Tomeşti watershed	2242	1,80	2,18	8.833	6.847
Cârjãoani watershed	1872	8,35	10,74	21.972	28.646
Right hill side	353	7,93	9,00	3.931	4.463
Means/total volume	event	5,03	6,18	66.056	77.204
	events				143.260

After mean annual rata in this reservoir coming in about 221,430-m3 sediment, but only to the remarkable events from excessive influence area it coming into the reservoir about 143,260-m3 sediment, that means about 65.0% from the total sediment coming into the reservoir. From these sediment volume, coming into the reservoir, 13.1% provide from the directly slope area and the difference provide from micro watersheds who are coming directly into the reservoir. These data point out the contribution of singular remarkable events to the sedimentation of the reservoirs through the great sediment effluence in comparative with mean annual sediment effluence currently used in the plan to establishing the sediment volume of the reservoirs.

Conclusions

- Rank and mean annual rhythm of sedimentation, for the reservoirs from Bârlad draining area, are differentiate in accordance with the watersheds and their placement into among the watersheds.
- Sedimentation rank: > 41 % from initial volume for these from Pereschiv watershed; < 33 % from initial volume for these from Tutova and Simila watersheds; > 63 % from initial volume for these from Racova watershed;
- Mean annual rhythm of sedimentation: > 4.1% of initial volume for these from middle and upper part of watersheds; < 3.3% from initial volume for these from lower part of watersheds;

- The small mean annual rhythm of sedimentation from the reservoirs placed in drainage area of Bârlad river are realised when: - watershed area is between 30,000 and 40,000 ha; the area of the excessive influence area regarding sediment transport is less then 4,000 ha; initial water volume at NLR is bigger then 6,000,000-m3; the water surface at NLR is between 200 and 260 ha.

- Every year the water surface at NLR is reducing mean on a 0.74 – 1.00 %.

- Along cross profile there are a different mean annual sedimentation rata: uniform (0.09 – 0.11 m) where isn't influence from lateral inputs and uninformed in area with directly influence of input from micro watersheds (0.53 m in the nearby of the input, 0.18 m in the middle area and 0.09 on the opus bank).

- The sedimentation rhythm and the thickness of sediments in area of directly inputs of the micro watersheds are from 4 – 5 times bigger then the area influenced only from the nearby slope of water area.

- The mean annual rata are in general from 20 times bigger than prognosis (221,430-mc comparative with 10,000-mc for Cuibul Vulturilor reservoir.

- The thickness of the deposited sediment throughout the length of reservoir has maximal values close to dam, thinning out to the end of the reservoir. The same was noticed about the granulometry of the sediment: it is finer at the far end of the reservoir and rougher close to the dam.

- The restoration of bathymetric measurements make render evident the thickness of sediment about 0.15 to 0.75 m (sediment stored in three years) with a means annual rata of sedimentation, in these period, from 0.05 to 0.25 m /year.

- 65 % from sedimentation mean annual rata provide from the excessive influence area (area placed nearby the surface of water.

- From the total volume of sediments, carry on into the reservoir from excessive influence area, 13.1 % provide from the slope (sheet erosion and slope gully) and 86.9 % provide from the micro watersheds with directly input into the reservoir (gully erosion and transport of sheet erosion from the watershed).

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EFLUENŢA ALUVIONARĂ ŞI DE ELEMENTE FERTILIZANTE DIN ZONA DE INFLUENŢĂ EXCESIVĂ PRIVIND TRANSPORTUL DE ALUVIUNI A ACUMULĂRII CUIBUL VULTURILOR

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Abstract

In the decision to diminution the sedimentation and fertiliser transit, when there are interest to protect the reservoirs, it must to accord interest "sediments process's" and "sediments storage's" who in the "sediments system" it must be distinctly regarding but, in time and space scale very well defined, and in connections. Concerning fertiliser it must be interested in their influence on water quality. In the frame of the sediment processes, the sediments sources analyse must be regarding tow aspects: provide area reported at watershed or the land use and the generating process, concerning fertiliser these must be regarding also tow aspect quantity of the inputs and the effect of water quality. It was establish the excessive influence area looking the impact of erosion processes of Cuibul Vulturilor reservoir. In these area it was make erosion and sediments effluence determinations who, at least it was analysed in complex with the rate and mode of reservoir sedimentation's.

Cuvinte cheie: eroziune, aluviuni, efluenţă, elemente fertilizante

Introducere

Tabloul general al eroziunii şi sedimentării în lacurile de baraj este alarmant, pe plan mondial nu doar regional, şi impune elaborarea unei strategii globale, începând de la studiul fenomenelor pe bazine hidrografice, până la concepţiile de amenajare, utilizare şi conservare a terenurilor, cursurilor de apă şi acumulărilor, Ichim Ioniţă (1993) consideră faptul că doar un concept denumit "Sistemul aluviunilor" poate oferi un cadru adecvat pentru elaborarea unei astfel de strategii care să asigure o mai profundă înţelegere a fenomenului precum şi o abordare mai pragmatică a reducerii eroziunii şi sedimentării acumulărilor, Conceptul este definit (Ichim Ioniţă, 1986) în termeni generali astfel: un subsistem al sistemului geomorfologic fluvial în care principalele intrări sunt factorii de control, transferul şi stocajul de depozite este asigurat de triada morfodinamică: eroziune–transport–sedimentare (ETS), iar ieşirea din sistem este producţia de aluviuni (PA) care poate fi asimilată şi cu raportul de efluenţă a aluviunilor (REF),

R. A. Apele Române evidenţiază că pe ansamblul ţării, într-o perioadă medie de 15 ani, în lacurile de pe râurile interioare, s-au depus cca. 200.000

mil, m^3 aluviuni (13,4 mil m^3 /an – 27% din transportul total de aluviuni mediu multianuale),

În cadrul proceselor de aluviuni, analiza surselor de aluviuni trebuie să aibă în vedere două aspecte: aria de provenienţă în raport cu bazinul (versant, albie sau alte formaţiuni geomorfologice) sau utilizarea terenurilor (agricultură, silvicultură, construcţii ş.a.) şi procesele generatoare (eroziune, alunecări, eroziune de maluri ş.a.),

Mircea Moţoc (1984) stabileşte un tablou general în ceea ce priveşte ponderea diferitelor arii de provenienţă în raport cu utilizarea terenurilor (*tabelul nr. 1*) precum şi ponderea diferitelor procese ca surse de aluviuni prezentând eroziunea totală, coeficienţii de efluenţă şi efluenţa aluvionară a surselor şi proceselor pentru teritoriul României,

Analizând datele prezentate de către M. Moţoc în tabelul nr. 1 se observă că:

- pe ansamblul ţării eroziunea totală este de 126,0 mil. to/an iar dintre acestea 44,6 mil. to/an constituie efluenţa aluvionară (0,35 coeficient de efluenţă);
- ***din punct de vedere al ariilor de provenienţă:***
- circa 84,5 % (106,8 mil. to/an) din eroziune provine din fondul agricol, ponderea cea mai mare având-o păşunile (35,7%), contribuind cu 34,2 mil. to/an la efluenţa aluvionară (0,32 coeficient de efluenţă);
- deşi, ca pondere în realizarea eroziunii totale, arabilul şi eroziunea de adâncime sunt sensibil egale, coeficienţii de efluenţă aluvionară realizaţi pe aceste categorii sunt net diferenţiaţi (0,28 pentru arabil respectiv 0,46 pentru eroziunea de adâncime), ca urmare şi aportul acestora la realizarea efluenţei aluvionare este net diferenţiat: 7,9 mil., to/an (17%) arabilul respectiv 13,8 mil. to/an (31,0 %) eroziunea de adâncime;
- ***din punct de vedere al proceselor generatoare:***
- circa 72,6 % (91,6 mil. to/an) din eroziunea totală provine din eroziunea de suprafaţă (49,0 % - 61,8 mil. to/an) şi eroziunea de adâncime (23,6 % - 29,8 mil. to/an);
- ca pondere în realizarea eroziunii totale, eroziunea de suprafaţă şi eroziunea de adâncime sunt net diferenţiate (49,0 – 23,6 %), coeficienţii de efluenţă aluvionară realizaţi pe aceste categorii sunt şi ei la rândul lor net diferenţiaţi (0,26 pentru eroziunea de suprafaţă respectiv 0,46 pentru eroziunea de adâncime).

Aportul acestora la realizarea efluenţei aluvionare este sensibil apropiat - 16,1 mil. to/an (36,2 %) eroziunea de suprafaţă respectiv 13,8 mil. to/an (31,0 %) eroziunea de adâncime.

Urmărind doar coeficienţii de efluenţă, cei mai mari se regăsesc pentru eroziunea de adâncime (0,46) şi pentru eroziunea din maluri şi albii (0,54), aceste două procese participând cu 46,3 % (20,6 mil. to/an) la efluenţa aluvionară totală

Tabelul nr. 1

Diferenţierea eroziunii şi efluenţei aluvionare în România
(după M. Moţoc, 1984)

Folosinţa terenului	Eroziunea totală		Coef. efl.	Efluenţa aluviunilor	
	mil.to/an	%		mil.to/an	%
Pe categorii de folosinţă (arii de provenienţă)					
Arabil	28,0	22,3	0,28	7,9	17,7
Păşuni	45,0	35,7	0,27	12,3	27,6
Plantaţii pomicole	2,1	1,7	0,29	0,6	1,4
Plantaţii viticole	1,7	1,2	0,28	0,5	1,1
Eroziune în adâncime	29,8	23,6	0,46	13,8	31,0
TOTAL fond agricol	***106,8***	***84,5***	***0,32***	***34,2***	***78,8***
Fond forestier (eroziune în adâncime + alunecări)	6,8	5,4	0,40	2,7	5,9
Eroziune de maluri la râuri	12,6	10,0	0,54	6,8	15,3
TOTAL	**126,0**	**100**	**0,35**	**44,6**	**100**
Pe forme de eroziune (procese generatoare)					
Eroziunea în suprafaţă	61,8	49,0	0,26	16,1	36,2
Eroziunea în adâncime	29,8	23,6	0,46	13,8	31,0
Alunecări	15,0	12,0	0,35	5,2	11,6
Eroziunea în adâncime şi alunecări în fondul forestier	6,8	5,4	0,40	2,7	5,9
Eroziune din maluri şi albii	12,6	10,0	0,50	6,8	15,3
TOTAL	**126,0**	**100**	**0,35**	**44,6**	**100**

Locul şi metoda de cercetare

Acumularea Cuibul Vulturilor, amplasată în bazinul inferior al râului Tutova, din cadrul Colinelor Tutovei care sunt amplasate între Siret şi Prut, în partea sud - vestică a Podişului Moldovei, la 34,5 km de la izvor, asigură o parte din necesarul de apă pentru populaţia municipiului Bârlad, Este realizată de un baraj de pământ (17 m înălţime şi 843 m lungime la coronament) cu călugăr deversor situat în zona centrală şi descărcător lateral de ape mari spre malul drept, Acumularea are suprafaţa bazinului de recepţie de 54.200 ha şi a intrat în exploatare în anul 1978, având următoarele caracteristici (la NNR) prevăzute prin proiectare: suprafaţa bazinului de recepţie – 54.200 ha; suprafaţa luciului de apă - 345 ha; volum de apă util – 9.500.000 m^3; volum mort –300.000 m^3; rata anuală de colmatare – 10.000 m^3,

S-a stabilit zona de influenţă excesivă privind transportul de aluviuni (suprafaţa bazinului direct aferent luciului de apă la NNR) reprezentată pentru această acumulare de cinci areale constituite din subbazinele cu intrare directă în acumulare şi versanţii direct adiacenţi luciului de apă (fig. nr. 1), suprafaţa ei fiind de 5.727 ha, reprezentând 10,5% din întregul bazin de recepţie (54.000 ha). Malului stâng îi revin 3.502 ha, din care 518 ha versantului direct adiacent luciului de apă şi 2.984 ha două microbazine (Roşcani 742 ha şi Iaura 2.242 ha) cu intrare directă în acumulare. Malului drept îi revin 2.252 ha, din care 353 ha versantului direct adiacent luciului de apă şi 1.872 ha microbazinului Cârjăoani cu intrare directă în acumulare. Modul de folosinţă a terenurilor în zona de influenţă excesivă privind transportul de aluviuni este prezentat în tabelul nr. 2.

Tabelul nr. 2

Folosinţele terenului, în zona de influenţă excesivă privind transportul de aluviuni, al acumulării Cuibul Vulturilor

Folosinţa	Total		Din care									
			Cârjăoani		Roşcani		Iaura		Versant stâng		Versant drept	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Arabil	2800,4	48,9	1237,4	66,1	254,5	34,3	867,7	38,7	194,8	37,6	246,0	69,7
Păşune	1560,7	27,3	302,6	16,2	373,2	50,3	692,8	30,9	122,2	23,6	69,9	19,8
Agricol	***4361,1***	***76,2***	***1540,0***	***82,3***	***627,7***	***84,6***	***1560,4***	***69,6***	***317,0***	***61,2***	***315,9***	***89,5***
Pădure	850,4	14,8	207,6	11,1	46,7	6,3	526,9	23,5	38,9	7,5	30,4	8,6
Construcţii	260,2	4,5	62,6	3,3	0,0	0,0	51,6	2,3	146,1	28,2	0,0	0,0
Neproductiv	255,1	4,5	61,7	3,3	67,5	9,1	103,1	4,6	16,1	3,1	6,7	1,9
Total	**5727,0**	**100**	**1872**	**100**	**742**	**100**	**2242**	**100**	**518**	**100**	**353**	**100**

Suprafaţa zonei de influenţă este distribuită asimetric faţă de acumulare 61,0 % revenindu-i malului stâng şi 39,0 % celui drept având forma unor dreptunghiuri a căror bază mică (lăţimea medie a bazinului) este cuprinsă între 0,59 km şi 2,69 km iar baza mare (lungimea bazinului) este cuprinsă între 3,0 km şi 11,1 km, Ponderea în suprafaţa zonei de influenţă excesivă o au microbazinele 79,0 % din total, restul de 21,0 % revenind versanţilor direct adiacenţi, Lăţimea medie a acestor cinci "microbazine" este relativ apropiată ea variind între 0,59 şi 1,72 km la versanţii direct adiacenţi respectiv între 1,48 şi 2,69 km la microbazine,

Densitatea talvegurilor este relativ uniformă la microbazine, fiind de 0,52; 0,88 şi 0,96 km/km^2 dar puternic diferenţiată la cei doi versanţi direct adiacenţi 0,68 km/km^2 la cel drept şi 1,31 km/km^2 la cel stâng puternic brăzdat de ravene de versant în diferite stadii de evoluţie,

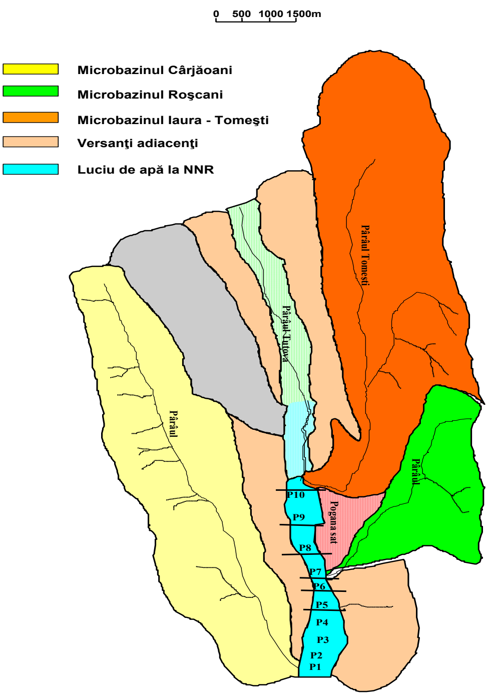
Diferenţa de nivel cea mai mare se întâlneşte pe versantul drept direct adiacent 198,5 m deşi baza de eroziune este mai mică 133,5 m, Talvegurile microbazinelor au pante medii cuprinse între 1,86 – 3,67 % iar panta maximă între 2,90 – 5,10 %, Calculul indicatorului energiei de eroziune (baza de eroziune / radicalul suprafeţei bazinului de recepţie) indică valori maxime în microbazinul Roşcani – 7,46 şi pe cei doi versanţi direcţi adiacenţi – 6,34 pentru versantul drept respectiv – 8,10 pentru versantul stâng, Panta medie a versanţilor este asemănătoare în microbazinele Roşcani şi Iaura ; mai mari în microbazinul Cârjăoani şi foarte diferite pentru cei doi versanţi direct adiacenţi (9,50 % versant stâng şi 22,60 % versant drept) aceasta datorită diferenţei dintre lungimile lor – 1,52 km respectiv 0,59 km la diferenţe de nivel de 133,50 m respectiv 198,50 m),

În cadrul celor cinci microbazine ("areale") ale zonei de influenţă excesivă privind transportul de aluviuni, lucrările de amenajare antierozională sunt diferite, microbazinele cu intrare directă în acumulare sunt lipsite de astfel de lucrări în aceeaşi situaţie fiind şi versantul drept adiacent luciului de apă ; lucrări de amenajare sub forma unor terase banchetă (înainte de 1989 şi culturi cu benzi înierbate) şi amenajarea prin lucrări hidrotehnice transversale a unor ravene de versant se găsesc doar pe versantul stâng adiacent luciului de apă.

Terasele banchetă ocupă o suprafaţă redusă, de circa 7,0 ha, distanţa dintre ele fiind de 40 m,

Pe versantul drept sunt un număr de 3 ravene de versant neamenajate dar stabilizate natural; pe versantul stâng sunt un număr de 8 ravene de versant, cinci neamenajate dar stabilizate natural şi trei amenajate cu lucrări transversale de tipul barajelor şi pragurilor din zidărie de piatră cu mortar de ciment sau căderi sub formă de jilip,

Fig.1 Acumularea Cuibul Vulturilor - zona de influenţă



Rezultate obţinute

Eroziunea din zona de influenţă excesivă

În zona de influenţă excesivă a acestei acumulări se întâlnesc toate formele de eroziune exceptând fenomenele de alunecări de teren, Eroziunea de suprafaţă este prezentă în toată zona, din determinările şi estimările făcute de S.C.C.C.E.S. Perieni în timpul dezgheţului rapid din lunile martie - aprilie 1996, aceasta a atins valori de 10 - 12 to/ha pe teren amenajat cu terase banchetă amplasate la distanţe de 40 m între ele pe un teren cu panta medie de 8 - 9 % iar pe teren ne amenajat, având aceiaşi pantă medie, eroziunea de suprafaţă (prin şiroiri şi rigole) a atins valori de 30 - 35 to/ha pe mirişte de porumb şi valori de 9 - 12 to/ha pe arătura de toamnă.

La acelaşi eveniment (în aceeaşi zonă) s-a format pe malul stâng, în partea amonte a lucrării de barare, o ravenă de versant având o lungime de circa 225 - 250 m; 4 - 5 m adâncime în zona de vârf şi lăţimi de 8 - 10 m, în acumulare a intrat un volum de aluviuni (estimat) din realizarea acestei ravene de 5.400 m^3,

În treimea inferioară a ravenelor de versant situate pe malul stâng al acumulării, actualmente amenajate, au apărut fenomene de afuiere, materializate prin praguri cu adâncimi de 0,5 - 1,5 m şi lăţimi de 3 – 5 m erodându-se volume de circa 80 - 120 m^3 / prag; volume care au ajuns în acumulare sub formă de aluviuni,

Efluenţa aluvionară din zona de influenţă excesivă

Efluenţa aluvionară din zona de influenţă excesivă privind transportul de aluviuni în acumulare a fost determinată la acelaşi eveniment de topire bruscă a zăpezii din lunile martie - aprilie şi la precipitaţiile din 21 - 24 septembrie care au atins valori cumulate de 139,4 mm (având intensităţi variabile 1,2 – 1,8 mm/min), Pentru aceasta s-au evidenţiat volumele de apă intrate şi ieşite din acumulare provenite din aceasta zonă în timpul producerii evenimentelor înainte de a ajunge unda de viitură de pe râul Tutova în zona acumulării. Din zona de influenţă excesivă s-au prelevat probe de apă cu turbidităţi din toate cele cinci "microbazine" (părţi) ale acesteia, în momentul producerii scurgerilor provocate de evenimentele menţionate, la intrările în acumulare din microbazinele adiacente (Roşcani; Iaura şi Cârjăoani) precum şi la intrările în acumulare din ravenele de versant existente pe cei doi versanţi direct adiacenţi. Scurgerile s-au produs pe toată suprafaţa zonei de influenţă şi au fost considerate ca fiind relativ uniforme; în această ipoteză, raportând volumul de apă intrat în acumulare la suprafaţa acestei zone de influenţă excesivă s-a determinat volumul scurgerilor aferent fiecărui "microbazin" (părţi), Prin prelucrarea probelor de apă prelevate s-a determinat gradul de încărcare cu aluviuni al scurgerilor care în final a condus la estimarea efluenţei aluvionare a fiecărui “microbazin” părţi (*tab. nr. 3*).

Din datele prezentate în tabelul nr,5,4, reiese faptul că efluenţa aluvionară cea mai puternică provine din microbazinele cu intrare directă în acumulare (0,68 – 6,81 to/ha de pe versanţii direct adiacenţi la diferite evenimente şi 1,24 – 21,05 to/ha din microbazine cu intrare directă în acumulare).

Conform ratei anuale medii de colmatare (*Gh. Purnavel 1995)* în această acumulare intră anual circa 221.430 m^3 aluviuni dar, în perioada 1996 - 2000 numai la evenimente deosebite din zona de influenţă excesivă au intrat circa 143.260 m^3 aluviuni ceea ce reprezintă 64,7 % din totalul aluviunilor intrate anual în acumulare, Din volumul de aluviuni intrate în acumulare 13,1 % provin de pe versanţii direct adiacenţi restul de 86,9 % provin din microbazinele cu intrare directă în aceasta, Acceptând faptul că în cursul anului din această zonă de influenţă excesivă mai sunt scurgeri care nu au fost evidenţiate în tabelul menţionat aportul acesteia la gradul şi implicit la ritmul de colmatare este de peste 65,0 %.

Tabel nr. 3

Efluenţa aluvionară şi volumele de aluviuni intrate, din zona de influenţă excesivă, în acumularea Cuibul Vulturilor, media anuală a evenimentelor din perioada 1996-2000

Nr. crt.	Denumire subbazin din cadrul zonei de influenţă excesivă	Suprafaţa (ha)	Aluviuni efluente (to/ha)		Volume de aluviuni intrate în lac (mc)	
			Eveniment		Eveniment	
			Topire zăpadă	Ploi de lungă durată	Topire zăpadă	Ploi de lungă durată
1	Versant stâng	372	8,89	9,87	4.639	5.158
2	Roşcani	742	25,36	30,52	26.432	31.797
3	Pogana sat	146	1,22	1,44	249	293
4	Iaura-Tomeşti	2242	1,80	2,18	8.833	6.847
5	Cârjăoani	1872	8,35	10,74	21.972	28.646
6	Versant drept	353	7,93	9,00	3.931	4.463
Total		***5.727***	***53,55***	***63,75***	***314.857***	***341.265***
Media volum total		**eveniment**	**5,03**	**6,18**	**66.056**	**77.204**
		evenimente				**143.260**

Concluzii:

- În zona neamenajată eroziunea de suprafaţă este de circa trei ori mai mare faţă de zona amenajată;
- În zona de influenţă excesivă există un risc potenţial ridicat de formare a ravenelor de versant în zonele de concentrare a scurgerilor (microdepresiuni şi drumuri);

- Lipsa amenajărilor corespunzătoare a ravenelor de versant în treimea lor inferioară face ca fenomenele de eroziune să fie prezente în continuare;
- Fenomenele singulare deosebite au un aport esenţial în colmatarea acumulării prin efluenţa aluvionară mare comparativ cu efluenţa aluvionară medie anuală care se ia în calcul în mod curent la stabilirea volumelor colmatate în proiectarea acumulărilor,
- Zona de influenţă excesivă, reprezentată de suprafaţa direct adiacentă luciului de apă cvasipermanent, contribuie cu peste 65% la aportul de aluviuni şi implicit la fenomenul de colmatare;
- Volumele cele mai mari de aluviuni din această zonă provin din microbazinele cu intrare directă în acumulare (86,9%) comparativ cu versanţii direct adiacenţi (13,1%).

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ESTIMATING OF WATER USE EFFICIENCY IN SOYBEAN VARIETIES BY USING OF CARBON ISOTOPIC DISCRIMINATION

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The isotopic ratio of ^{13}C to ^{12}C in plant tissues is less then the isotopic ratio of ^{13}C to ^{12}C in the atmosphere, indicating that plants discriminate against ^{13}C during the photosynthesis. The values of CID in plants, after 24 days of water stress, have been ranged between 17.12-17.86, thus the lowest value belongs to Conquista cultivar, while the highest belongs to Aurora variety. Between WUE and CID there is a linear negative correlation with a high coefficient (r^2 = 0.927).

Keywords: *drought, stabile isotopes, water use efficiency.*

Water is one of the most limiting factors for crops yield especially in the arid and semiarid areas. Water use efficiency is one of the most important characteristics in order to obtain plants with a good drought tolerance.

High water use efficiency is a trait that should be associated with high biomass and seed yield, where water availability is limited. The substantial effort in measuring WUE has limited its use in plant breeding until recent research has shown that indirect measures of WUE can be provided by leaf carbon isotope discrimination and also by the specific leaf area.

The drought strength is also species characteristic, but that can be improved in breeding process of new plant varieties. There are many techniques for establish the drought resistance. Water Use Efficiency is the most used method for drought tolerance.

The isotopic ratio of ^{13}C to ^{12}C in plant tissues is less then the isotopic ratio of ^{13}C to ^{12}C in the atmosphere, indicating that plants discriminate against ^{13}C during the photosynthesis.

Farquhar and Richards, 1984 found that in C3 plants and particularly in cereals, a strong relationship has been noted between WUE and carbon isotope discrimination (Δ) [2].

There was highly significant correlation between CID and WUE in an experiment conducted by D.S. White in 1996. The results suggest that CID may be a useful selection index for improved WUE in soybean breeding programs [3].

MATERIALS & METHODS

The experiment has been carried out at J.I.RC.A.S. Isolation Green House.

The experiment started on 2004, July 12. The experiment type is 4*2*5, which means 4 varieties, two stress conditions in five replications.

Seeds of four determinate soybean (*Glycine max* L. Merr.) cultivars, **BRS-185** and **Aurora** (drought-sensitive or intermediate), **BRS-183** and **Conquista** (drought-tolerant), were sown in a 1/1000 a pot.

All these varieties were cultivated in two different soil moisture conditions:

1. Stress condition respectively drought conditions
2. Ideal soil moisture for plant growth - control variants (field capacity).

Until the flowering stage (most sensitive to drought stress), plants were grown in ideal soil moisture with keeping the field capacity by regular irrigation. Soil surface was covered with plastic film to avoid evaporation.

From August 25, irrigation was stopped in a half of the pots to start the water stress treatment, whereas another half to remain the field capacity as control. The total weight (pot + soil + plant) and the amount of irrigated water of each pot were monitored every week to calculate the amount of water transpired by plants.

The greenhouse experiment has been finished at September 21, 2004. In all this time carried out a range of measurements: photosynthesis, transpiration, monitoring of soil moisture.

Photosynthesis and transpiration have been measured by using a portable photosynthesis analyzer LI- 6400. These analyses have been performed weekly. Also the water consumption was monitored weekly by measuring the pots weight and soil moisture.

The sampling has been done by four times as following: first sampling on August, 27 before starting treatment; the second sampling on September 03, the third sampling on September 13, and the last one, on September 21.

The entire plant was sampled, then for each sample was measured the leaves area, and every leaf was cut and dry in a special dryer for three days at 80 ^{0}C. After drying, the total dry matter was calculated, and these results were used for calculating the water use efficiency as below:

WUE (g L^{-1}) = (Total above-ground dry matter) / (total water transpired)

After drying the leaves were grinded and then analyzed for δ^{13}C. For these analyses the most active leaves has been chosen.

Carbon isotope ratio (δ^{13}Cp: ‰) was measured for the youngest fully expanded trifoliate with an isotope ratio mass spectrometer (ThermoFinnigan Delta XP^{plus}). Carbon isotope discrimination was calculated with use of δ^{13}Cp values as below:

CID: Δ (‰) = (δ^{13}Ca – δ^{13}Cp) / (1+ δ^{13}C/1000)

where δ^{13}Ca is the δ^{13}C value of the air (-8.0‰), and δ^{13}Cp is the measured value of the plant.

RESULTS & DISCUTIONS

Water use efficiency as a ratio between the dry matter and the water transpired has been calculated four times for each variety. **Water-stressed** plants with 24 days of limited water supply, WUE was apparently increased in all cultivars. The results shows that there are significant differences, among soybean varieties but the most important differences have occurred after 24 days of water stress. So, the first place has belonged to ***Conquista*** cultivar, with 3.65g/l, followed by ***BRS 185*** (3.49 g/l), ***BRS 183*** (3.41 g/l) and on the fourth place ***Aurora*** cultivar with 3.27 g/l.

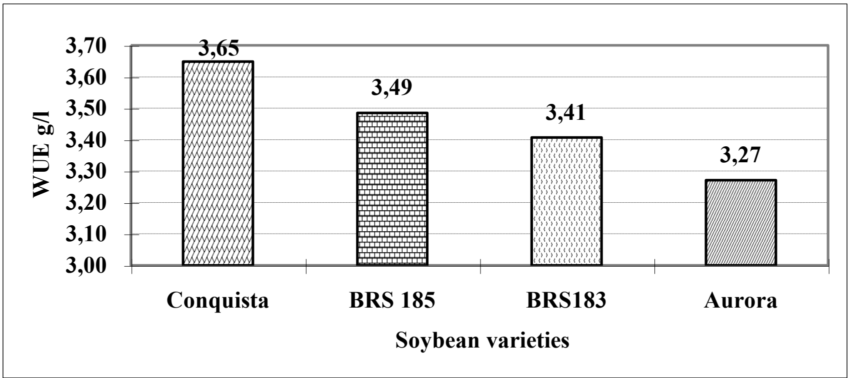

Figura 1 **The variation of WUE after 24 days of water stress**

Instantaneous observation at 24 days after water stress also showed that WUEi was higher in Conquista to be 10.2 μmol CO_2/mol H_2O, whereas 8.75, 8.01 and 7.14 μ mol CO_2/mol H_2O in BRS-185, BRS-183 and Aurora, respectively fig.2.

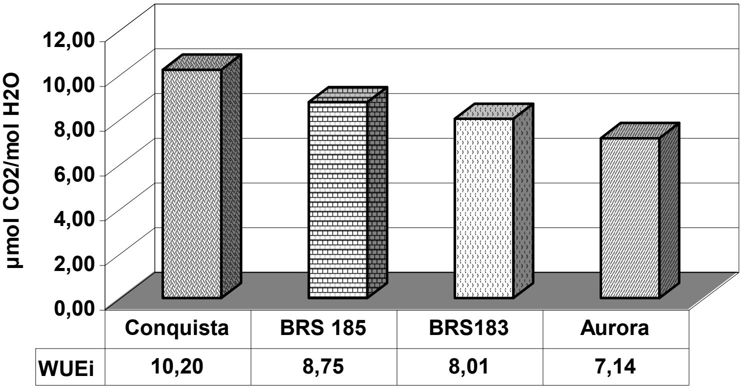

Fig.2 **The variation of WUEi after 24 days of water stress**

The analyzing of Carbon Isotope Discrimination (CID) shows that among those four soybean varieties there are important differences. The values of CID in plants, after 24 days of water stress, have been ranged between 17.12-17.86, thus the lowest value belongs to Conquista variety, while the highest belongs to Aurora variety, fig 3.

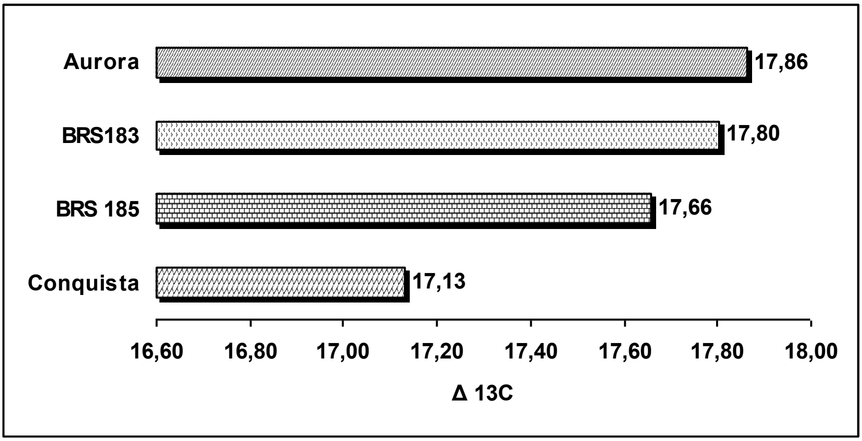

Figura 3 **CID after 24 days of water stress**

Fig. 4 shows the relationship between WUE and Δ in water-stressed (24 days) and non-stressed soybean cultivars at 68 days after sowing. There was **a negative linear correlation** in-between with a high coefficient (***r*²** **= 0.927**). Therefore, it would be reasonable to estimate water use efficiency in field-grown soybean plants with the measurement of Δ .

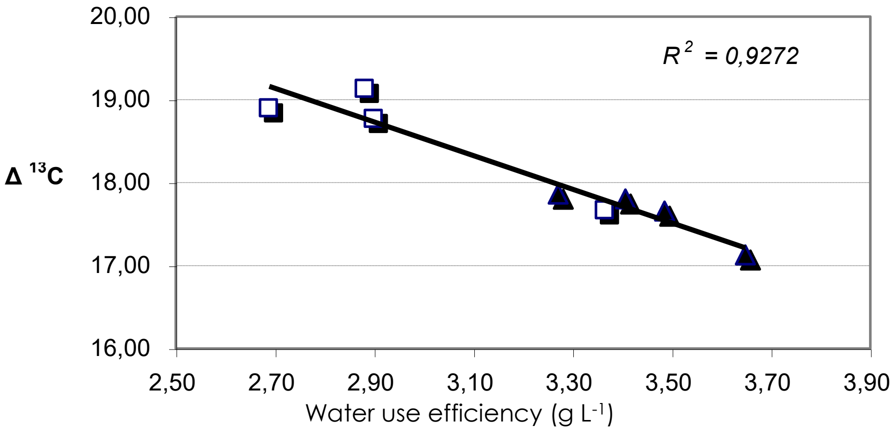

Fig.4 **Relationship between WUE and CID in water stressed or not water stressed soybean plants**

CONCLUSIONS

◊Cumulative mean of water use efficiency of field grown soybean plants could be estimated by measuring of carbon isotope ratio ($\delta^{13}C$) of the plants.

◊ Conquista, a drought-tolerant cultivar, would have a mechanism associated with better water use efficiency, as compared with another tolerant cultivar, BRS-183.

◊ WUE were distinct for each soybean cultivar, and after 24 days of drought varying between 3.65-3.27.The highest value belonging to Conquista cultivar and was strongly influenced by the rate of transpiration

◊ A strongly correlation between CID and WUE was established, during the entire period of treatment, both under water stressesd and not water stressed

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USE OF FALLOUT RADIONUCLIDES FOR ESTIMATING SOIL EROSION RATES ON CULTIVATED LAND IN SOME SMALL WATERSHEDS FROM TUTOVA ROLLING HILLS, ROMANIA

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Abstract

The study was made in some representative small watersheds from Tutova Rolling Hills, Romania which comprehend a whole range of natural conditions and categories of soil conservation measures: stripcrops, bench terraces, shelter belts and an adequate agricultural exploitation road network.

The reference sites have been under continuous vegetation cover in the last 60 years. One of them is used like a pasture and the other is an old rural burial ground.

Soil and water samples for determining of ^{7}Be and ^{137}Cs activity were analyzed at the Institute of Physics and Nuclear Engineering (IPNE) Magurele – Bucharest, Romania.

^{137}Cs inventory for sampling points that presented values below the reference is related to both erosion by water and tillage erosion. Lowest values of the ^{137}Cs inventory (e.g. 1.95 kBq/m^2) have been determined in places where a significant part of the topsoil was removed when camp roads were constructed. High values of ^{137}Cs inventory have been determined on points situated on the platform of agroterraces where the sedimentation process is much evident. High values of ^{137}Cs inventory (7.98 – 11.22 kBq/m^2) have also been observed in sample points that are placed inside of forest belts, owing to canopy processing of rain and soil disturbance from root throws. However, the distribution of ^{137}Cs content in soil profile, as well as field observations, shown that the sedimentation process inside the shelter belts was reduced.

The analyze of soil samples from reference sites, from runoff plots and some representative terrains with and without conservation measures, showed that the level of ^{7}Be activity, after important rain events (e.g. rain from May 7, 2005) were under minimum detectable activity, even for a collecting time of 10000 seconds, thus the measurements on soil samples could not distinguish the presence of ^{7}Be in the environment.

INTRODUCTION

The study has been conducted to establish relationships between soil losses, measured by combined 137 Cs, and 7 Be technique, under natural conditions and the main factors like: land use, characteristics of soils, relief and, specific conservation measures.

The following objectives have been in sight:

- to use of ^{137}Cs, and ^{7}Be technique for measuring soil erosion over several spatial and time scales.

- to utilize these techniques to assess the impact of short-term changes in land use practices and the effectiveness of specific soil conservation measures from Romania in controlling soil erosion for sustainable crop production.

Materials and methods

The study was made in three representative small watersheds that comprise a range of natural conditions and categories of soil conservation measures: stripcroping, bufferstrips, bench terraces, shelter belts and an adequate agricultural exploitation road network. In Tarnii basin, a study on runoff plots, all with a cropping history, fully instrumented for measuring runoff and soil loss under different conditions concerning vegetative cover, was also made.

The comparative study between behavior of contour system and up-and-down slope system was extended in Tutova Valley, in the neighborhood of Cuibul Vulturilor Reservoir. Here, like in many parts of the hilly area from Romania, after the revolution from 1989, the land was realloted to the landowners in narrow plots disposed up-and-down slope.

In order to obtain referenced data concerning ^{7}Be activity, water samples from every rain event, especially in warm season, were analyzed, knowing that the peak of fallout ^{7}Be is associated with precipitations.

For ^{137}Cs "in situ" measurement a Canbera Ge HP portable detector, 18% efficiency, has been used.

Concerning sampling method, a scraper device and conventional soil augers has been used. Where the depth of sediment in depositional areas was thin or in reference sites where neither soil loss nor sediment deposition occurred, the samples were collected at 1 or 2 cm intervals. In deep sediments, depth increments were usually 10 or 20 cm, depending on the auger bucket. The mass of soil collected varied between 0.5-1.5 kg and depended on the dimensions of the scraper (20 x 50cm), the bulk density and the depth increment involved.

In order to obtain referenced data concerning ^{7}Be activity it was necessary to analyze the water from precipitation.

The reference sites have been under continuous vegetation cover in the last 60 years and are situated on the top of the hills. The first one is an old rural burial ground and the second is an area used like a pasture (photo 7-8).

In order to obtain data referring to the agradation of the platform of agroterraces owing to tillage translocation, topographical measurements were made since 1998, each time on 5 parallel transects at 1 m distance, whereas diminishing of errors due to roughness of soil surface.

The project has been realized in collaboration with the National Institute of Physics and Nuclear Engineering “Horia Hulubei”, IFIN-HH Magurele – Bucharest.

Results obtained

Upper Tarnii Valley (300 ha), with long and uniform slopes, is very well characterized by the transect shown in figure 1, through three agroterraces and two shelter belts. Here slope varies between 12 and 14%, and the width of stripcrops is about 100m. It can be observed that measurements were made in the upper part, middle part and platform of agroterraces in order to determine relationships between ^{137}Cs activity and the redistribution of eroded soil along the slope. The transect is situated approximately in the middle of the distance between the reference site no.1 where calculated ^{137}Cs inventory is 6.90 kBq/m^2 and the reference site no.2 where ^{137}Cs inventory is 4.98 kBq/m^2. In consequence, an average of 5.94 kBq/m^2 for ^{137}Cs inventory reference was considered.

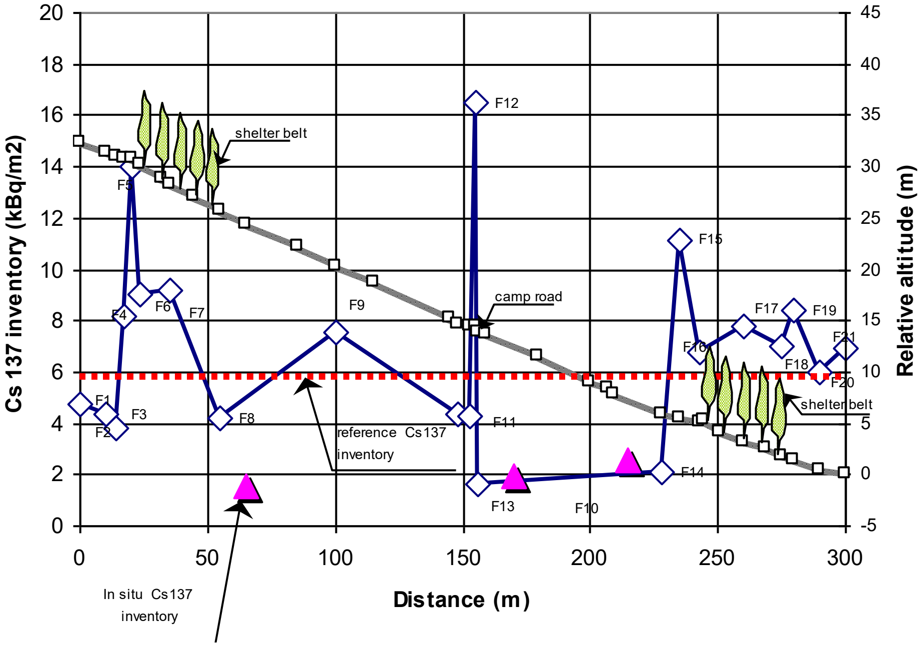

Figure 1 Transect in Tarnii basin through the main conservation measures

However, in the neighborhood of the shelter belts, this value has to be reconsidered due to the influence of the trees on the wind velocity which, probable, influenced initial ^{137}Cs deposition. This effect is very well illustrated during the winter when the dominant wind from NW to SE determines every year a significant snow deposition. It can be an explanation for the high values of ^{137}Cs inventory in T-F9, T-F20 and T-F21 sampling points situated in the upper part of stripcrops, where the soil is usually affected by erosion.

^{137}Cs inventory for sampling points T-F1, T-F2, T-F3, T-F10, T-F11, and T-F14 presented values below the reference line because they are situated in the area where the soil loss is mostly related to erosion by water. In F8, soil loss can be explained by the influence of the tillage erosion.

The lowest value of the ^{137}Cs activity can be observed in TF13 (1.95 kBq/m^2) where a significant part of the topsoil was removed in 1993 when a camp road was constructed.

T-F4, T-F5, T-F12, T-F15 and T-F16 sampling points are situated on the platform of agroterraces where the slope is less than 5% and the sedimentation process that is dominant is reflected in high values of the ^{137}Cs inventory.

T-F6, T-F7, T-F17 and T-F18, which are placed inside the forest belts, have a high variability of ^{137}Cs inventory (7.98 – 11.22 kBq/m^2) owing to canopy processing of rain and soil disturbance from root throws but the averages (11.04 kBq/m^2 for SB1and 8.66 kBq/m^2 for SB2) are above the reference inventory. However, field observations shown that the sedimentation process inside the shelter belts is very reduced.

A comparative study related to stage of erosion process under two distinct types of soil conservation measures, situated on the same hillslope, with similar pedological characteristics, was made in Tutova Valley, near Cuibul Vulturilor reservoir.

Analyze of measurements on the old traditional up-and-down system used during almost 13 years, revealed that the rates of erosion and sedimentation on the up-and-down the hill disposed plots were between 1.5-2.0 times higher in comparison with surfaces where the contour system was applied.

In order to obtain referenced data concerning ^7Be activity it was necessary to analyze the water, sampled by rain gauge during the warm season. Data showed that ^7Be activity from water of rain has a high variability and, also has a weak connection with the level of precipitation.

Conclusions

- In Tarnii basin that is characterized by long slopes, ^{137}Cs inventory for the sampling points that presented values below the reference is mostly related to erosion by water while in Gheltag basin with steep slopes the tillage erosion is dominant.

- Lowest values of the ^{137}Cs inventory (e.g. 1.95 kBq/m^2) have been determined in places where a significant part of the topsoil was removed when camp roads were constructed.

- High values of ^{137}Cs inventory have been determined on points situated on the platform of agroterraces where the sedimentation process is much evident.

- High values of ^{137}Cs inventory (7.98 – 11.22 kBq/m^2) have also been observed in sample points that are placed inside of forest belts, owing to canopy processing of rain and soil disturbance from root throws. However, the distribution of ^{137}Cs content in soil profile, as well as field observations, shown that the sedimentation process inside the shelter belts was very low.

- The comparative analyze between "in-situ" and laboratory measurements revealed that the portable detector has to be used with care, especially on slopes where many discontinuities can be met. Otherwise, "in-situ" measurements give good estimations of soil erosion and sedimentation.

- The maximum value of sedimentation process was located on the platform of agroterraces and it is equivalent with an increasing of altitude of those points up to 16.6 mm/year. In comparison with data obtained by topographical measurements that indicated an agradation of the same point with 45.0 mm/yr, estimated deposition is underpredicted

- Deposition inside of shelter belts was overpredicted owing to influence of canopy processing of rain on the accumulation of ^{137}Cs.

- ^{7}Be activity measured in water collected from rains has a high variability and, has a weak connection with the level of precipitation.

- In most cases ^{7}Be was under minimum detectable activity even for a collecting time of 10000 seconds, so, the measurements could not distinguish the presence of ^{7}Be in the environment.

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