STUDY ON THE ANALYSIS OF PEDOCLIMATIC AND HYDROGRAPHIC CONDITIONS IN ORDER TO INTRODUCE IRRIGATION IN AN AGRICULTURAL FARM IN THE HILLY AREA

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Abstract

The observations made through this paper aim to analyse local conditions and identify optimal solutions for introducing irrigation in an agricultural farm in a hill area, located in the north of Oltenia region, Romania, more precisely Ghioroiu, Valcea County. The relief of the area is characteristic of the hill area with numerous plateaus and valleys, valleys made over the years by the hydrographic network and from the runoff from the slopes. In such areas apparently several sources of water are available, but only part of them can be used for irrigation.

Water sources available in the area have been identified, namely groundwater, surface springs and surface waters (Olteț River belonging to the Olt River hydrographic basin). These sources were analysed if they can be used for agriculture through irrigation, and the result was that the Olteț River can be used in crop irrigation.

The areas of agricultural land that are exploited by the respective agricultural farm were also analysed to determine which areas can be irrigated and by what method of watering.

Key words**: **surface, water source, landscaping, irrigation,

INTRODUCTION

Agriculture is dependent on water availability. Irrigation helps farmers protect themselves against irregular rainfall and helps increase crop viability, yield and quality, but puts significant pressure on water resources.

Although only around 6% of EU agricultural area was irrigated in 2016, the sector was responsible for 24% of total water abstraction. (*www.eca.europa.eu/Lists/ECADocuments*)

Population growth, economic activities and climate change intensify water scarcity in the EU, both seasonal and long-term. A significant part of the territory is already affected by water abstractions exceeding available reserves, and current trends point to increasing water stress. (*www.eca.europa.eu/Lists/ECADocuments)*

According to the World Bank, over the last 55 years, the EU has seen a 17% decrease in renewable water resources per capita (3,688 m3 in 1961 and 3,037 m3 in 2020) . While this is partly due to population growth, pressures from economic activities and climate change are also exacerbating seasonal or year-long water scarcity in parts of the EU. (*https://data.worldbank.org/indicator*)

FAO (Food and Agriculture Organization) has embarked on a long-term programme on "Combating water scarcity – the role of agriculture". A conceptual framework for addressing food security issues in conditions of water scarcity was developed based on the findings of an expert consultation. (*Faire face à la pénurie d'eau (fao.org)*).

Global warming is a known phenomenon widely publicised throughout the European population and is expected to lead to an increase in the intensity of rainy episodes, increasing the risks of sudden floods alternating with hot and dry periods causing hydrological, atmospheric and soil drought in these regions.

By examining the climatic parameters of desert regions, it turned out that the decrease in rainfall levels led to a significant increase in temperature. Thus, prevailing circumstances may lead to a slight increase in the frequency and magnitude of drought patterns. In fact, the main rationale about changing drought circumstances is that it will deplete real water resources. In this way, the lack of water availability can further damage the conditions considered suitable for human survival (Kumar P., et al., 2021).

In several regions, but especially in semi-arid areas, the increase in frequency, duration and intensity of drought events, driven mainly by climate change dynamics, will dramatically reduce current stocks of freshwater resources, limiting crop development, especially where agriculture is largely dependent on irrigation. Achieving an affordable and sustainable balance between available water resources and irrigation demand is mainly related to the planning and implementation of strategies and actions. (Ronco P., et al., 2017). Ronco P. et al. (2017) conducted a study in the Puglia region, Italy, an agricultural area with a semi-arid climate. He proposed a state-of-the-art conceptual framework and calculation methodology to assess the potential risk of water scarcity, based on the Regional Risk Assessment (RRA) approach, applied within a scenario-based hazard framework as a result of changes in trends and climate variability.

Risk assessment implies the existence of methodologies that can be applied in areas where drought can bring imbalances and notable material losses: agriculture, water supply and the environment. Each sector must be properly quantified as drought-related risk in clear terms. There appears to be a need to use appropriate methods for each sector of activity at risk of drought in order to obtain true estimates. (Corduneanu Flaviana, et al., 2021)

In Romania, at present, agriculture is dependent on weather in most agricultural areas. In 2020, the phenomenon of "soil drought", i.e. the low water supply in the soil, caused the destruction of millions of hectares of crops.

It is estimated that if dry periods occur in autumn, it will be extended throughout the winter period and for the entire growing season of the following year. A severe drought that began in autumn 2011 remained throughout the winter until the next growing season (2012). And the incidence of droughts in the Moldavian Plain resulted in a drying phenomenon in the middle basin of the Prut River. Rivers dried up at a frequency of 40-50% in river basins with an area of 15-20 km2 and over 90% in river basins with areas of less than 5 km2. (Corduneanu Flaviana, et al., 2016)

Great environmental challenges arise from climate change as soil drought can also be regarded as an environmental disaster representing a severe deficit of soil moisture which, even under satisfactory atmospheric conditions, does not allow plants to absorb sufficient soil water.

The following principles were analyzed when developing the environmental protection strategy

in irrigation facilities:

- preservation and improvement of living conditions;
- sustainable development;

- avoiding pollution through preventive measures;
- stimulating environmental recovery activity. (Nicolescu C., et al., 2016)

Irrigation is the measure of agricultural technique that contributes to the appreciable increase in production. It consists of the directed supply of various amounts of water to the soil in addition to those naturally received from precipitation and the upward influx of water from the groundwater.

Irrigation is an input for agricultural production, and by practicing irrigation, the agricultural producer improves his competitiveness and has the security of a high and relatively stable production from year to year, especially in the current period of uncertainty and instability.

Irrigation also plays an important role in environmental protection by stabilizing soils subject to wind erosion, aridization and desertification, phenomena produced by the increasingly obvious global warming trend as a consequence of obvious climate change.

In recent decades, there has been both the development of new developments in arid and semi-arid areas, as well as the extension of irrigation to increasingly higher latitudes, especially in the Northern Hemisphere, in areas with irregular rainfall regime or sandy soils, even in desert areas (Cismaru, Gabor, 2004).

Over time, irrigation took multiple forms, both in terms of conceptions and technical methods of application. Depending on natural, social-organizational and technical conditions, networks and distribution-irrigation methods have evolved and diversified in scope.

According to climatic zones, permanent irrigation and complementary irrigation are differentiated, and as hydrotechnical schemes are networks whose technical conception and realization (arrangement) reflect ancient structures, or networks in modern technical concepts based on decentralized organizational structures (Pelea G.N., 2021).

On the entire hydrographic network of the country (Romania) extreme weather phenomena alternate (dry periods and major floods), these tend to become the main feature to which Romanian agriculture must adapt. In the near future, hydroameliorative developments throughout the country need to be reviewed and adapted to the local conditions where they are carried out, in order to capitalize on the benefits they bring.

In the context of climate change, irrigation at farm level is a future measure that ensures stability at farm level from a technological and economic point of view.

In order to build and put into operation an irrigation system, it is necessary to go through stages of elaboration that lead to an optimal investment.

MATERIALS AND METHODS

The working method consisted of:

- analysis of soil characteristics within the farm;
- general characterization of climate;
- identification and description of the available water source;
- identification of areas suitable for irrigation;

The rational choice of watering method requires knowledge and analysis of natural factors (orographic, pedological, hydrological, climatic), technical and economic, which favor or limit the use of one or more watering methods.

The great diversity of physical and geographical factors, especially lithological and relief conditions, determined the identification of a diversified soil cover, both in terms of the category of soils present and their distribution within the perimeter.

The relief within the analyzed territory is represented by the following forms: Plateaus, Slopes, Terraces, Meadow terraces, Meadow / Valley.

The plateaus occupy most of the surface of the territory, with altitudes of about 400 m, presenting a slight general slope N-S, variable widths, increasing to the south. The slopes also occupy a share within the territory, have various shapes and slopes, but the predominant ones are the slopes of 12-18% and 18-25%, and the microrelief forms on the slopes are completed in areas affected by slips (slopes of 35-35%). The terraces are represented fragmentarily on the valley of the Pestana River and on the valley of the Olteţ River by 2 levels, one upper, located at the relative altitude of 35-40 cm, the other lower, somewhat more extended, on which is located the built-up area of Ghioroiu commune, with a relative altitude of 10-15 m. They appear as relatively uniform surfaces, weakly inclined towards the watercourse that created them. The terrace valley is actually the high meadow of the Olteț River as well as the high meadow of the Pesteana River, which function as meadow terraces due to the recent deepening of the watercourses. They are non-floodable, raised by 3-6m from the level of the watercourse, with the surface almost horizontal. The meadow terrace of Pestana has widths of 500-600 m, and that of Olteț reaches 1.5 km. The meadow/valley itself is poorly represented, only in a few areas. It has almost horizontal surfaces, floodable from time to time at high water flows caused by torrential rains or sudden melting of snow in the supply basin. They are quite narrow, the widest of several hundred meters, follow the sinuous path of the rivers that created them, developed from one side to the other of the valley line.

From a hydrographic point of view, the analyzed territory belongs to the hydrographic basin of the Olt River, Olteţ subbasin. Except for Olteț (the main collector), which is a river with a mountain origin, the entire hydrographic network within the territory has its origins within the piedmont area. The hydrographic regime registers large fluctuations depending on the rainfall regime within the supply basin.

Given the configuration of the relief and the lithological constitution, groundwater is found at great depths (over 10 m) within the piedmont plateaus as well as on the slopes. Within the slopes appear in places small suspended aquifers from which springs appear, some intercepted by locals and arranged as small wells for drinking water supply.

Within the upper terraces, the groundwater also has great depths (over 10 m). In the case of the lower terrace the depth of groundwater is 5-10 m, within the meadow terrace it is 3-5 m, and within the meadow the groundwater is 1-3 m.

To characterize the climate regime were used meteorological data from the Drăgăşani weather station, located about 40 km E, as well as from the Balcesti precipitation station, located at 10-15 km SSE.

The average multiannual temperature is 10.4 degrees C. The average multiannual rainfall amounts to 612.9 mm, but due to their uneven distribution in time, there may be rainy years, with over 1100 mm and dry years, with less than 400 mm, as actually happened, being frequent years when spring crops (corn, peas) suffered a lot, with productions below the economic threshold.

The wind regime is characterized by the predominance of winds from the N and NW directions.

Even if at multiannual level the climate analysis would not impose the need for irrigation, the alternation of years deficient in rainfall in the summer months determines the decision to invest in irrigation for medium and long-term economic safety for the farm.

In order to identify the soils present at farm level and to characterize the soils in the area where irrigation is to be carried out, pedological studies carried out at farm level were analysed.

Irrigation at farm level requires knowledge of several technical elements (design-operation) such as carrying out authorization-approval procedures.

RESULTS AND DISCUSSIONS

Currently, the company manages an area of 1,200 ha, located in several localities: Ghioroiu, Balcesti, Valcea County and Bulzesti, Dolj County, an area leased and owned. The distribution of areas in the area can be seen in figure 1.

At farm level, most areas are merged into soles with areas suitable for intensive agriculture and modern machinery, but with very irregular shapes determined by the bound limits specific to the hill area (fig. 1).

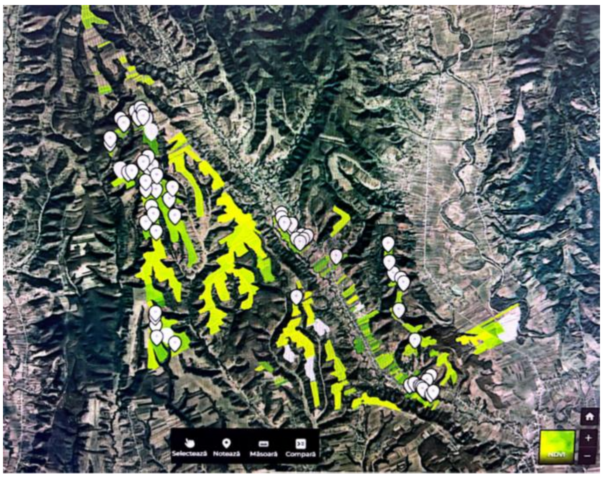

Figure 1. Distribution of land areas

Analysing all the aspects necessary to irrigate a land area, it resulted that at the level of the analysed company an area of 92 ha located on the bank of the Olteț River is suitable for this objective (figure 1 and figure 2).

This area is suitable for irrigation for the following reasons:

-The physical characteristics of the soil allow irrigation to be applied smoothly (medium texture), characteristics presented by the Soil Units (U.S.) in Tables 1-6;

-The relief does not pose problems;

-There is a source of water - it borders the Olteţ River;

-The area is included in the area with proposals for irrigation arrangements in the Valcea County Spatial Planning Plan (figure 3);

-Offers the premises of a lower investment compared to other surfaces;

-It also provides the prerequisites for obtaining authorizations.

The territorial positioning of the area suitable for irrigation can be seen in figure 1, and the interior arrangement for irrigation is shown in figure 2.

Figure 2. Satellite image of land areas suitable for irrigation

All other areas managed by the company do not provide the prerequisites for irrigation because (figure 1):

- are not near an easily accessible water source,
- They are located on the upper terraces,
- They have very irregular shapes, - The physical properties of the soil would pose problems in the application of irrigation (fine texture).

Characterization of soil units:

U.S. no. 1 Typical eutricambosol (sandy loot), relief: terrace, represents the dominant soil for plots: 1 and 2.

Table 1. ANALITICAL DATA U.S. No. 1

HORIZONS	Ao	AB	Bv
Harvesting depth	5-15	30-40	45-105
Coarse sand(2,0-0,2mm)%	15,24	13,21	12,06
Fine sand(0,2-0,002mm)%	42,81	40,94	41,94
Dust(0,02-0,002mm)%	27,5	25,4	19,10
Clay(<0,01 mm)%	24,7	30,45	33,65
Physical clay (<0,01mm)%	34,7	40,45	40,40
TEXTURE	LN	LN	LAN
Apparent density (g/cmc)	1,35		
Total porosity (PT%)	50		
Degree of compaction (GT%)	-1,98		
Hygroscopicity coefficient	5,80		
Wilting point (Wp%)	8,7		
pH	6,28	6,10	

The soil is well drained; The depth of groundwater is between 5-10m. The texture is medium; the soil is uncompacted with high total porosity and low apparent density in the first horizon; edaphic volume is large; The wilting coefficient has medium values. The soil reaction is weakly acidic.

U.S. nr.2 Eutricambosol aluvic slab gleizat (luto argilos/argilo lutos), relief: terasă, reprezintă solul dominant pentru parcela: 3.

The soil is moderately drained; The depth of groundwater is between 2-3m. The texture is fine in the first horizon and medium in the rest; the soil is poorly compacted with total porosity and medium apparent density in the first horizon; edaphic volume is very large; The wilting coefficient has medium values. The soil reaction is weakly acidic.

Table 2. ANALITICAL DATA U.S. No. 2

HORIZONS	AP	AB	Bt
Harvesting depth	10-20	30-40	60-70
Coarse sand(2,0-0,2mm)%	13,3	25,3	9,2
Fine sand(0,2-0,002mm)%	25,7	27,8	38,3
Dust (0,02-0,002mm)%	27,5	17,5	21,2
Clay(<0,01 mm)%	33,5	29,4	31,3
Physical clay (<0,01mm)%	47,7	38,7	42,2
TEXTURE	LA	LN	LN
Apparent density (g/cmc)	1,39	1,41	
Total porosity (PT%)	48,52	47,77	
Degree of compaction (GT%)	3,84	4,06	
Hygroscopicity coefficient	7,85	5,9	6,9
Wilting point (Wp%)	11,77	8,85	
pH	6,30	5,86	

U.S. no.3 Preluvosol stagnic (weakly stagnogleized), loamy clay / clay, relief: terrace, represents the soil for about 30% of the plot: 3

Table 3. ANALITICAL DATA U.S. No. 3

HORIZONS	Ap	AB	Btw
Harvesting depth	5-15	25-35	60-70
Coarse sand(2,0-0,2mm)%	5,4	2,9	2,8
Fine sand(0,2-0,002mm)%	22,5	14,5	21,3
Dust(0,02-0,002mm)%	29,6	30,2	20,2
Clay(<0,01 mm)%	42,5	52,4	55,4
Physical clay (<0,01mm)%	60,3	76,4	66,3
TEXTURE	LA	AL	AL
Apparent density (g/cmc)	1,33		
Total porosity (PT%)	50,74		
Degree of compaction (GT%)	2,29		
Hygroscopicity coefficient	9,95	13,34	11,32
Wilting point (Wp%)	14,93	20,10	16,98
pH	6,21	6,19	

The soil is moderately drained; The depth of groundwater is between 5-10m. The texture is fine; the soil is poorly compacted with total porosity and medium apparent density in the first horizon; edaphic volume is very large; The wilting coefficient has high values. The soil reaction is weakly acidic.

U.S. no. 4 Preluvosol stagnar (moderately stagnogleized, strongly coluvionated), dusty loamy/loamy loamy. Terrain: terrace, Represents the dominant soil for the plot: 4.

Table 4. ANALITICAL DATA U.S. No. 4

HORIZONS	Ap	Ao	Btl w
Harvesting depth	5-15	25-35	40-50
Coarse sand(2,0-0,2mm)%	6,1	3,9	2,3
Fine sand(0,2-0,002mm)%	16,8	25,6	24,1
Dust(0,02-0,002mm)%	32,5	33,1	27,5
Clay(<0,01 mm)%	44,6	37,4	46,1
Physical clay (<0,01mm)%	63,9	62,3	64,3
TEXTURE	LA	LA	AL
Apparent density (g/cmc)	1„33		
Total porosity (PT%)	50,74		
Degree of compaction (GT%)	3,01		
Hygroscopicity coefficient	10,44		
Wilting point (Wp%)	15,66		
pH	6,39		

The soil is moderately drained; The depth of groundwater is between 5-10m. The texture is fine; the soil is poorly compacted with total porosity and medium apparent density in the first horizon; edaphic volume is very large; The wilting coefficient has high values. The soil reaction is weakly acidic.

U.S.no.5 Preluvosol vertic stagnic (moderately stagnogleized, moderately eroded), clayey, relief: hill, represents the dominant soil for plot: 7.

The soil is moderately drained; The groundwater depth is located above L0 m. The texture is fine; the soil is poorly compacted with total porosity and medium apparent density in the first horizon; edaphic volume is very large; The wilting coefficient has medium values. The reaction of the soil is weakly acidic.

U.S. No.7 Planosol vertic, stagnar (weakly stagnogleized), loamy loamy, Terrain: hill, represents the dominant soil for plots: 5 and 6.

Table 5. ANALITICAL DATA U.S. No. 5

HORIZONS	Ap	Btw	BCw
Harvesting depth	5-15	30-40	60-70
Coarse sand(2,0-0,2mm)%	10,6	12,3	17,4
Fine sand(0,2-0,002mm)%	23,4	24,6	23,8
Dust(0,02-0,002mm)%	20,3	13,7	18,8
Clay(<0,01 mm)%	45,7	49,4	40,0
Physical clay (<0,01mm)%	62,6	55,5	52,7
TEXTURE	AL	AL	LA
Apparent density (g/cmc)	1,30		
Total porosity (PT%)	51,85		
Degree of compaction (GT%)	1,14		
Hygroscopicity coefficient	8,2	8,4	9,5
Wilting point (Wp%)	16,05		
pH	5,91		

Table 6. ANALITICAL DATA U.S. No. 7

HORIZONS	Ao	El	Btw
Harvesting depth	10-20	25-35	45-55
Coarse sand(2,0-0,2mm)%	7,7	8,8	3,3
Fine sand(0,2-0,002mm)%	33,1	23,1	17,9
Dust(0,02-0,002mm)%	23,6	29,4	21,8
Clay(<0,01 mm)%	35,6	38,7	57,0
Physical clay (<0,01mm)%	42,5	52,2	68,5
TEXTURE	LA	LA	AL
Apparent density (g/cmc)	1,25	1,27	1,30
Total porosity (PT%)	53,7		
Degree of compaction (GT%)	-5,70		
Hygroscopicity coefficient	6,7	8,1	12,7
Wilting point (Wp%)	10,5		
pH	5,78		

The soil is moderately drained; The groundwater depth is over 10 m. The texture is fine; the soil is uncompacted with high total porosity and low apparent density in the first horizon; edaphic volume is very large; The wilting coefficient has medium values. The reaction of the soil is moderately acidic.

When arranging the interior for irrigation, the existing configuration was taken into account, determined by the obliged limits: river bed, forests, county road, drainage channels, relief, soil units. This resulted in

7 plots with areas between 6.4 ha and 21.9 ha (figure 2, Table 7).

In order to achieve the objective, it is necessary to place a pumping station as well as to build a water storage lagoon for the irrigation system for the large crop in the Olteț riverbed.

Table 7. Situation of irrigated parcels

Plot	Surface (ha)	Soil unit	No watering areas
P1	17,2	US 1	2
P2	21,9	US 1	2
P3	15,0	US 2, US 3	2
P4	12,5	US 4	1
P5	6,4	US 7	1
P6	9,7	US 7	1
P7	9,4	US 5	1

The choice of water source for an agricultural use is made on the basis of studies that determine technical elements (flow, quality) for several possible variants and that allow the selection of the optimal variant, so that it ensures:

- the required water flow,
- water quality,
- operational safety,
- economic efficiency,
- be nearby.

Analyzing the situation of local conditions, from a hydrological point of view, from the point of view of the location of the agricultural land areas managed by the company in question, it can be seen that they are framed by the Olteţ River and its tributary, the Pestana River.

The two rivers register large fluctuations depending on the rainfall regime within the supply basin.

Given the configuration of the relief and the lithological constitution within the perimeter, phreatic aquifers were identified, included in the groundwater body in the meadow and the terraces of the lower Olt, under the Olteţ basin

According to the Valcea County Spatial Planning Plan, chapter Water management and agricultural developments, the area afferent to the right bank of the Olteț River, north of the town of Balcesti (where the company in question works around 100 ha) is an area with unexploited groundwater resources (figure 3) and proposed to be used in the development of water supply systems for the population (green triangle), and the existence of groundwater abstractions at depths of more than 50 m in operation for the population (blue triangle).

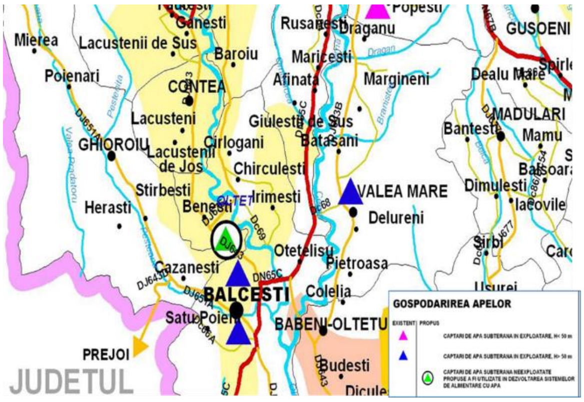

Figure 3. Available water sources (extract from PATJ Valcea)

From the above, it can be seen that there are alternatives to water sources in the area, but the possibility of them being available or used for irrigation imposes certain restrictions or measures to achieve this objective (Table 8).

The identification of a water source with the possibility of being used in irrigation has been over time and will continue to be the decisive factor in arranging an irrigation system, regardless of its size.

In general, the available water source determines the area that can be arranged for irrigation, the watering method that can be used, the crops that can be established in the irrigated area and the economic level of investment for irrigation and use.

Water sources identified as being available for irrigation on the analysed farm are summarised in Table 8. Most land allows the use of several watering methods and sometimes the decision is determined by economic criteria. The basis for choosing the watering method will have to be the specific investment and, in particular, the annual operating expenses, as well as the value of the production increase to be obtained through irrigation. Under the same economic conditions, preference will be given to the method that leads to higher water use efficiency and better productivity when applying waterings.

Table 8. Characterization of water sources

Water source	Possibility of use for irrigation	Features / Restrictions / Measures to achieve goals
Groundwater (wells)	No	The existence of groundwater abstractions for the population and proposals for extending them for use in the development of water supply systems for the population.
Spring capture	Nu	Area proposed for groundwater abstraction to be used in the development of water supply systems for the population. For irrigation, very large investments, difficult approval/authorization
Peșteana River	No	Insufficient flow
Olteț River	Yes	Sufficient flow rate (12.8 m3/s i.e. 46080 m3/h), there is precedent for approval

Analyzing all the factors listed above, it turned out that there are 2 irrigation application alternatives for the identified area.

An alternative is sprinkler irrigation using mixed drum and hose irrigation systems (watering ramp and cannon sprinkler), but the very uneven terrain configuration and the existence of drainage channels make it difficult to use these installations. In order to be able to use these installations, landscaping works (levelling, new drainage channels) would be required, and the fact that the surface is not all owned could hardly be achieved.

The second alternative is the drip watering method, either above ground or underground, which has been taken into account to achieve the goal.

CONCLUSIONS

The analysis of land areas resulted in the possibility of arranging for irrigation an area of 92 ha, out of the 1200 ha exploited.

Knowledge of soil characteristics before irrigation is carried out are mandatory and absolutely necessary measures, as they serve to design the irrigation system and determine the irrigation regime.

Knowledge of texture is necessary to:

- choice of irrigation arrangement system,
- choice of watering method,
- application of waterings.

The identified soils have medium texture, and irrigation will be applied with high watering norms at long intervals, using all watering methods.

The physical properties of the soils identified in the area suitable for irrigation allow the use of crop irrigation without restrictions.

The analysis of the water sources available in the area showed that only the Olteț River can be used for irrigation, the other sources being restricted in terms of flow and the fact that they are used as water supplies for the population.

In hilly areas the possibility of applying irrigation is conditioned by:

- relief characterized by valleys, slopes, terraces, slope;
- the shape of soils, which is often irregular, determined by the limits obliged,

- water source, sometimes difficult to access, insufficient flow, or used for other uses;
- soil characteristics, which can create problems related to infiltration, erosion, water availability.

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