THE SYSTEMIC APPROACH IN THE ELECTION PROCESS, OF SOIL MOISTURE REGIME IN THE CONDITIONS OF IRRIGATION

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Abstract

In this work a new method of the rationalization of the soil moisture regimes is presented. For that purpose we have elaborated a new model of planification and maintenance of rationalized/optimized soil moisture regimes based on aridity index. The algorithms for the determination and the maintenance of irrigation regime that we have elaborated, can be used either while planning the systems of irrigation, or further, while their exploitation when there appears a necessity of saving water for irrigation. This method offers the possibility of planification and maintenance of a hydrothermal regime allocated for irrigated enclosure. The algorithms for determination and maintenance of irrigation regime that we have elaborated, can be used either while ecological optimization of hydrothermal regime of irrigated surface, or, while economic optimization of irrigation systems expenses. The results of our investigation were verified in conditions of lysimeters installed in the State Hydro meteorological Service area. The components of radiation balance used in the elaboration were taken from the State Hydro meteorological Service.

Key words: rationalization, index of aridity, radiation balance

The problem of the rationalization of water consumption in irrigation is one of the most difficult in optimization of expenses for water for irrigation. The majority of studies and investigations are dedicated to this theme.

Thus, according to (Ajdarov I.P., Korol'kov A.I.,1986, Adamenko V.N., 1979), the efficient ones are those regimes which provide irrigations with frequent moistures and small norms. Therefore, it is considered, that water can be economized and there is no place for percolation.

Other researchers (Bogrov M. N., Žarikov E.M., 1986, and others), on the contrary, affirm that moistures with small norms can lead to unproductive losses while evaporating, and can create premises for non-conformance to the regime of irrigation because of some organizational muffs.

According to (Bud'ko M. I., 1977, Egorov V.V., 1984, Gamaûn I. M., et all., 2005, Koronovskij A. D., 1991, and others), the efficient ones can be called the regimes that provide segregated irrigation. This method provides that the vegetation seasons should be divided into many periods, called 'critic', when the development of some plant growing phases begins. In these phases, it is considered, the bottom limit of soil humidity has to be increased. Before and after this critic period, the limit can be decreased with 10-15%, without diminution of harvest level.

In case of water for irrigation deficit, some authors (Koronovskij A., et all., 2008) propose that the diminution of water expenses be effectuated as follows:

- The diminution of moisture norms;
- The expansion of the intervals between moistures.

These proposals, recommendations and methods have some disadvantages, such as:

- Impossibility of planification and maintenance of some definite humidity regime;
- The inclination towards steady diminution of soil humidity during irrigation season;
- The diminution of economic effect established in the phase of irrigation system planning.

In our point of view, to avoid these disadvantages it is necessary to emphasize the legitimacy between radiation regime of irrigated area and soil humidity regime. Thus, using the aridity index elaborated by (Lasee G.F., 1978) is possible as the factor of planification of irrigated area microclimate

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(radiation balance and soil humidity), and as the marking indicator when irrigation regime elaborating.

The purpose of the work:

The rationalization of water consumption in irrigation using aridity indexes.

MATERIAL AND METHOD

The research was effectuated using own results (the investigation of the impact of humidity regime of soil on its fertility), and other researchers` results in the domain

RESULTS AND DISCUSSIONS

The ratio used in our study is as follows:

$$\check{R} = \frac{R}{L \times (P+I)}, \qquad (1)$$

Where: Ř – aridity index; R – radiation balance; L – latent evaporation energy; P – rainfall.

The index of aridity represents to what extent is balanced the hydrothermal regime of ecosystem: if Ř> 1 then the climate is arid; if Ř <1 then it is humid; if Ř = 1, then the quantity of solar energy in ecosystem is equal to the quantity of energy necessary for absolute evaporation of water in ecosystem (for Republic of Moldova, according to ((Pancov Û. I., et all., 1983), 1,67 ≥Ř≥ 1.1, and its value grows from north to south, where the aridity is more pronounced (Ř =1,67)).

By irrigating an area, we artificially enhance the quantity of water coming in this ecosystem. In the end, the value of radiation balance ‘R’ as well as the value of aridity index ‘Ř’ is modified.

So, using irrigations, we change aridity index of the area depending on the quantity of the water used. Following this legitimacy, theoretically, we are able to reason the possibility of aridity index programming for irrigated areas dependent on ecologic or economic necessities. In order to argue this affirmation, the ratio (1) was presented as follows:

$$\check{R} = \frac{R}{L \times (P+I)}, \qquad (2)$$

Where: I – the quantity if water allocated for irrigation; Ř – aridity index; R – radiation balance. With the help of the ratio (2) we can plan ‘Ř’ knowing ‘R’, irrigation norm ‘I’ and rainfall ‘P’.

In case when for an irrigated surface we know or determine aridity index ‘Ř’, rainfall ‘P’ and radiation balance ‘R’, we are able to plan irrigation norm ‘I’, using:

$$I == \frac{R}{\check{R} \times L} - P, \qquad (3)$$

In order to prevent water percolations or any other negative effects, the aridity index ‘Ř’ has to be between 0,9 ÷ 1,2.

However, depending on the purpose of the irrigation regime or any other motives, it may have many more values.

In the mathematical point of view, the ratio (2) represents asymptotic curve of both axes of the coordinates (figure 1): when the quantity of water (P+I) that came in the micro ecosystem tends to zero, the value of the aridity index tends to infinite; when the quantity of water (P+I) that came in the micro ecosystem tends to extremely high values, the value of the aridity index tends to zero.

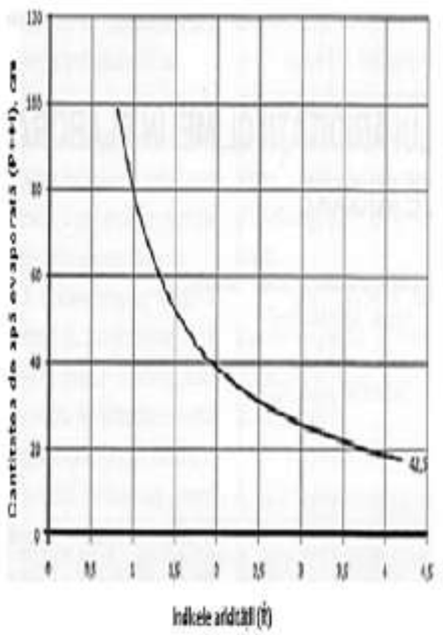

Figure 1 Dependence between the quantity of evaporated water and aridity index and radiation balance

X-axis – Aridity index (Ř), Y-axis – evaporated quantity of water (P+I)

Whereas the irrigated surfaces are situated in zones where the solar radiation balance is different, in this diagram we can make a group of curves that belong to various radiation balance levels (figure 2).

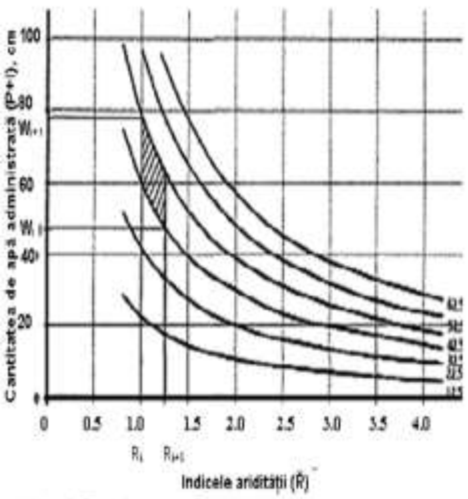

Figura 2 Dependenţa cantităţii de apă administrată de indicele aridităţii pentru diferită valoare a bilanţului radiativ

Figure 2 **Dependence between the quantity of water provided by aridity index for different radiarion balance value**
X-axis – Aridity index (Ř), Y-axis – used quantity of water (P+I)

In these charts we observe that by limiting the aridity index of micro ecosystem to particular values (R_i, R_{i+1}) on the Y-axis for particular radiation balance values, we find the quantity of water (P+I=f(W_i, W_{i+1}) that can be potentially evaporated in definite radiation conditions. I.e., it can be used as a hydrothermal characteristic of any irrigated zone. In the context of irrigation systems projecting it is necessary to fine the irrigation norm (I), that is strongly legated with the pluviometric regime (P), the potential evaporation of particular area (W), radiation regime (Ř ,R) and can be calculated according to the ratio (3). This ratio is presented in the figure 3 with some curves grouped by the rainfall provision degree.

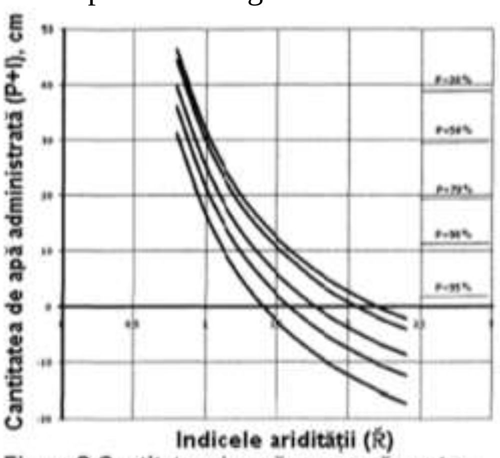

Figura 3 Cantitatea de apă necesară pentru planificarea regimului de ariditate pentru diferit grad de asigurare cu precipitaţii (P%)

Figure 3 **The quantity of water necessary for aridity regime planning for different rainfall provision degree (P%)**
X-axis – Aridity index (Ř), Y-axis – used quantity of water (P+I)

With the help of these curves, for any rainfall provision degree we determine the irrigation norm, which comes out of the degree of the aridity index of the microclimate of irrigated surface. In its turn, the aridity index of the microclimate of irrigated surface is determined in dependence of the pluviometric regime of the area, the irrigation regime, the access to water resources and the scientific recommendations related to optimal regime of soil humidity. So, theoretically, from ecologic or economic point of view, the aridity indexes of the irrigated surface can be determined, varying artificially the quantity of water in the ecosystem.

In case of water resources deficit, the irrigation regime can be established appearing from the quantity of water available, by the method of energy norm (**n_r**). They energy norm represents the necessary quantity of energy for micro ecosystem for moisture norm evaporation. For this, in advance, we calculate the aridity index **(Ř)** of the surface microclimate. The formula for energy norm calculation is as follows:

$$\mathbf{n_r = Ř \times n \times L,} \qquad \mathbf{(4)}$$

Where: n_r - reduced moisture norm; n – optimal moisture norm.

Having the theoretical base of the calculation, we present two types of algorithms to determinate the irrigation regime:

I. Economical regime

1.Determine the available volume of water.

2.Determine the aridity index degree of the irrigated surface in dependence of the radiation balance extension and the available volume of water.

3.Determine moisture norm according to the aridity index of the irrigated surface.

4.Line up the curve of the whole sum of the radiation balance degree.

5.Determine the graphic of moistures.

Using this algorithm, in order to economize if there is the water deficit, we get the possibility to elaborate and maintain any irrigation regime by using the aridity index for irrigated surface. In the figure 4 in graphical form the dynamics of aridity regime for the surface after applying our algorithm is presented. Mention the facr that hydrothermal regime of the surface is maintained in the limits estimated in the algorithm (Ř = 0.9 ÷1.2).

This possibility is not available when using modern methods that concern the water resources economy and, that is why makes it impossible to elaborate and maintain one particular regime of irrigation (figure 5). In figure 5 we notice that particular phases of harvest development serve as the indicator of the moment of moisture. The hydrothermal parameters of the surface as the main factors of harvest development and of the maintenance of microbiological soil activity cannot be neither used, nor controlled.

II. Optimal regime of irrigation

1.Determine the aridity indexes of the surface within the limits 1.1+1.2 in order to be able to use in a rational way the rainfall as well as the water for irrigation, because thus, if the moment of the moisture and the rainfall overlap, then the water percolation in the majority of cases excludes.

2. Determine the value of the radiation balance of the surface during the vegetation period of the crop.

3. Determine the quantity of water necessary for maintenance of the aridity index of the surface emerging from the radiation balance value.

4. Determine the optimal moisture norm.

5. Determine moistures chart.

The verification of these algorithms was effectuated on the base of our experimental information.

In both cases, while the determination of the irrigation regime, we used the limits of aridity index of the surface as the indicator of moisture activation. It offered us the possibility to maintain the soil humidity in particular frames which were established beforehand.

The inaccuracy of the irrigation norm calculation is approximately 10-15% when using the lysimeters in the field, but after the calculations based on the present method the inaccuracy was approximately 30%.

The *hydromodule`s ordinate calculated on the base of above mentioned method was about* (0.60÷1.14) l/(s * ha), varying due to real evapotranspiration intensity. In present it is approximately 0.5 l/(s * ha), which diminishes very much irrigation systems` capacity of maintenance of the determined irrigation regimes.

CONCLUSIONS

The algorithms of the determination and the maintenance of the irrigation regime, that we have elaborated, can be used while the irrigation systems planning, or further, while their exploitation when there appears a necessity of saving water for irrigation.

The present methods of saving the water for irrigation do not offer the possibility to plan and maintain one particular hydrothermal regime determined for irrigated enclosure.

The algorithms for determination and maintenance of irrigation regime that we have elaborated, can be used either while ecological optimization of hydrothermal regime of irrigated surface, or, while economic optimization of irrigation systems expenses.

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