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THE DETERMINATION OF THE MOST OPTIMAL METHODS FOR THE IRRIGATION OF CROPS ON DIFFERENT SOIL TYPES

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Abstract
Climate change due to multiple pollution problems (forest clearing, overgrazing, motor vehicle emissions, construction expansion, etc.), has led to increased global average temperature and reduced rainfall. Under these conditions, the mineralization of organic matter is intensified, the activity of soil microorganisms is reduced and implicitly decreases soil trophicity. These aspects further show the need to apply irrigation in the agricultural sector, rationalysing water, managing it and recommending the best methods of water distribution, on soils with different textural classes. In this regard, research was carried out on water permeability, on soils formed in different pedo-climatic conditions. Thus, three soil profiles were opened, in the Tecuci Plain, on a typical arenosoil, in the Dobrogea Plateau, on a calcaric chernozem and in the Gavanu-Burdea Plain on a chromic luvisol. Soil profiles were characterized morphologically and physico-chemically, soil samples were collected both in natural and modified settlement (metal cylinders). The physico-chemical analyses for the three soil types were determined within INCDPA laboratories Bucharest. Based on soil samples collected in metal cylinders, water permeability was determined using the ratio between the thickness of the soil horizon and the time of water infiltration. Depending on the permeability of the soil on the three different soil types, the most suitable and economical watering methods for the current climatic conditions have been established and recommended.
Keywords: irrigation methods, chromic luvisol, typical arenosol, calcaric chernozem

INTRODUCTION

The degradation of the soil due to human activities has reduced the productivity of the soil, and damaged ecosystems surrounding it. At the global level, erosion by tillage and irrigation remains one of the major causes of the degradation of the soil and is a paramount concern for the environment. Also, the degradation can be a result of the mineralization of the coverage of vegetation, the oxidation of the organic matter in the soil and damage to the properties and processes of biological, chemical and physical properties of the soil (Winding et al. 2005, Miao et al. 2015).Without a policy for the protection of the soil, the soil is damaged, and the problems, such as ground water contamination, erosion, and desertification, the insufficient capacity of retaining water, susceptibility to pests, reduced fertility of the soil, and the natural heritage are limited. In fact, the realization of the policy is on the rise in the level of the regional, national, and international levels (WHAT, for example, IN 2002; NEPP4, 2001) and the policy of requiring the use of tools for a sustainable use of the land. The concept of the modern, for the irrigation of crops is based on a reconsideration of the system, the soil-water-plant-atmosphere system is the physical, integrated and continuous. The components of a system are interconnected, so that the availability of water to plants is dependent on a part of the hidrophysical characteristics of the soil, and on the other hand, the morphology of the plants, and the evolution of the climate, which, by the solar radiation, and relative humidity of the air changes, the values of the parameters involved in the movement of water from plants to the atmosphere. The productivity of agricultural crops, fluctuates from one year to the next, heavily influenced by the variability of climatic conditions and, in particular, the occurrence of extreme climate events. Climate variability is influencing all sectors of the economy, but most vulnerable remain, agriculture (Moreover, et al., 2013). Global warming is a phenomenon that is widely accepted by the international scientific community, as has been pointed out by the analysis of the data of observations over long periods of time. Simulations are carried out with the help of weather patterns around the world have shown that the main factors that determine this phenomenon is that the natural (changes in solar radiation and volcanic activity) and anthropogenic (changes in the composition of the atmosphere due to human activities). Only the combined effect of these two factors may explain the observed changes in global mean temperature over the past 150 years. The increase in the concentration of greenhouse gases in the atmosphere, especially carbon dioxide, has been the main cause of the warming is pronounced in the last 50 years of the TWENTIETH century, 0.13 C, about 2 times the value of the last 100 years (EEA Report No. 3 of 2013). The quality of the soil may be defined as the capacity of a specific soil to function as a living system, within ecosystem, natural or managed, is to support the health and productivity of plants and animals, to maintain or improve the quality of the air, and the environment to support human health (Winding et al.al, 2005)

MATERIAL AND METHODS

Physico-geographical conditions

***Table 1*.The Main physical-geographical conditions**

Location	Geology and lithology	Climatic factors	Groundwater	Soil types
Tecuci, GL (altitude: 80-100 m)	The Field Tecuci -psamos deposits	*min. t.*>-30°C *max. t*>40°C *July av.*> 23°C *Aaat*- 10,8 °C - 11.0°C *aar* - 550-600 mm	> 10 m	typical arenosol
Gradina, CT (altitude: 150-200 m)	Medgidia Plateau -sedimentary deposits	*min. t.*>-30°C *max. t*>38°C *July av.* 22 - 23°C *aaat* - 11°C - 12.0°C *aar* - 380-420 mm	> 10 m	calcaric chernozem
Dobrotesti, TR (altitude 60-80 m)	Gavanu Burdea Plain -sedimentary deposits	*min. t.*>-30°C *max. t*>40°C *July av.*> 23°C *aaat* - 10°C - 11°C *aar* - 500-550 mm	> 10 m	chromic luvisol

min. t. - minimum temperature; max. t - maximum temperature; July av. - average temperature in July;
-aaat - average annual;aar - average annual rainfall

In figure 1, the determination of soil permeability is presented, in the laboratory, with the help of metal cylinders, on the three types of soil studied.

Figure1. Determination of soil permeability

For the determination of the permeability of the medium (Mi), we have used the relation:
Km = H/K
where: H - the thickness of the layer of the soil, and the K – hydraulic conductivity

- for psamosol, 10 $cm.^3$ ......0,8 minutes = 12,5 ~ Km of the sea;
- for calcaricchernozem, 10 $cm.^3$ ....4 minutes = 2.5 to ~ Km in the middle;
- for chromic luvisol, 10 $cm.^3$ ....6 mins = 1,6 ~ Km in the

The interpretation of the results was in line with the ind. 50 of the MESP, 1987, vol. III. On the basis of the results of the permeability of the soil, has established the methods of watering favourable terms for each type of ground that the objective of the study.

The soil influences the choice of the method of watering the texture, the capacity of water storage in the soil, the rate of seepage, the soil resistance to erosion, and the intensity of salinization

The force of the water retention in the soil varies from one soil to another, depending on the texture.

The water is accessible to the plants are located between the ability of a water-in-field (CC), and the wilting coefficient (CO). The minimum threshold marks the lower limit of the moisture content easily available to the plants. Water is easily accessible and is within the range of the capacity of the water, in the field the minimum requirement.

Thus, the values of the minimum threshold corresponding to, and in the texture of the soil was calculated using the relationship:

$p_{min.}$ = CO+ 1/3 (CC– CO), for the light sandy soils, the structure of the micro-aggregated;

$p_{min.}$ = CO + 1/2 (CC – CO), for soils with medium texture, and the glomerular structure;

$p_{min.}$ = CO + 2/3 (CC-CO), for soil is clay, with a glomerular structure;

Soil analysis

The samples were analysed in INCDPA Bucharest laboratories. Soil samples were dried at room temperature; soil subsamples were homogenized, milled, and sieved through a 250 µm sieve.

The following analytical methods were used to determine the chemical properties:

- organic matter (humus): volumetric determination, (Walkley-Black humidification method, STAS 7184/21-82);
- $CaCO_3$ (carbonates): gasometrical method (Scheibler calcimeter, SR ISO 10693: 1998, %);
- the nitrogen content, by calculation, based on the humus content and the degree of saturation with bases (IN = humus x V/100);
- mobile phosphorus content, (Egner-Riehm-Domingo method and colorimetric molybdenum blue, Murphy-Riley method ascorbic acid reduction);
- mobile potassium content (Egner-Riehm-Domingo extraction and flame photometry);
- pH (potentiometric method in aqueous suspension at soil/ water ratio of 1/2.5 - SR 7184 /13-2001);
- hydrolytic acidity, extraction with sodium acetate at pH 8.2;
- degree of bases saturation V% (Kappen Schoffield method)

The following physical characteristics were determined:

- determination of granulometric fractions:
- pipette method, for fractions ≤ 0.002 mm;
- wet grinding method for fractions of 0.002-0.2 mm and dry grinding method for fractions > 0.2 mm. The results are expressed as a percentage of the material remaining after pretreatment.
- bulk density (BD): The known volume of metal cylinders (100 cm^3) at the instant soil moisture (g/cm^3) - total porosity (PT): by calculation (% by volume -% v/v);
- aeration porosity (PA): by calculation (% volume -% v/v);
- compaction degree (GT): by calculation (% by volume -% v/v), where: PMN - minimum required porosity, clay of the sample is calculated with the formula PMN = 45 + 0.163 A (% by volume -% v/v); PT = total porosity (% v/v); A - clay content (% w/w),
- hygroscopicity coefficient (HC): drying at 105°C of a pre-moistened soil sample at equilibrium with a saturated atmosphere with water vapor (in the presence of 10% H_2SO_4 solution) - % by weight (% w/g);
- wilting coefficient (WC, %, g/g), calculated based on hygroscopicity coefficient;
- field water capacity (FWC, % w/w), calculated based on Dumitru et al. (2009) formula, considering clay content (%), silt content (%), bulk density (g/cm^3), and layer depth (cm);
- useful water capacity (UWC, % w/w) is calculated as the difference between field

capacity (% w/w) and wilting coefficient (% w/w);

- total water capacity (TC, % w/w) is determined as the report between total porosity (% v/v) and bulk density (g/cm^3).

For the complete soil characterization, in terms of both the physico-chemical properties of the soil and physico-geographic conditions in which the soil was formed, soil properties are represented as symbols grouped in ecopedological indicators, according to the methodology in force (ICPA, 1987; Munteanu and Florea, 2009).

RESULTS AND DISCUSSIONS

According to the available data, the main physical-geographical conditions of the two testing sites are illustrated in Table 1.

Soil characterization

***The profile of 1 –Typical arenosol,* Tecuci, GL**

The rock: deposits of wind

***Relief:** the field of the corrugated*

***Usage:** plantation of vines, aged for more than 30 years.*

***Water**: more than 10 m*

Figure 2 Profile of the representative

The morphological characterization of the soil profile

Horizon At (0 - 12 cm) sand, silty fine, light brown hues of 7.5 YR 2/2 with a wet and a total of 7.5 YR 3/4, dry, texture, grainy, average, moderately developed, and the wet, the numerous changes made to the skinny, the fine roots of the frequent non-adhesive, neoplastic, passing gradually into the lower;

Horizon Ao (0-26 cm) sand, silty fine, light brown hues of 7.5 YR 2/3 of the wet-7.5 YR 4/4 beat in the dry, texture, grainy, moderately developed, with a moist, fine roots common non-adhesive, neoplastic, movement is moderate, and pass to the clear right.

Horizon C_1 (26-54 cm) loamy sand, coarse-grained, brown-yellow hues of 7.5 YR 3/4, moist, and 7.5 YR 6/4 dry, poorly structured, the grain of sand can be seen in the surface area of the aggregates, non-adhesive, neoplastic, excitement, strong, passing through the clear wavy towards the bottom;

Horizon C_2 (54-86 cm) sand, coarse, yellow-brown with hues of 7.5 YR 4/6 wet and 7.5 YR 6/6 in a dry, rich, very, very friable, excitement, strong;

Horizon C_3 (86-120 (165 cm) sand, coarse, yellow-brown with hues of 7.5 YR 4/6 wet and 7.5 YR 6/6 in a dry, rich, very, very friable, excitement, strong;

Physico-chemical characterization of the soil profile

The soil samples were analyzed physical, chemical, and the results are shown in table 2.

Table 2. Characteristics of the typical arenosol, Tecuci area

Horizon	**Aț**	**Ao**	**C_1**	**C_2**	**C_3**
Depth (cm)	0-12	12-26	26-54	54-86	86-120
Coarse sand (2-0.2 mm)	29,8	32,8	35,6	43,4	39.8
Fine sand (0.2-0.02 mm)	31,6	30,1	29,4	30,3	32.6
Dust (0.02-0.002 mm)	30,4	29,8	28,7	25,6	24.3
Clay (< 0.002 mm)	8,2	7,3	6,3	0,7	3.3
Soil texture	UF	UF	UG	NG	NG
Soil reaction (pH)	5.72	5.76	6.26	6.45	6.41
Humus content (%)	0.78	0,72	0,30	0.24	0.12
Apparent density (g/cm^3)	1.46	1.49	1.46	1,33	-
Total porosity (%)	48	46	48	50	-
Degree of compaction GT (%)	moderately	moderately	non-compacted	non-compacted	-
Chloride (mg/l)	0,0	0,0	0,0	0,0	-
IN	0,56	0,53	0,23	0,18	-
Degree of saturation V (%)	72	74	76	77	-
Mobile P (ppm)	16	13	-	-	-
Mobile K (ppm)	110	83	-	-	-
Carbonates	1.2	2.8	4.5	6.2	8.7
The coefficient of higros. %	2,8	3,2	2.6	-	-
Permanent wilting point (%)	4,2	4,8	3.9	-	-
Field capacity (%)	7,6	8,7	7.0	-	-
Useful water capacity (%)	3,4	3,9	3.1	-	-
Total water capacity (%)	32,8	30,8	32,8	-	-
Humus reserve (t/ha)	13,66	15,01	12,26	-	-

Due to the climatic conditions, irrigation is required as a mandatory measure in the improvement of the psammite soils. The optimum water to support the carrying out of the processes of the development of the psammite soils.

The fertility of the psammite soils is determined by certain properties, such as coefficient of fading low, and the permeability, good air, the absence of cracks, and the phenomenon of swelling and shrinkage, the adhesion of the small and the drainage is good, but some of the unfavourable properties: the contents of the low in humus and nutrients, high content of sand and low clay, what causes wind erosion, leaching of heavy chemical elements in the nutrient, the amplitudes of the high-temperature and mineralization of the high organic matter content.

In the case of the psammite soils schemes of hydraulic engineering of the facilities of the water we need to ensure that the application of the rules of watering of small (300-400 m^3/h) at a time at short intervals of time (every 5 to 7 days).

The methods of watering are recommended in this type of soil drip irrigation and underground aspersions they are able to ensure the application of the rules of the small watering can to a short period of time.

The profile of 2 calcaric chernozem, Grădina, CT (figure 3)

Coordinates: $44^0$31'26" N and $28^0$29'45" 's

The rock: loessoid deposits

Usage: arable stubble straw (barley)

Water: > 10 m

The morphological characterization of the soil profile

***Horizon Am* (0 - 32 cm)** clay, dusty, light-brown (10 YR 2/3 of the wet-and 10-YR 3/4 of it on the road),

glomerular structure, moderately developed, and the porous, permeable, fine roots common from did is the vegetation of the education, movement, weak, gradual progression from the right on the horizonlower

Horizon AC (32-56 cm) medium loam, brownish-yellow (10 YR 4/3 in the wet, and the 10-YR 4/5 of the land), the structure of the glomerular developed in the upper half of the horizon from the transition easy for friable and non-friable, porous, loose, with the accumulation of carbonates in the form of a pseudo mycelium, joy, moderate;

Figure 3. An overview of the profile of the ground

Horizon Cca (56-115 cm) sandy loam soil powdery, yellowish brown (10 YR 5/4 in the wet), the rich, friable and non-friable, porous, loose, with the accumulation of carbonates in the form of a pseudo mycelium, and the forms and shapes of the small sultry, movement is strong

Horizon C (115-145 cm) sandy loam soil of the middle, yellowish brown (10 YR 5/5 wet), non-structured, very friable, porous, loose, with the accumulation of carbonates in the form of a pseudo mycelium, and the forms and shapes of the small crumbly and moderate.

Physico-chemical characterization of the soil profile

The soil samples were analyzed physical, chemical, and the results are shown in table 3.

Appearance, are the soils that are representative for the area of the steppe, and at the same time one of the most important soil types in the Romania due to the surface tension that we take care of the fertility of the natural high.

Appearance are, generally, soils with good fertility, due to the chemical and physical properties are favourable. Fertility it is. I often very much lower, due to the adverse fallout.

The schemes of hydraulic characteristics of the facilities you need to ensure that the application of the rules of the wetting between the 700-1l50 m^3/ha, with an interval of 10-15 days to the cultivation of the field, and from 7 to 20 days for vegetable crops (between 8 and 10 days to the tomato-7 and 8 days ago in chili, from 9 to 12 days, the onion, about 15 to 20 days from the root crop)

Table 3. Characteristics of the calcaric chernozem, Grădina area

Horizon	**Am**	**AC**	**Ccca**	**C**
Depth (cm)	0-32	32-56	56-115	115-145
Coarse sand (2-0.2 mm)	5,7	14,2	14,1	-
Fine sand (0.2-0.02 mm)	32.0	30,1	29.5	-
Dust (0.02-0.002 mm)	37,6	29,8	39.4	-
Clay (< 0.002 mm)	24,7	25,9	17,0	-
Soil texture	LP	LL	SS	SM
Soil reaction (pH)	7,42	8,18	8,47	8,35
Humus content (%)	2,86	1,31	0,66	0,45
Apparent density (g/cm^3)	1.27	1.26	1.30	-
Total porosity (%)	52.5	54.7	51.2	-
Degree of compaction GT (%)	non-compacted	non-compacted	non-compacted	soil layer
Chloride (mg/l)	3,2	6.5	12,9	12,5
IN	96	100	100	100
Degree of saturation V (%)	2,74	1,31	0,66	-
Mobile P (ppm)	49	22	14	-
Mobile K (ppm)	169	98	81	-
Carbonates	8,9	8,1	7,3	-
The coefficient of higros. %	13,3	12,1	11	-
Permanent wilting point (%)	24,2	22,1	20	-
Field capacity (%)	41	43	39	-
Useful water capacity (%)	116	40	51	-
Total water capacity (%)	0-32	32-56	56-115	115-145
Humus reserve (t/ha)	5,7	14,2	14,1	-

The methods of watering are recommended for this type of soil they're dripping, aspersion, watering the brazed, irrigation and underground and submersion.

The profile of 3, Chromic luvisol – Dobroteşti TR (figure 4)
Coordinates: *44⁰18'8" N and 24⁰55'43" - E*
*The soil**: Loess***
Relief: ***A plain, level surface.***
*Level of ground water:**> 10 m***
Usage: ***Arable field***

Fig.4. Profile representative

The morphological characterization of the soil profile

Horizon Am (0- 32 cm) clay, dusty, brown, dark (of 7.5 YR 2/2 of the material in the wet state and a total of 7.5 YR 3/2 of the material in the dry state); the structure grainy well developed in the upper part of the horizon, and the polyhedral environment, developed on the basis of the latter, the units are crashing hard, the horizon is faintly pounded, hard in the wet, hard when dry, that it is hard plastic and sticky, weakly compact and weakly cemented.

Horizon AB (32 - 64 cm), medium loam, dark brown (7.5 YR 3/2 of the material in the wet state and a total of 7.5 YR 3/3 of the material in the dry state), a structure that od is moderately well developed, moderately compressed, loud, wet, hard when dry, soft plastic grip, compact, moderately cemented, the passage clearly right.

Horizon Bt_1 (64-135 cm) clay-clay medium, light brown (7,5 YR 4/3 of the material in the wet state and a total of 7.5 YR 5/4 of the material in the dry state), the columnoid-cell medium, and large; the fabric is very wet and very hard when dry, very plastic and sticky, very compact.

Horizon **Bt_2 (135-186 cm)** clay-clay medium, light brown (7,5 YR 4/4 of the material in the wet state and a total of 7.5 YR 5/6 of the material in the dry state), the structure of the cell medium and large, with frequent cracks are fine; the fabric is very wet and very hard when dry, very plastic and sticky, very compact, it can be observed new formations waste in the form of film of clay on the faces of the aggregates, structures, passing through the clear right

***Horizon* Ck (> 186 cm)** clay, medium brown, yellowish brown (7,5 YR 5/4 of the material in the wet state and a total of 7.5 YR 6/6 material on a dry basis), the fabric is a rich, friable and non-friable when wet, that it is cohesive in the dry state, shows the grain of sand, and the rare spots of the $CaCo_3$, movement of moderate severity.

Physical and chemical properties of the soil, they are in line with the physical and geographical conditions of the formation of the latter. The analytical data for the chromic luvosol, they are presented in the table 4.

Table 4. Characteristics of the chromic luvisol, Dobroteşti area

Horizon	Am	AB	Bt_1	Bt_2	Ck
Depth (cm)	0-32	32-64	36-135	135-186	> 186
Coarse sand (2-0.2 mm)	19.0	17.3	13.7	10.7	15.9
Fine sand (0.2-0.02 mm)	16.6	24.6	16.9	19.5	29.5
Dust (0.02-0.002 mm)	34.4	28.5	25.8	27.5	28.2
Clay (< 0.002 mm)	30	29.6	43.6	42.3	26.4
Soil texture	LP	LL	TT	TT	LL
Soil reaction (pH)	5.4	5.8	6.2	6.5	7.2
Humus content (%)	3.2	2.3	1.7	1.3	0.8
Apparent density (g/cm^3)	1.31	1.41	1.46	1.47	1.39
Total porosity (%)	48.5	46.2	45.7	45.7	47.7
Degree of compaction GT (%)	non-compacted	moderately	moderately	moderately	non-compacted
Chloride (mg/l)	0	0	0	0	9.7
IN	32	23	18	10	-
Degree of saturation V (%)	254	167	112	67	-
Mobile P (ppm)	2.43	1.79	1.36	1.05	-
Mobile K (ppm)	76	78	80	81	92
Carbonates	7.9	9.2	12.3	12.2	4.7
The coefficient of higros. %	1.9	13.8	16.9	18.3	12.7
Permanent wilting point (%)	21.2	25.1	24.2	24.5	23.5
Field capacity (%)	9.3	11.3	7.3	6.2	10.8
Useful water capacity (%)	34.4	32.7	33.1	33.9	33.6
Total water capacity (%)	156	103	109	81.2	21.6

Solutions loamy-clay soils, are considered to be heavy soils with a high content of clay and the high-density. There are soils that are relatively heavy, which will benefit from the nutrients in large amounts.

The speed of the infiltration of the water is low and the capacity of water retention is high. In the case of these two features, the drainage of the water in the soil is deficient of this is likely, in the way of the natural phenomenon of the puddling.

Thus, they will be excluded from the methods of de-watering the sod, irrigation, underground, and submersion.

The schemes of hydraulic characteristics of the facilities you need to ensure that the application of the rules of the wetting between 350-650 m^3/ha, at average intervals of time.

The methods of watering are recommended for this type of soil must be capable of maintaining the pluviometry average hourly earning less than or equal to the speed of water infiltration in the soil, in order to avoid the phenomenon of puddling., and the drain to the surface.

Thus, the methods of watering are recommended to be dripping, respectively, aspersion with the rules in the medium and longer duration of watering.

CONCLUSIONS

The average permeability values were in the case of calcareous psamosol from Tecuci Km = 12.5 ~ considered a high value; for calcaric chernozem from Grădina Km = 2.5 ~ considered a middle value and for chromic luvosol from Dobrotesti Km = 1.6 ~ considered a low value;

In the case of limestone typical arenosol studied in Tecuci, Galati County, the recommended watering methods are drip, underground irrigation and sprinkling with small watering norms (300-400 m^3 /ha) with return at short intervals (5-7 days).

The recommended watering methods for the calcaric chernozems studied in Gradina, Constanta County, are dripping, sprinkling, watering on furrows, underground irrigation and submersion with large watering norms between 700-1l50 m3/ha, with return at large intervals between watering's (10-15 days).

The recommended watering methods chromic luvosol, studied in Dobrotesti, Teleorman county are drip, sprinkling with average norms of 350-650 m^3/ha, with return time between watering's of (7-12 days).

For chromic luvosol are not recommended watering on furrows, underground irrigation and submersion, because this type of soil is characterized by a low rate of infiltration and is naturally prone to puddling and surface runoff phenomena.

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