COMPLEX ARGUMENTATION OF IRRIGATIONSL REGIMES

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Abstract

In this work we develop the idea of the elaboration of irrigational regimes based on the usage of the relation between hydrothermal regime and the processes of soil formation. The utilization of aridity coefficient offers us the possibility of hydrothermal regime planification (the norm of irrigation N and the indexes of irrigational aridity $Ř_{irig}$) proceeding from the laws of its influence upon soil formation process. The result of this research gives us the possibility to predict, using irrigation, all the modifications that would intervene in the circuit of energy and substance between soil and environment, thus avoiding negative processes which have brought to the actual situation the soil and water torrents are now in.

Key words: aridity index, irrigation regime, the direction of soil formation processes.

The more intense exploitation of soil lacking some ecological technologies have brought in a relatively short period of time to their overt degradation. This fact can be elucidated by the growing deficit of the balance of organic and mineral matter of the soil, by the worsening of its hydrothermal and biological regime (Frunze Nina, 2006, Zagorcea C., et. all., 2001, Jigău Gh., et all.,2001, Corduneanu P. N. 1985) and the intensification of mineral and organic components migration dissolved in soil (Corduneanu P. N. 1985, Ajdarov I.P. et al., 1987).

This situation led to the changing of the direction and intensity of the currents of matter and energy as comparing to the natural conditions and as a result – natural soil`s fertility diminution. Trying to stop the physico-chemical and biological degradation of soil we used various methods and technologies: the utilization of organic and chemical fertilizers, new agrarian techniques, chemical and hydric amelioration. But the result remained the same: qualitative and quantitative indexes of soil fertility have worsened.

In our opinion, the motive of this state of things consists of the fact that the research is done by the classic method which means that the actions made upon soil are with different norms of studied factor (in case of irrigations – different norms of moisture), and that the recording of the impacts` effect (positive or negative) on organic, biological and mineral complex is expressed by agricultural productivity.

As we know, the effect of the impact, in general, is the synergetic result of all the soil components` reaction, and that is why it conducts to the erroneous conclusions. In some cases the result can be positive, in another case; in the same conditions of the research, it can be negative.

In order to avoid these disadvantages it is necessary to emphasize the laws of the influence of the natural factors upon the direction of soil formation processes – the relation of hydrothermal regime (the index of climate aridity, elaborated by (9)) of the soil and the process of soil formation.

The goal of this work is: The utilization of relation between hydrothermal regime and the processes of soil formation whilst irrigational regime elaboration.

MATERIAL AND METHOD

The methidology of the research is based on the synthesys of our results of our study and of the other researchers in this domain. The studies were made in lysimetres in the field.

As a hypothesis in this work stands out the creation of the hydrothermal conditions in the limits of which the plants are in their maximum of development. This would mean:

1. The aridity index is equal to the planificated one or it is in the limits of its natural frames.

2. The agrocultural harvest is maximum in these conditions.

3.The irrigational aridity index is equal to 1,0.

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That is why the methodology is based on the laws of the dependence of hydrothermal, phisical and chemical assimilation of the soil on the natural hydrothermal regime of the studied area. In the research we chose 3 options of limits of moistures launching and 3 options of maximal limit of the moisture:

1 – natural;
2 - (0,7 – 0,8)CC;
3 - (0,7 – 0,9)CC;
4 - (0,7 – 1,0)CC; (low limit 0,7CC);
5 - (0,8 – 0,9)CC;
6 - (0,8 – 1,0)CC; (low limit 0,8CC);
7 - (0,9 – 1,0)CC.(low limit 0,9CC).

The radiation regime was monitored with the help of standard devices and methodologies for this kind of the measurements.

RESULTS AND DISCUSSIONS

For the identification of the intensity and the directions of processes that took place in soil under the influence of climate factors, which form the hydrothermal regime of the soil, the researchers have elaborated various criteria. These criteria were deduced after the experiments of such famous scientists as Budyko M.I. 1977; Ivanov N.N 1947; Kostâkov A.N.1951; Mezencev V.C.1957; Selânikov G.G 1937; Šaško D.N 1967. Budyko M.I. in 1977 proposed the aridity index, in our opinion, it was the most complex and the most logical way to reflect the direction, the character and the intensity of the soil formation processe in case of controlling hyrdic regime of the soil:

$$\check{R} = \frac{\Sigma R}{L \times P} \qquad (1)$$

Where, ΣR- annual radiation balance (kcal/(cm^2 × yr)); L – latent energy of water vaporization (kcal/kg); P — annual precipitations, (cm).

This formula characterizes the grade of the energy quantity coverage necessary for the vaporization of the total volume of precipitations in the studied area.

The correlation between hydrothermal regime and hydro physical and chemical assimilation of the soil and of their fertility was discussed by many researchers (Budyko M. I., 1977, Kosteakov A. N. 1951, Šaško D. I. et al. 1967).

As a synthesis of all those results Budyko M. I. (1987) has established the relations between all these factors (*Figure 1 and 2*).

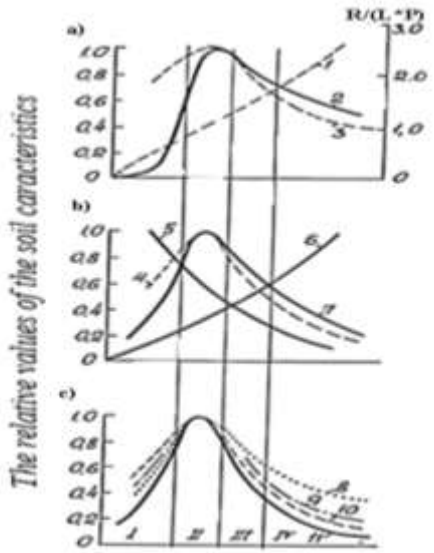

Figure 1. **The dependence of soil characteristics and the factors of soil formation:**
Where: Factors - a) of soil formation,b) hydro physical c) physic chemical; I –humus zone; II – heath zone; III – arid heath zone; IV – desert zone;1 – coefficient R/(L*P); 2 – the relation of the vegetal remains and biological mass; 3 – solification energy; 4 – the components of soil particles with d< 0,001 mm; 5 – soil humidity; 6 – the grade of soil aeration; 8 – acceptability of nutrition substance ; 9 – the relation of humus acids to fulvic acids; 10 – the soil absorption capacity; 11 – humus content.

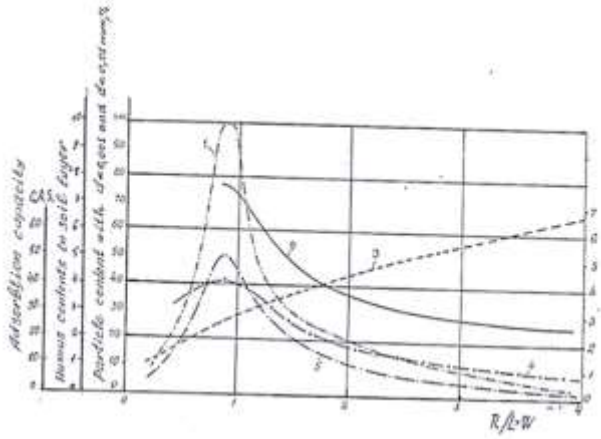

Figure 2. **The relations between soil assimilation and aridity index R/(L*W)**
Where: 1 – humus content in the layer 0-50 cm, %; 2 – clay content (d<0,01 mm); 3 – relation SiO_2/Al_2O_3; 4 - clay content (d<0,001 mm), %; 5 – absorbant complex capacity CAS, mg-ech/100g soil.

From the graphics above it can be seen that the soils of heath zone (R/(L*W) ≈ 1)have more reserves of the energy accumulated in humus, of clay (it his gives to the soil the significant capacity when speaking of cation change) and of stabile hydric structure.

In the desert zone (R/(L*W) ≥ 2) the soil productivity is low (see curves 8 and 10, *Figure 1*). This tendency can be noticed and with the other characteristics.

In the *Fig. 2* we observe the same bearing of soil characteristics as against to the aridity index level. In case of R/(L*W) ≥ 1 the solification takes place in the conditions of chemical elements and organic components accumulation because the

process of water movement in soil is a desuctive one. In case of R/(L*W) $<$ 1, the soil formation takes place under the influence of descendent water currents which provoke the leaching af all the substances in soil layer.

From the analysis of this research we can make a conclusion that the optimal conditions of soil formation are encompassed in the limits: $1{,}15 \geq$ R/(L*W) $\geq$ 0,80. In this limit the processes of soil formation and of the accumulation have the maximum intensity and the soil of these zones are the most fertile and with the maximum productivity potential (black earth of all types).

Ungureanu F.V. (1984), basing on this criterion has elaborated the division into zones for Republic of Moldova (*Figure 3*).

Figure 3. **The division into zones of the territory of our country according to the annual aridity index (Ř).**
Where: Numerator – aridity index in conditions of irrigation; denominator – aridity index in natural conditions.

In the figure we observe the connection between soil properties (moving to the south of the country the soils become sandier) and the aridity index that increases its value from the north do the south of the country and it permits us to make a conclusion about the directions of the changing of soil formation processes.

Keeping in mind this connection, it is logical to suppose that this can function in the activity of choosing the irrigational regimes for the agriculture (from the ecological, economical point of view or in case of water volumes limitation for the irrigations).

In this context, we have rewritten the formula replacing in the numerator the factor „P" with the volume ETR (evapotranspiration) for all the vegetation period.

Namely, **ETR = P + N**, m^3/ha season (2)
Where: P – the volume of precipitation in the vegetation period, m^3; N – irrigation norm (deficit of evapotranspiration), m^3.

Replacing formula (2) in (1), we get

$$\check{\mathbf{R}}_{\mathbf{irig.}} = \frac{\Sigma R}{L \times (P+N)}, \quad (3)$$

Where, $\check{\mathbf{R}}_{\mathbf{irig.}}$– aridity index planned for irrigations.

With the help of formula (3) we can calculate the irrigation norm „N" for different hydrothermal conditions:

$$\mathbf{N} = \frac{\Sigma R}{\check{R}irig \times L.} - \mathbf{P}, \text{ m}^3\text{/ha*season} \quad (4).$$

This formula permitted us to plan the irrigation norms and the aridity index for the irrigations, knowing the radiation balance (ΣR) of the enclosure (*Figure 4*).

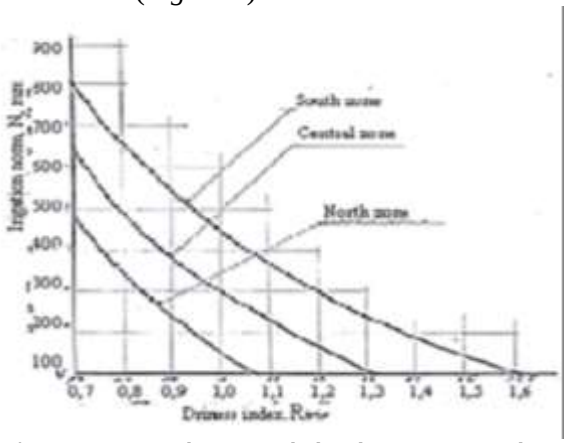

Figure 4**. Dependence on irrigation norms to the driness index of geographical areas**

As we can notice from the figure, the irrigation norms depend on the geographic area and the aridity index. As the aridity index grows, the irrigation norm lowers. The irrigation norm lowers in the direction south-north.

From the figure we can make a conclusion that for the central area (the place of the experiment) the irrigational aridity index equal to 1, 0 corresponds with the irrigation norm N=300 mm.

In the result of the experimental research (*Fig.5*) we have determined that the only one option (var.3) corresponds with the initial hypothesis ($Ř_{irig.}$= 1,0).

This effect is explained by the fact that in this option the agric cultures have consumed the biggest quantity of water (ETR = f(U), *fig. 5*). At its turn the maximum consummation is explained by the fact that this variant assures optimal conditions of soil formation processes development and the growth of agricultural harvest (Coronovschi A. et all, 2009). All the other options of humidity, as we notice in the fig. 5, do not create the optimal conditions for soil formation processes development. As a result ETR was also at a low level, increasing this way „$Ř_{irig.}$" value. From the mentioned figure we notice the increasing of „$Ř_{irig.}$" in case of humidity growing more than the optimal level (right curve of the

graphic $Ř_{irig.}$ = f(U)). The reason for this growing consists of the fact that the cultures have experienced a sub development because of high humidity level of the soil (U > optimal). The same situation we meet in case of the humidity less than optimal (U< optimal) (Coronovschi A. et all., 2009) except for the situation when the ETR level has suffered from the low humidity norm. In other words when humidity growes from its natural level to the optimal one, „$Ř_{irig}$ ” lowers. In case of humidity growth to the highest level, „$Ř_{irig}$ ” tends to grow. This effect needs to me kept in mind while humidity level and „$Ř_{irig}$ ” level choosing.

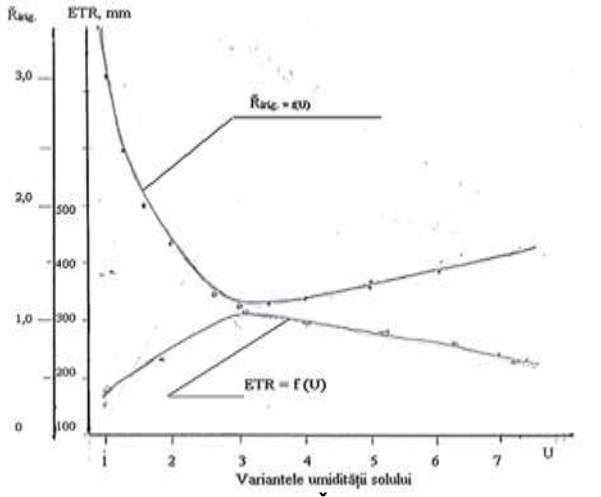

Figure 5. **The dependence „$Ř_{irig.}$” and „ETR” on the planned humidity regimes „U”.**

According to the laws exposed in fig.2, the territory of Republic of Moldova is situated in the conditions of heath in the north and the codri area, and in the conditions of arid heath in the center and south area. The research that was made can argue the fact that in the result of irrigations, planning „$Ř_{irig}$ ” and the irrigation norms, it could be possible to improve hydrothermal conditions of the irrigated area to the heath conditions. Thus, using the relations between the hydrothermal regime and the processes of soil formation, we would be able to plan and maintain the humidity regimes which would response to the ecological, economical necessities and to the necessities of restriction in the domain of hydroamelioration.

CONCLUSIONS

The initial hypothesis proposed for the verification was successfully argued with the results of our own research and of the scientists from the domain.

The results relating hydrothermal regime and the processes of soil formation give us the possibility to appreciate the direction of these processes in case of hydroamelioration application. Besides, these relations give us the possibility to a complex argumentation of fertilizers.

The usage of the aridity coefficient gives us the possibility to plan the hydrothermal regime (irrigation norms „N” and the aridity index „$Ř_{irig.}$”) proceeding from the laws of its influence upon the soil formation processes. The result of all these studies gives us the possibility to predict, using irrigations, the modifications that would be able to intervene the substance and energy circuit between soil and environment, thus preventing negative processes which have led to the actual situation of the soils and water currents.

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