CROPS IRRIGATION – A TECHNOLOGICAL PROCESS FOR A PROSPER AND ECOLOGICAL AGRICULTURE

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Abstract: For the future of Romania, a plenty of convincing arguments point out the fact that the agriculture can and should become a fundamental branch, even a turn-table of the Romanian economy.

The agriculture is a branch of strategic importance for the national economy of our country, with various functions, such as biological and ecological, is the main source of food security and economic activity, of exportation and environmental protection, a way of life, a technical tradition and culture, and why not, a civilization.

This book has been carried out by a team of valuable researchers, who have been working within the Agricultural Research-Development Unit, Caracal, Olt County, and have performed a long and fruitful activity in the domain.

The approached theme is of present interest for the agriculture of Romania, in the conditions in which good and quality crops can be obtained only by irrigations or by the help of a pluviometric regime favorable to the water demands of agricultural plants.

The book synthesizes a great volume of research data and presents the proper results obtained over a 3-decade interval, for the conditions of south-east Oltenia Plain, which can be extrapolated in areas with similar climatic conditions.

The irrigation of crops is an objective demand for the areas with reduced precipitation amounts, as those in the southern part of the country, and this agricultural work imposes itself as a necessity for the increase and stability of the agricultural crops, and for the performing of a modern, profitable, cost-effective and sustainable agriculture.

Keywords: agriculture, irrigation, agricultural production, food security, agricultural crops.

The foundation of nine experimental stations, including Studina within the Romanian Agronomy Research Institute (RARI) in 1941 has created the possibility to place the first experimental irrigated field in which data on irrigation technique could be obtained, namely: the quantity of water necessary to different types of soil; the most indicated species and varieties of plants for irrigation; the optimum periods of irrigation for every crop; the leakages and evapotranspiration; the fertilizers influence combined with irrigations etc.

The data obtained in the experimental field at Studina showed that there is a droughty area in the south of Oltenia Plain, where, sixty-one of one hundred years are droughty. In this kind of areas, the agricultural production depends in the first place on the sum of precipitations and their repartition in time, and, secondly, on the level of the applied agrotechnics. In a droughty area the irrigation is the main

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measure which ensures big and sure production, the irrigation being necessary for all the crops, not only as supply watering, but also as maintenance watering during the vegetation period.

Crops experimental researches and statistical processing showed the necessity of an irrigation system in Romania.

Following the complex analysis of the climatic, pedological and consumption data of water, there was established the irrigation norm divided in the territory of the country, rendered in a fractional form namely:

- the norm of water supply, which refers to the cold period of the year, including October-March
- the irrigation norm in the period of vegetation, which refers to the period April-September

In the south-east of Oltenia Plain, in order to differentiate the irrigation norm on sections of natural conditions and crops, the following grouping was made:

➢ *for soil,* using both the genetic and textural criterion, three categories were delimited: middle zones (sandy-clayey, clayey-sandy, clayey), heavy zones (clayey-argillaceous, argillaceous-clayey, argillaceous) and sands of dunes;

➢ *for winter precipitations* all the three zones are presented A, B, C, (150–300 mm), but we are interested in zone B = 200–250 mm and zone C = 250–300 mm;

➢ *for summer precipitations,* which intervenes in the dimensioning of irrigation norm in the vegetation period, and we are interested in zone A = 150–200 mm, zone B = 200–250 mm and zone C = 250–300 mm.

➢ *for the total soil water consumption* we separated three groups of crops.

– The supply watering is necessary on the middle soil in zone Pi = 200–250 mm, with a norm of 700–1.050 mc/ha and on the sands of dunes, the norm being of 1.150–1.500 mc/ha.

– The irrigation norm of the vegetation period was established at 1.000–5.500 mc/ha on the middle and sandy (dunes) soils, in zone Pv = 200–250 mm and 1.700–6.200 mc/ha on the heavy soils, in zone Pv = 200–250 mm;

– For the area of Oltenia Plain, situated between Jiu and Olt, 18 sections of the irrigation norm were established, which was rendered in a totalizing and fractional way as supply watering and watering in the vegetation period and the medium hydromodule on crops.

The researches have highlighted the utility of the method of soil water balance which relies on the effective elements established directly on the field, namely:

– the precipitations of the vegetation period (every ten years);

– soil physical and hydrophysical properties of the considered hydromodule section (Cc, Co, Cv, Gsp, Hy);

– daily average water consumption of plants;

– minimum ceilings of soil humidity for different plants;

– calculation of the irrigation system on crops.

The requirements related to water during the vegetation period have been differentiated, at the main crops (wheat, corn, sunflower, soy, sugar beet, potato, alfalfa):

♦ The abovementioned crops react very favorable at fertilization and irrigation, technological process that contribute to big and sure productions, not only in the normal years in what the precipitation are concerned, but also in the droughty and very droughty years; the increases of production are of 20% in wheat, 70% in corn, 98% in soy, 40% in sunflower, 61% in sugar beet and over 60% in alfalfa green mass;

♦ On the permanent small channels with intermittent functioning the efficiency is obviously influenced by the phenomenon of earth cracking, and it is reduced with 50% on earths with a strong tendency of cracking;

♦ The continuous compaction and functioning increases the efficiency of the permanent small channels;

♦ Earth compaction from channels is best done, for a work of 5–10 kg/dm^2, at a humidity whose value is close to the field capacity for water, that is 22–25% on the clayey-argillaceous soils and 27–35% on the clayey black earths;

♦ The efficiency of the temporary linking furrows is higher than of the permanent small channels with intermittent functioning; it is of 0.72–0.77 on the clayey and clayey-argillaceous soils and it is not influenced by the phenomenon of earth cracking;

♦ The replacement of small channels with intermittent functioning with the temporary linking furrows increases the efficiency by reducing the infiltration losses and creates the advantage of using a quantity of the lost water for the crops damaged by the temporary system.

♦ On the middle permanent channels with continuous functioning, built in embankment, the losses at the derivation vans can be removed by using the transportable siphons;

♦ The decrease of the section useful for channels by installing and increasing the vegetation, strongly reduces their efficiency and, therefore, it is necessary its periodical destruction using different methods;

♦ Natural clogging of the channels dipped perimeter is the most powerful and efficient way to reduce the infiltration water losses.

The main aim of the researches coordinated by the Romanian Agronomy Research Institute (RARI) and the Research and Technological Engineering Institute for Irrigation and Drainage Băneasa-Guirgiu (RTEIID) was highlighted in two major domains, namely: the quantitative delimitation of the optimum humidity interval, that is the quantitative specification of the minimum ceiling under which the function of plants are no longer optimum; water consumption of the main crops in a network of experimental fields which would comprise the diversity of the natural conditions existing in the irrigated massifs.

Since 1970, the experimental field concerning the correlation between the water soil consumption and the main crops production from Research and

Agricultural Development Station (RADS) Caracal, was included in the research program "Exploitation and modernization of the drainage and irrigation equipping" aiming to achieve research results in the natural conditions of the south-east of Oltenia Plain in order to be available to the irrigation systems and the production unities in this area (29, 30, 32).

The paper presents data on the physical, hydrophysical and chemical characteristics of black earths:

▪ in the perimeter occupied by the two irrigation systems Stoeneşti and Corabia Terrace which totalize about 60.000 ha, more than a third of the surface arranged for irrigation in Olt county, there have been studied twenty two soil units from three types of mollisols, proper black earth, cambic black earth, and argillaceous-illuvial black earth;

▪ data shows that loam soils are characterized by a moderate clay content and quite an equilibrated dust and sand content, so that none of these fractions have excessive influences which would lead to a moderate permeability for water and air. They do not have an excessive consistency and can be well and quite easily worked, since they are middle soils; the loam-argillaceous and argillaceous-loam soils are similar to the loam soils in point of characteristics, excepting the higher loam content which dominated and reduces the influence of sand and dust fractions and, consequently, they have a greater capacity for water and a reduced permeability for water and air.

In the process of water retention in soil phenomena, forces intervene, which manifest themselves in the interaction of the solid phase with the liquid phase determining soil hydrophysical indexes.

The hydrophysical indexes represent values specific to humidity which give indications concerning water mobility and accessibility for plants:

➢ among the hydrophysical indexes, the water capacity in field (Cc) together with the withering coefficient have a great importance in the irrigation application;

➢ the hygroscopicity coefficient (CH), which was determined at all the studied types of soil, is used to calculate the withering coefficient;

➢ data presented show that the black earths on Olt and Danube terraces have a good capacity for water and air.

Taking into account the chemical and nutritional characteristics, the black earths from the studied region are included in the category of best soils since:

♦ they are rich in humus, which is of high quality;

♦ their degree of saturation in bases is comprised between 90–100%;

♦ they are soils with a very intense microbiological activity, highly potassium supplied, average phosphorus supplied and poorly azote supplied;

♦ the researches carried out have shown that, in all the investigation stages, the mineral residue was generally of 20–50 mg/100 g. soil; there has not been noted large accumulations of mineral residue in time, but a slight growing tendency, the slight variations being in plus or minus, in the limits of the non-salted soils; it is noted that the pH evolution is comprised between 6.8 and 8.00 being soils with a poor acid reaction, neutral or alkaline.

The importance of water as vegetation factor in the plants' life has been known since the appearance of agriculture. Consequently, studies and researches have been carried out concerning the water consumption of crops as an element of the water balance in soil, in different stages of vegetation and in different pedoclimatic conditions:

➢ the research results obtained in a period of twenty five years (1971–1995) show that, in Romanaților Plain, 45–50% of the total water consumption comes from precipitations, 35–45% from watering and between 6–20% from the water reserve in soil;

➢ the total water consumption varies from year to year, depending on the climatic conditions and the production obtained. There is a linear correlation between the consumption and production whose correlation coefficients are distinct and very significant.

The water consumption in ***corn*** is of 5.310 mc/ha, its variation being comprised between 3.527 mc/ha and 6.688 mc/ha; the monthly and daily water consumption is increasing till July, being of 1.589 mc/ha and 51.3 mc/ha/day; the total water consumption in unirrigated corn has the average value of 3.825 mc/ha, with the minimum value 1.476 mc/ha in 1993 and the maximum value of 6.127 mc/ha in 1991.

In the ***autumn wheat*** the total consumption, the multiannual mean, was of 3.231 mc/ha, with oscillations from 2.530 mc/ha in 1998 and 4.141 mc/ha in 1991; the daily average consumption was of 41.5 mc/ha/day in the peak month, namely May; in unirrigated wheat the total water consumption was of 2658 mc/ha.

The water consumption in ***sunflower*** was of 4.953 mc/ha, and of 1.462 mc/ha in the peak month, the daily average consumption registering the maximum value of 48.7 mc/ha/day in June.

The value of the annual average water consumption in ***soya*** was of 5.068 mc/ha, with limits from 3.502 in 1999 to 6.783 mc/ha in 1975; the monthly maximum consumption is of 1.503 mc/ha, the diurnal maximum consumption being of 48.5 mc/ha/day in July.

For the prognosis and warning of the watering application it was necessary to determine the moment of watering for every crop, depending on the momentary water provision in soil.

When establishing the moment of the watering application, a balance is made by means of a *monthly record,* for every crops, in which, the daily average water consumption and the transformation coefficients (kt) of the water evaporation from the evaporimeter type BAC class A are used apart the other elements.

In the south-east of Oltenia Plain the question of highlighting the report between the obtained productions and the quantities of water consummated by the crops arose. In this regard, a linear variation of the production of alfalfa, soya, bean and potato was noted, highlighting clear possibilities of increasing the crops using the same water consumption on the product tone, of course, to a certain limit. In sunflower a more slow production increase is noted, and in sugar beet a production capping at the level of 65 tones/ha.

The coefficients of total and irrigation water use were calculated in order to establish the mean of water use by the crops used in the research, in the pedoclimatic conditions specific to our area of reference. The data indicate a good use of the total and irrigation water by the crops of corn, wheat, summer potato, sugar beet and alfalfa. In unirrigated crops, the corn, wheat, sunflower and sugar beet to a great extent ensures a good use of the total water. The irrigation water is used well by corn, bean, potato and sugar beet.

Not only in the experimental field, but also in the big existing systems an established professional irrigation system was applied, so that the productions highly increased in all the crops. Consequently, productions of 6.000 to 8.000 kg/ha were obtained in wheat. The mean on twenty one years proves that irrigation brings increases of over 25%.

In unirrigated corn the production were of 10.000–13.500 kg/ha, in sugar beet of 40–85 tones/ha, and in soya and sunflower of 3.00–5.000 kg/ha.

The average data on two decades show that in big water consuming crops, such as the corn and soya, the rational irrigation can double the production, i.e. the increase can be of 217% and of 207%.

It is important to note that, in droughty or excessively droughty years (1985, 1989, 1993), the big water consuming crops with a long vegetation period realized, in unirrigated crops (observer), productions of fourth to twelfth times smaller than in irrigated crops. The irrigated productions, in these years, were bigger in corn with 485–1.088%, in soya with 363–1.235%, in sugar beet with 235–961% and in sunflower with 544–1.132%.

Once with the entry into operation of the two big irrigation systems in Romanaților Plain, Stoenești and Coraboia Terrace, after 1970, the laboratory staff of Land Improvement of R.A.D.S. Caracal has carried out studies and researches on the increasing of the irrigation systems efficiency by increasing the efficiency of transport and water distribution and by improving the methods, equipment for the water distribution and administration, as well as monitoring the evolution of the level of the phreatic and irrigation water chemism. Furthermore, they established measures in order to prevent the appearance of some negative phenomena related to soils and works.

The researches aimed to establish the infiltration water losses, measures and methods to reduce them in the irrigation network, the phreatic water dynamics and the monitor of the hydrogeological evolution, the saline regime of the irrigated and phreatic water, the evolution of soils.

The researches on the infiltration water losses were carried out on sections of channels of a great variety, non-lined, lined with monolithic concrete, concrete slabs of different sizes (50/50/5 cm; 2/1,0; 3/1,0; 2/1,5 and 3/1,5 m) and lined with polyethylene thin sheets and plasticized PVC. The measurements were done in static, functioning and dynamic regime.

The results obtained using the method in static regime shows that on the non-lined channels, executed in excavation, located on argillaceous-loam soils, the infiltration water losses are of 690–770 l/m^2/day and of 830 l/m^2/day the ones in waste and can reach 1.210 l/m^2/day on the channels built on the fields with a higher, loam or loam-sandy texture. Due to the lining with concrete slabs, the water losses are highly reduced, being of 262–287 l/m^2/day where the slabs are small (50/50/5 cm) and of 198–227 l/m^2/day where the slabs are big, of 2/1 or 3/1.5 m. Very small water losses, of 31.2–45.8 l/m^2/day, are registered on the channels lined with polyethylene thin sheets or PVC covered (fixed) with ground or slabs.

The experiment carried out in Stoeneşti system is illustrative for the role of the consolidation joints between the slabs in determining the water losses, because in a section in which the joints were left non-lined, these losses are 2–3 higher (580–685 l/m^2/day) in comparison to those realized in the section with the joints stuffed with concrete mortar (120–270 l/m^2/day).

By lining the joints between the slabs, the infiltration water losses can be significantly reduced with 11.5–33.8%, their absolute value being of 191–257 l/m^2/day in comparison to those on unpolished stone packing where the loses were of 483–645 l/m^2/day.

The identification of the hydrological situation in the exploitation of systems and the evolution in time of the phreatic waters needed tenths and hundreds of hydrological drillings in order to measure the level of the phreatic water. By processing the weekly or every ten days readings, there were drafted variation charts of the level of phreatic water. These enable us to establish the annual dynamics, as well as the influence of the main factor which directly determines the hydrogeology of an irrigation system, and the total water volume which enters in the system perimeter. The total water volume has two main sources namely: the water coming from precipitations (snow, rain) and the water introduced by pumping for the crops irrigation.

The contribution of the two water sources in the warm period of the year oscillates from month to month in the same year, and from year to year. Data showed that the precipitations contribute in a proportion of 29.0–70.3%, and the water volumes introduced by pumping in a proportion of 25–65%, but the contribution is opposite to that of precipitations, i.e. it is small in the rainy years and big in the droughty years.

The monitor of the phreatic water dynamics under the influence of the natural and anthropic factors has led to the data change into surfaces and percentages representing different groups established according to the depth of the phreatic water which can be more or less unfavorable for the soil or crops.

The hydrological evolution in Stoeneşti systems and Corabia Terrace shows a degradation in the period until 1985 and an obvious improvement in the period

1985–1995. Consequently, the irrigations contribute to the evolution of the phreatic level when the infiltration water losses of the channels network is superposed on the general raising of the underground waters due to the precipitations contribution.

The continuous data processing in the form of maps with isophreates enabled the localization of the regions with a critical phreatic level, as well as the surface groups of deeper water in the systems of irrigation Corabia Terrace and Stoeneşti.

On the surfaces with a critical phreatic level (0–1 m, 1–2 m and 2–3 m depth) hydro-improving works recommended by the research are maintained and executed, such as the completion of the drainage network, the lining of the adduction and distribution channels with concrete slabs and polyethylene thin sheets and PVC, the microzoning of the irrigation system, the improvement of the water recording and distribution within the irrigation systems.

The processing of data and observations on the level of the phreatic waters on extended territories gives evolution indexes of the hydrogeological regime on tenths of hectares. The presented data shows us that in the south-east of Oltenia Plain the surfaces with high levels of the phreatic water decreased and those with low levels (3–5 m, over 5 m) increased. The phenomenon can be explained by the climatic regime poorer in precipitations in this period, with higher ETP, as well as by the extension and completion of the draining network in the regions exposed to the humidity excess.

In what the quality of the irrigation water from the Olt River is concerned, the researches carried out within the program of R.T.E.I.I.D. Băneasa-Giurgiu by the Research and Agricultural Development Station Caracal, showed some fluctuations from one period to another of the total mineral residue, but with a clear growing tendency.

The results of the monthly analyses presented confirm this phenomenon and it is noted that beginning with 1975, , sudden increases of the fixed mineral residue and of the chlorine content appeared in some months, such as April 1975, June, July and August 1976, September 1981 etc. The quality indexes of the irrigation water starting with 1976 shows the class ***“satisfying”*** more and more frequently, although, previously, the class ***“good water”*** for irrigation predominated.

It is also noted that that the content in chlorines is permanently of over 200 mg/l, and in 1988 of 400–500 mg/l; the total mineral residue exceeds 700 mg/l and reaches 1.260 mg/l in 1988; this fact caused serious problems in that stage, related to the use of the water from Olt in irrigations because, according to the Romanian and foreign usual norms (FAO), the degree of moderate restrictions appear in the concentrations of chlorine comprised between 150–350 mg/l; a similar situation is also noted in the sodium (component of NaCl) which reached to 180 mg/l in comparison to 50–80 mg/l in the period 1970–1980; the increase of the total content of salts, chlorine and sodium during a year is usually produced in March-April and September-October.

The research carried out show that the main impurity source of the River Olt water is the chemical Platform of Râmnicu Vâlcea-Govora. The improvement of the quality of River Olt water needs the chemical industries which in present discharge high quantities of waste water take the necessary measures to protect the environment.

After 25 years of exploiting the Stoeneşti system and 20 years the Corabia Terrace, the total mineral residue maintained its values between 0.6 and 1.0 g/l in the first and between 0.5 and 0.8 g/l in the second.

In what the chemical components are concerned, a high content of chlorines of over 150 mg/l resulted in the Stoeneşti system and of 100 mg/l in the system Corabia Terrace. The content of sodium maintained its value, in general, under 100 mg/l while the content of calcium and magnesium varied between 60–80 mg/l.

Due to the obtained data, the regions where the content of chorins is high were estblished, such as Slăveni, Cilieni and Rusăneşti, of the Stoeneşti system and Vişina-Veche of the system Corabia Terrace.

In time, the obtained data were processed in order to see the influence on the environment of the phreatic water consumed by man and animals as drinking water.

Data classification in the drinkability norms, after ten indicators very important enabled us to establish the problematic regions, such as the region Stoeneşti-Slăveni and Cilieni.

The data shows us that water has an alkaline reaction to the exceptional limit (pH = 8–9), but it is drinkable since more than 70% of the samples fell in the permissible limits, of 100–800 mg/l total content of salts.

In addition, the content of cations (calcium, magnesium, sodium and potassium) which fell in the limits permitted under the health standards in force indicates drinkable phreatic water.

For the soils evolution, 22 points of pedological control were established in the two systems. The samples taken and analyzed every two years on a depth of 0–150 cm and on layers of 15 cm provided many data on the pH and the total mineral residue.

Analyzing the data obtained in a long period of time, mentioned above, we notice that the total mineral residue oscillated in plus or in minus from one stage to another, but in the reduced limits of 50–80 mg/100 g soil. There wasn't noticed an obvious accumulation of salts. Furthermore, not even the soils pH indicates a negative evolution in the perimeters arranged for irrigations.

The results obtained by RADS Caracal enable to establish and to use in agricultural practice some multiple and differentiate research results, which would ensures significant productions in all the crops from the concerned area, but also for a positive evolution of the systems arranged for irrigation and environment protection, which would maintain and determine the ecosystems favorable evolution in the south-east Oltenia Plain.

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