RESEARCH ON EXCESS MOISTURE AND SOIL SALINIZATION AT CELEBRATING 20 YEARS FROM THE FOUNDING OF FACULTY OF ENVIRONMENTAL PROTECTION, ORADEA

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Abstract

The objective of this paper is to present the rich backgrounds and experience gained by the teaching staff and researchers from the Faculty of Environmental Protection in combating waterlogging and salinisation of soils in Northwest Romania.

The first research in the combat of excess moisture in Bihor County began in 1967, when a Laboratory on Soil and Land Reclamation, headed by PhD Eng. Iuliu Colibaş and Maria Colibaş, was founded within the Agricultural Research and Development Station Oradea.

Research on waterlogging and soil salinisation during the last two decades has been carried out in parallel for a period of time by the researchers trained at the Research and Development Station Oradea - the Laboratory of Soil Science and Land Reclamation, who had also approached a university teaching career; the research had been subsequently more elaborated and diversified.

Key words: waterlogging, soil salinization, monitoring, drainage field, DrenVSubIR program.

INTRODUCTION

As a blessed coincidence, the Faculty of Environmental Protection - one of the most dynamic faculties, established in the academic year 1993-1994 - joins the celebration of 50 years of continuous academic education in our city as we are also celebrating 20 years of its existence. On this anniversary, demonstrating its full maturity, our faculty shows off its remarkable achievements in the education and scientific research.

Sustainable agriculture involves the development of efficient agricultural systems in terms of agricultural production amid amelioration and protection of soils embedding certain degree of fertility. In this respect one should consider the main factors limiting the crops and which are affecting soil fertility in Romania i.e. drought, excess moisture, erosion and landslides, salinisation, compaction, poor supply of humus and nutrients. (Sabău et al., 2002).

Excess moisture is the limiting factor with the largest spread which is often associated with a high argillaceous content and compaction of soil (the primary one in Bt horizon of alluvial clay soil and the secondary one i.e. anthropogenic one affecting the arable layer and the layer placed immediately below), the acidity or alkalinity and alkalization, highlighting

the need to apply hydro- and pedo-ameliorative works on large agricultural areas (Colibaş et al., 1988).

For the conditions Romania faces it is estimated that excess moisture occurring in different periods of time, affects an agricultural land totalling 8.9 million ha. If one removes from this area the surface affected by water excess for relatively short periods of time and which do not generate significant shortcomings, there are still remaining 7.5 million ha of agricultural land and about 4.2 million hectares of arable land which are facing large losses in terms of crops during rainy years.

The total area occupied by halomorphic, unproductive or less productive soils in Romania is estimated at approx. 500,000 ha, of which about 200,000 ha are located in the West Plain (Sabău, Şandor, 2003).

Due to the high pace of developing hydro-ameliorative works completed before 1989 on the land affected by various factors limiting crops in Romania, one reached at the end of communist age at irrigation systems covering 3.2 million ha and the same area was covered by drainage works while 2.3 million ha were arranged by soil erosion control works (Sabău, 1997).

The objective of this paper is to present the rich backgrounds and experience gained by the teaching staff and researchers from the Faculty of Environmental Protection in combating waterlogging and salinisation of soils in Northwest Romania.

Brief history

For the Northwest Romania's climatic conditions, the Bihor county land surface undergoing degradation for different reasons is 307,000 ha, i.e. a 63 % share of the total county's agricultural area (490,000 ha), of which the lands which are affected by permanent excess moisture along with the acid lands affected by temporary excess moisture and the saline and alkaline lands total 246,000 ha, i.e. < 50 % of the whole agricultural area of the county.

Taking into account the above mentioned data, the research carried out by the Agricultural Research and Development Station Oradea (which celebrated in 2012 half century of activity) has been streamlined towards these lines of actions.

Early research in the fight against excess moisture in Bihor County begun in 1967, when a Laboratory on Soil and Land Reclamation, headed by PhD Eng. Iuliu Colibaş and Maria Colibaş, was founded within the Agricultural Research and Development Station Oradea (Şandor M., 2012).

Since the first year of the founding of Laboratory on Soil and Land Reclamation, its team initiated research on knowledge of and ameliorating surface heavy soils affected by excess moisture from precipitation, by

means of pedo-ameliorative characterization of the great diversity of soils within the area and emplacement of some experimental fields designed to provide technical solutions for future drainage facilities in the studied area.

Thus, in 1967, it was established the first experimental drainage field located in Western Romania in the Holod depression, on the second terrace of Crişul Negru river, followed by experimental fields located at: Bunteşti (1974), Beiuş depression and Sânmartin (1986) within the piedmont plain of Crişul Repede river. Research continued on improving soils affected by mixed excess moisture i.e. from precipitation and groundwater in the following experimental fields: Cefa (1982) from the Criş rivers meander plain, Avram Iancu (1983) into the low plain of Crişul Negru river and Diosig (1987) from the holm of Valea Ierului (Sabău, Șandor, 2003).

The variants studied in the afore mentioned experimental fields varied a lot, from surface drainage methods represented by land shaping in ridge strips of different widths and ending with underground drainage solutions made of local materials, ceramic tubes and PVC corrugated pipes placed at different distances between the absorbent drain or non-systematic wires with or without ballast made filtering prisms of different heights. For heavy and compacted soil conditions, they were associated with various pedo- ameliorative works, mole drainage, soil deep loosening, scarifying, amendment and fertilisation.

Among the outstanding achievements of this period (1968) one should have referred to the first introduction of soil loosening in the Romanian agriculture by means of the "Progress Braila" rooter carried by the S-1300 tractor and subsequently the making of the device for common administration along with scarifying of soils addition and fertilizers on scarifying slots for which PhD Eng. Mr. Iuliu Colibaş was awarded with the innovation patent no. 1136 of 12.14.1989 "Device for chemical pedo-ameliorative fertilization" by the Academy of Agriculture and Forestry Sciences (Şandor, 2012).

Research on Crişana's halomorphic soils genesis and characterization is older than the Oradea's Agricultural Research and Development Station, being connected to research made at the Experimental Station for the Improvement of Socodor Salina (Arad County) where Messrs. PhD Eng. Maria and Iuliu Colibaş had being working before 1967.

Since 1968, Oradea Agricultural Research and Development Station, under the direct supervision of Mrs. Maria Colibas, PhD engineer, it was carried out a research programme called "Knowledge of soil quality evolution within some land reclamation schemes secondary salinization and sloughing" as part of the national research program "Preventing and combating soil pollution" theme "National monitoring system of soil

quality" within the research programme of the Research Institute for Soil Science and Agro-Chemistry Bucharest (Colibaş M. et al., 2012).

This research focused on monitoring the quality of groundwater and surface water quality, and soil quality of that land reclamation systems located in Ier valley and Salonta plain and which were subsequently extended to the Mureş - Crişul Repede rivers drain area, the latest research being exploited by Mrs. Maria Colibas by means of a highly scientific PhD thesis called "Research on the influence of plains Mureş - Crişul Repede area groundwater chemistry on soil and agricultural plants" held in 1975 (Colibaş M., Colibaş I., 1988).

The outstanding results in achieved in experimental fields and those targeting the characterization and improvement of salsodisoils were capitalized by extending them to the desiccation-drainage arrangements made before 1989 in Bihor county, which area is 161,000 ha equipped with drainage works and 1,348 ha drained (Table 1).

Table 1

Landscaped areas with desiccation-drainage works in Bihor County
(after: Sabău N.C., Crăciun L., 1992)

Ameliorating Unit	Existing facilities		The necessary additions			New facilities needed	
	Desiccation (thousand ha)	Drainage (ha)	Desiccation (thousand ha)	Drainage (ha)	Washing salts (ha)	Desiccation (thousand ha)	Drainage (ha)
Sands Valea lui Mihai	-	-	-	-	-	8.8	1300
Valea Ier	27.6	70	1.0	2309	1420	-	-
Barcău downstream Sălard	9.6	-	6.4	-	630	-	-
Barcău downstream Sărsig	-	-	-	-	-	10.6	700
Criş Repede downstream Oradea	9.6	276	1.3	165	70	-	-
Criş Repede upstream Oradea	-	-	-	-	-	6.4	500
Criş Negru, Tinca zone	-	-	-	-	-	3.5	-
Colector Channel	87.1	522	41.6	1805	5220	-	-
CES Systems	27.1	480	-	531	-	13.5	-
TOTAL	161.0	1348	50.3	4810	7340	42.8	2500

After the retirement of Messrs. Maria and Iuliu Colibaş, PhD, in 1997, the Laboratory of Soil Science and Land Reclamation is led by Ms. Maria Şandor, PhD engineer, and the research in this area has been diversified and carried-on by researchers trained in this laboratory who then became professors at the Faculty of Environmental Protection Oradea.

MATERIAL AND METHOD

From a climate perspective, the experimental field site covers a very large area starting from the varied from cool-humid climate of Beiuş depression, characterized by a humidity average surplus of 136 mm annually to the moderately warm semi-moisty Ier valley where there is an annual moisture deficit of -1 mm (Table 2).

Table 2

Average annual values of the main climatic elements of experimental fields (after: Sabău, Şandor, 2003)

Meteorological Station (The experimental field)	Climatic element			
	Rainfall (mm)	Air Temperature (°C)	Potential evapotranspiration ETP (mm)	Surplus/deficit of moisture (mm)
ŞTEI (Bunteşti)	711	9,6	575	+136
HOLOD (Petid)	707	10,1	587	+120
ORADEA (Sînmartin)	635	10,5	552	+83
SALONTA (Cefa şi Avram Iancu)	560	11,4	525	+35
SĂCUIENI (Diosig)	575	10,3	576	-1

Out of the soil and climatic conditions analysis it results that the excessive humidity due to heavy precipitation within the experimental fields of Petid, Bunteşti and Sînmartin is enhanced by the presence on the soil profile of a Bt Argic horizon, containing over 36.7 % colloidal clay, and which is compact (DA > 1.50 g/ cm^3), presents a low permeability, (K < 0.9 mm/h) to prevent depth infiltration of surface water and leading to the formation of an stagnogleyzation horizon above it. Chemically these soils embed acid reaction and low fertility.

In the case of experimental fields of Cefa, Avram Iancu and Diosig, the source of excess moisture is mixed rainfall and a high groundwater level showed by the presence of the G gleyzation horizons at the base of the soil profile. Their chemical properties indicates a neutral reaction in the case of gley molik chernozem from Avram Iancu and alkalization processes in the soils samples from experimental fields of Cefa and Diosig (Na changeable from T = 5.1 to 42.1 %) and their weak supply with nutrients.

In these circumstances the works of removing excess moisture consisting of surface drainage (modelling land in ridge strips) in the first case, and underground tubes based drainage in the second case, should be

associated with mole drainage or deep loosening works to ensure Argic horizon permeability, administration of additions to correct soil acidity or alkalinity and mineral and organic fertilisation in order to improve nutrients supply.

RESULTS AND DISCUSSION

Research on waterlogging and soil salinisation during the last two decades (i.e. the period since the establishment of Faculty of Environmental Protection of Oradea) has been carried out in parallel for a period of time by the researchers trained at the Research and Development Station Oradea - the Laboratory of Soil Science and Land Reclamation, who had also approached a university teaching career; the research had been subsequently more elaborated and diversified.

Thus, the observations and research programme in the experimental fields of Sînmartin, Diosig and Cefa have continued after 1990.

The research conducted at Sînmartin between 1987 and 1993 has showed superior behaviour from the point of view of the hydrological effectiveness of ridge strips modelling variants of 22.4 and 33.6 m width respectively, which eliminates 5.43 % and 3.76 % of rainfall compared to its corrugated PVC drain variant of Φ = 65 mm (V6), the distance between absorbent drain wires L = 30 m, with topsoil made filtering prism, without associated works, which removes only 0.31% of rainfall (Figure 1).

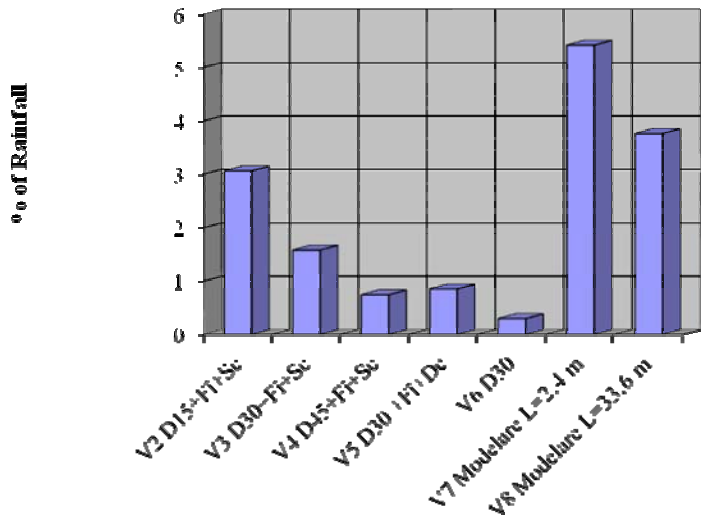

Fig. 1. Average volume of drainage water discharged from Sînmatin variants, Bihor (1987-1993)

This demonstrates that the combination of underground drainage pipes made of corrugated PVC and filtering prism made of ballast of 15 - 20

cm height with deep loosening works reduces the volume of water discharged from the soil profile due to the fact that through soil scarifying and loosening the soil profile increases its water storing capacity.

Production increases compared to the undrained control sample, early periods when the research was carried out, were distinct and very significant except for the V6 version drainage placed at 30 m distance, with filtering prism made of topsoil without scarifying which was the only one that recorded loss. In recent years of research, the statistical significance of crops increases has been lost due to the decreasing effect of scarifying over time.

After analysing the hydro-ameliorative behaviour and the technical behaviour, and economic effectiveness of Sînmartin variants, the drainage variant (V3) with corrugated PVC tubes was recommended for extension of drainage facilities in the area: this variant has a 30m distance between absorbing drains, filtering prism made of ballast of 15-20 cm high associated with deep loosening through scarifying.

Research conducted in the period 1989 - 1994 within the hydro-ameliorative perimeter of Ier valley and in the drainage experimental field of Diosig by Sabău N.C. (1996), was used by the PhD thesis "Studies and research on the hydro-ameliorative capacity and economic effectiveness of drain/drainage works in the Ier valley hydrographical basin".

Research conducted on the whole perimeter of Ier valley has showed the following findings: statistically significant correlations between the rainfall recorded in the area and the water levels measured at drain channels level, a specific drainage flow by providing the 5 % specific margin; highly significant correlations between the emissary water level and groundwater depth, highlighting the distance up to which the Ier river drain groundwater as wells as the evolution of groundwater and soil quality under the influence of desiccation-drainage works (Figure 2).

Of the 13 variants of underground drainage with Φ = 65 mm PVC corrugated tubes with filtering prism of sorted ballast and 20 - 50 m distance between drains (D = 20 - 50 m), and one variant of unsystematic drainage, drawn through the lowlands of the land, associated or not with cross scarifying and addition with 15 t/ha phosphogypsum and given the effectiveness of hydro-ameliorative (volume of water discharged), the improvement of the physicochemical properties of the soil, the crops increases and economic effectiveness one recommended the variant V11 D = 25 m with deep loosening through scarifying and addition of phosphogypsum to be implemented within the Ier river drainage area (Sabău N.C., 1997).

The research on Cefa experimental field was resumed in 1994 by Mrs. Șandor Maria; the results of such research were the object of the PhD

thesis entitled “Research on the operational behaviour of Inand drain/drainage system in the Crișurilor Plain" (Șandor M., 2003).

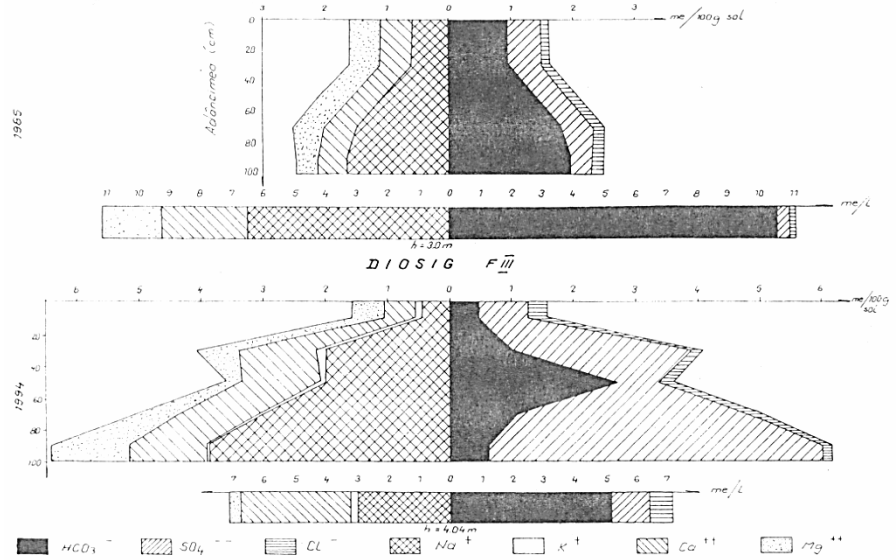

Fig. 2. Evolution profiles of soluble salts of a Solonetz from pedo hydro geological stationary, Diosig F III, 1985-1994

The observations made within the Inand drain/drainage system on the operating behaviour of the drainage channels system, 15 years after its completion, have highlighted the importance of the quantity of precipitation on water levels and flows discharged, the increase of groundwater depth by 0.58 - 0.87 m, reducing groundwater mineralization from moderately-strong (0.2 to 6.1 g/ l) to moderate (0.5 - 0.8 g/ l) and the average increase of agricultural crops by 1,100 kg/ha for wheat and 1,450 kg / ha for maize. It also worthy noticing that the effect of lack of operation and maintenance of drainage works, manifested by the reduced capacity of transport due to clogging of the channel section by 5 - 30 % of active surface, the deformation of cross-section of channels from the land affected by salinisation by increasing the large base and decreasing the small one as a result of reducing slope inclination, damage to works of art, culverts, weirs, fords crossings, etc. (Șandor M., 2012).

Research conducted in the last stage at Cefa confirms the results obtained during the first phase, i.e. the dominance of the underground drainage variant based on PVC corrugated tube at 30 m distance with high ballast filtering prism and loosening through cross scarifying. Regarding the effect of underground drainage 15 years after works completion both its positive effects on soil properties and the nitrogen losses of 25 - 86 kg/ha by water discharged have been noticed; there have been also notices the

deformation and clogging of drain tubes transport section by 20 % (Șandor M., 2003).

The tradition of research in the fight against excess moisture and the need for diversifying the research topics specific to our faculty have both led to winning in 2001, by means of competition, of the first CNCSIS RESERCH GRAND, entitled "Interaction between dumps from Oradea Power-Thermal Plant and land improvement works in the area, and their impact on the environment" (Sabău N.C. et al., 2001).

Research conducted under this contract allowed the identification of sources of pollution in the area and the pollutants affecting the air, surface water and groundwater and soils, and that the ascending trend for groundwater in the area, even in dry periods due to water loss from the tailings pond at Oradea Plant and the high degree of clogging in the drainage canals (Table 3).

Table 3

Quality of recycled water from tailing pond Santău

Indication	Unit of measure	Recycling Collector
pH	pH units	7,10
HCO_3	mg/l	18,3
Conductivities	µS/cm	1922
Temperature	°C	12,0
Fixed residue	mg/l	1095
Chloride	mg/l	34,78
Sulphates	mg/l	193,46
Calcium	mg/l	47,62
Magnesium	mg/l	16,58
Sodium	mg/l	41,79
Potassium	mg/l	10,44
Mineral Residue	mg/l	363

In the early 2000s and under the influence of global climate change evidence, researches aimed at comparing the climatic indices used in Romania to those applied worldwide, improving and validating the them former by correlations with the agricultural output of main crops (Sabău N.C. et al., 2002; Domuța C. et al., 2003).

The findings of the researches afore mentioned are confirmed by climatograms made for decades 1970-1980 and 1990-2000 respectively, using climatic data recorded at the Oradea weather station which shows that although average decade temperature rose from 10.12°C to 10.5°C there was also increase in the average precipitation quota from a 601.7 mm to 640.5 mm. Graphic representation of the differences between precipitation and potential evapotranspiration (monthly average) indicate a surplus of moisture in the cold season i.e. months X-III followed by a moisture deficit

in summer i.e. months IV - IX. If during the first decade the excessive moisture peak of 38.9 mm is recorded in the twelfth month, in the second decade analysed the excessive moisture peak increases to 60.5 mm. Doing the same comparison between maximum deficits in the two decades recorded in August, one notice the same increase i.e. from -35.2 mm to -60.9 mm. Therefore, over two decades there were increases in both the winter precipitation excess and deficit of moisture in summer (Figure 3).

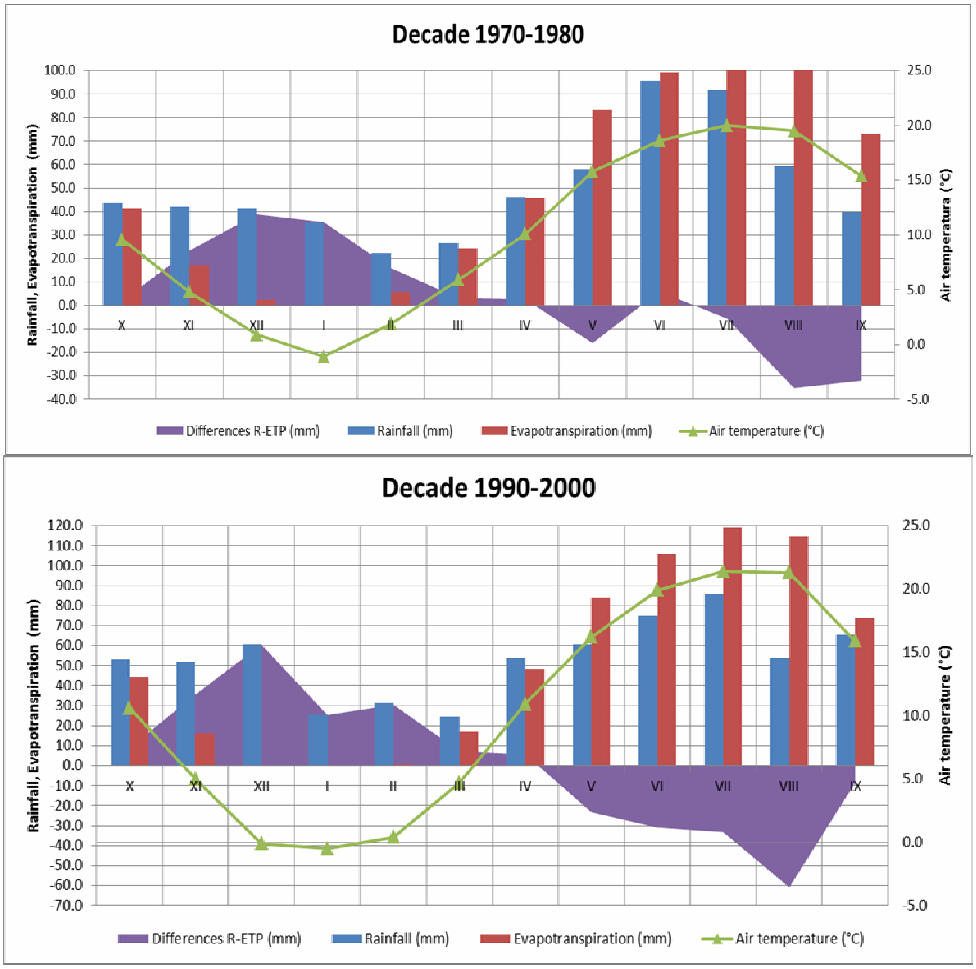

Fig. 3. Comparative climatogrames between decades 1970-1980 and 1990-2000

The need for sustainable agriculture which involves maximizing the crops without neglecting the quality of the soil, under current climate change has led to focus research in this field on improving the integrated management of natural resources: i.e. soil, water, plants.

From the point of seeing the work control waterlogging and salinisation of soils research it occurs the need to approach research works

on the way the amount of water in excess during the cold season be preserved, looking for ways in which it could stored in the channels and therefore be used during summer to cover all or part of the water deficit during the plants growing season.

Thus, while aligning ourselves to the global trends of research in the field drainage, one has addressed issued regarding the design of controlled drainage and the way the use of drainage works areas in order to manage the irrigation water to plant by means of sub-irrigation. Since 2007, on the initiative of Mrs. Marinela Bodog in collaboration with A.C. Teuşdea and with the support of staff from the Faculty of Hydrotechnics Timisoara, a software called DrenVSubIR was developed for the design of conventional underground drainage tubes, and check of its reversibility in sub-irrigation system (Bodog et al., 2007; Teuşdea et al., 2008).

Research on the development of DrenVSubIR software has been exploited by the PhD thesis "Interaction of irrigation-drainage systems and their impact on the environment of Criş rivers basin" held at the "Politehnica" University of Timişoara, Faculty of Hydrotechnical Engineering (Bodog., 2008).

Since there had been known the results of research in the Diosig, Cefa and Avram Iancu experimental fields to remove excess moisture, during next stage studies were conducted to investigate whether DrenVSubIR software is operational under the conditions of heavy and compacted soils within this area.

To simulate conditions in experimental fields one started from the physicochemical properties of the soils, pointing out that the design pattern of the distance between drains takes into consideration the bi-layer soil, the separation between the two layers being provided by the drains plan, that the hydraulic of the two layers is required by drilling method and that the software considers that the filter used is circular around the drainage tube and it does not take into account the effect of deep loosening works of the soil layer above the drain tubes.

By testing the software in the conditions existing in the Diosig experimental drainage field there were established ways of using soil analysis, as input data for the software in order to design the design of crossover drainage which is specific to heavy and compacted soils where it is associated with filtering prisms mad of ballast and deep loosening works (Table 4).

To check the reversibility of designed drainage, in sub-irrigation system there were chosen conditions existing in the Avram Iancu experimental field (Figure 4) where there were established correlations between groundwater level to be maintained under conditions of controlled drainage in order that the soil moisture in its surface horizon be maintained

at a level ranging between field capacity (FC) and the easily available water content (Wea) (Sabău N.C., 2009).

Table 4

Values of distance between drains calculated with DrenVSubIR program, in conditions of experimental field Diosig, Bihor (after: Sabău N.C. et al., 2008)

Variant	Characteristics	Hydraulic pressure losses in water entering the drain-filter complex ζ_{i+f}	The distance between the drains L (m)
Perfect drain	Without drainage tube	0	4,1
PVC corrugated tube	Φ = 65 mm	0,15472	2,1
Small filtering prism	h = 10 cm	- 3,4159	15,2
Large filtering prism	H = 20 cm	- 5,5020	23,4

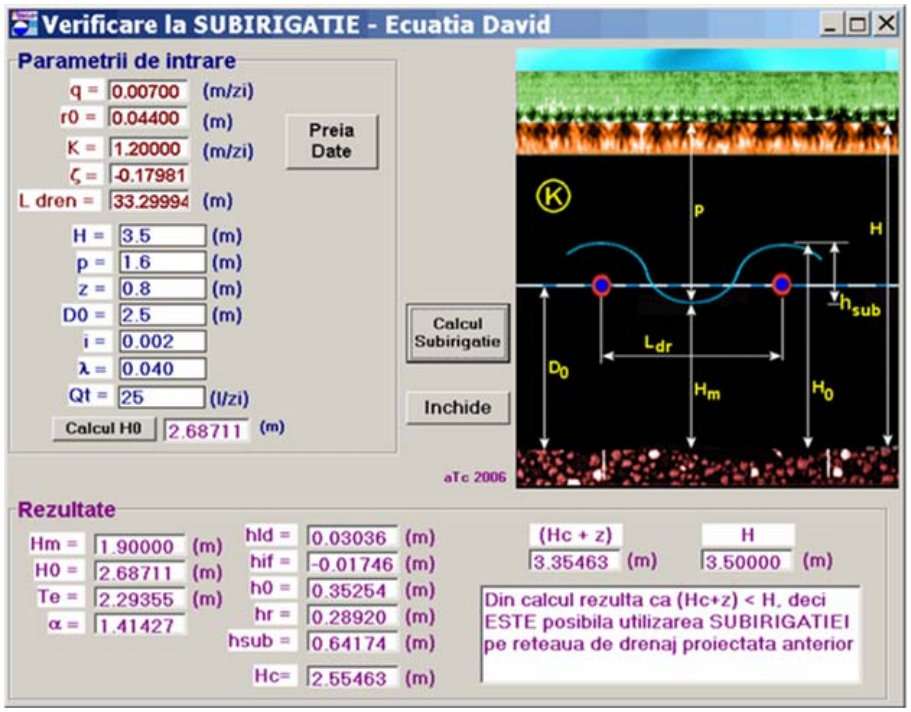

Fig. 4. The module for checking the reversibility of drainage in sub-irrigation of DrenVSubIR program

These concerns related to the putting the DrenVSubIR software to test under field conditions revealed the strengths and weaknesses of this software's operability (Sabău, 2010). On the basis of these observations one will develop in the future research seeking the improvement this software by adding new modules designed to automatically solve the problems occurred.

CONCLUSIONS

Researches conducted in Ier valley and Inand desiccation-drainage systems and respectively Diosig and Cefa experimental fields were used by two PhD theses.

The tradition of developed researches have led to winning in 2001, by means of competition, of the first CNCSIS RESERCH GRAND from our faculty, entitled "Interaction between dumps from Oradea Power-Thermal Plant and land improvement works in the area, and their impact on the environment".

Our faculty researchers in collaboration with the Faculty of Hydrotechnics Timişoara developed DrenVSubIR program, intended to verify reversibility of conventional drainage in sub-irrigation, also exploited by a successful thesis.

Based on research in the last years, looking the DrenVSubIR software testing under experimental fields conditions were highlighted some shortcomings, that will be removed in the future by adding new modules to the program.

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