THE METHOD OF ECOLOGICAL OPTIMISATION OF THE EFFECTS OF THE IMPACT OF IRRIGATION REGIMES ON THE SOIL (BIOINDICATION METHOD)

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Abstract. *Preserving the fertility of the chernozem when applying irrigation on the territory of the Republic of Moldova is a major problem, which can be achieved in particular by monitoring the quality of irrigation water supply and optimizing the irrigation regimes appropriate to each type of soil and crop, as well as by applying some measures to improve the organic matter contents of the soil.*

There is a bioindicator defined in the methodology used in the research, according to which irrigation regimes can be optimised in terms of soil fertility maintenance. Such an index was chosen by soil microbiological activity which can be characterized by its intensity. That is, by measuring the concentration of carbon dioxide (CO_2) in the soil atmosphere.

Thus, [3] there has been established the extent to which different soil characteristics and environmental factors can alter the CO_2 production processes in soil atmosphere and what the pathways for regulating this process may be. According to the research of these authorsthere was determined that one of the external factors may be soil moisture.

Thus, considering that microorganisms are the main factor on which the potential fertility of soils depends, it is logical to conclude that in order to improve fertility it is necessary to create optimal conditions for their activity. In the light of the above this means that the concentration/content of CO_2 in the soil atmosphere should be at a maximum level.

In the case of irrigation, it is necessary to keep the moisture regime within the optimum range for the activity of soil micro-organisms.

Key words*: bioindicator; irrigation; irrigation regime; potential soil fertility.*

Introduction

Irrigation can negatively influence the direction of development of solification processes. It is therefore necessary to know the direction of development of these processes at the research stage in order to counteract them if necessary. This impact can take several forms: reduction or even inhibition of soil microbiological activity, causing destabilisation of the organic matter circuit; leaching of organic matter in the lower part of the soil and physical degradation; siltation; dehumidification; secondary dewatering; solonisation; excess moisture (waterlogging); irrigation erosion and pollution.

Based on these forms of degradation, many researchers have expressed doubts about the need to irrigate cernozems. However, it should be considered a proper opinion that cernozems should be irrigated only if irrigation practices are improved [1]. In cernozems irrigation, special attention should be paid to irrigation water quality and regimes, as they intensify oxidation processes, which in the absence of measures of improving soil organic matter can lead to a drastic decrease in fertility potential.

The problem of maintaining soil fertility when irrigation is applied is of great importance because even the most fertile soils can become depleted in humus and other nutrients, making it impossible to ensure high crop yields.

It is therefore necessary for the methodology used in the research to have a bioindicator against which we can optimise irrigation regimes in terms of maintaining soil fertility.

1. Methods of conducting research in developing ecosystem methodologies

The surveys were carried out in soil lysimeters with disturbed structure. Soil - ordinary cernozem. Soil characteristics are shown in Table 1.

Crop - autumn wheat "Porada", variety approved in Moldova.

Observations and surveys were carried out as follows:

- soil moisture - daily;
- atmospheric precipitation;
- CO_2 concentration in the soil;

Soil moisture was measured using tensiometers installed in lysimeters at a depth of 25 cm in each lysimeter. For observations of the moisture dynamics on the profile and the nutrients added, two more tensiometers were installed at depths of 15 cm and 45 cm for one replicate of each moisture variant. As soil moisture variants the following has been established:

1 - (0,7- 0,8) CC; 2 - (0,7-0,9) CC; 3 - (0,7-1,0) CC;

4 - (0,8-0,9) CC; 5 - (0,8- 1,0) CC; 6 - (0,9-1,0) CC.

The moisture variants were chosen in such a way that the results of the research could be comparable with different maximum and minimum moisture levels and different watering norms as common factors. Repetitions - 3.

2. Results and discussions

Bioindication, according to [2] is the assessment of the state of the environment using living organisms. Since the modification of biological systems is conditioned by anthropogenic factors, 'Bioindication' when used in the amelioration research can be defined as follows: 'Bioindication' is the identification and determination of the level of anthropogenic load based on the response of the living component of the soil to it.

Such an index was chosen by soil microbiological activity which can be characterized by its intensity. That is, by measuring the concentration of carbon dioxide (CO_2) in the soil atmosphere. Thus, [3] there has been established the extent to which different soil characteristics and environmental factors can alter the CO_2 production processes in soil atmosphere and what the pathways for regulating this process may be. According to the research of these authorsthere was determined that one of the external factors may be soil moisture.

Figure 1 shows the dynamics of CO_2 production depending on the soil moisture dynamics as a result of their research.

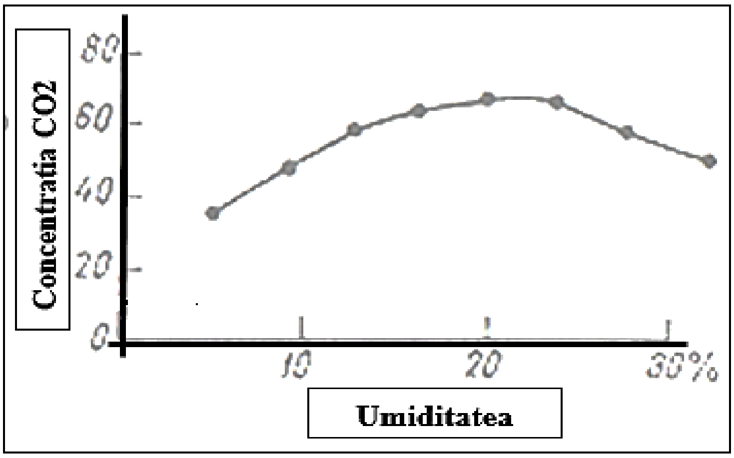


Figure 1. Dependence of CO_2 concentration in the soil atmosphere on the level of soil moisture

The figure shows that the dynamics demonstrated have a CO_2 optimum at a certain soil moisture range which is in the range of 16-24% for the soil type investigated. According to these researchers, for other soil types the optimum will be in a different moisture range.

In the same context, Moldovan researchers [4] state that «In the biogeochemical cycle, the main end product of the metabolism of many groups of soil microorganisms is CO_2 - the total indicator of the intensity of energy metabolism of all living organisms living in the soil». [5,6] show that there is a strong correlation between the amount of microorganisms in the soil, humus content (r = 0.72) and soil moisture (r = 0.82). It turns out that it is possible to use this correlation as an indicator for research and not only as a secondary result.

Thus, given that micro-organisms are the main factor on which the potential fertility of soils depends, it is logical to conclude that in order to improve fertility it is necessary to create optimal conditions for their activity. In the light of the above this means that the concentration/content of CO_2 in the soil atmosphere should be at a maximum level.

In the case of irrigation, it is necessary to maintain the moisture regime within the optimal range for the activity of soil microorganisms. But the current research methodology lacks the arsenal to directly optimise the influence of irrigation regimes on soil. Many researchers have shown this influence, but only as a by-product of research and not as a working hypothesis.

So, the soil moisture limit at which the CO_2 optimum is located (maximum level) can therefore be accepted as a biological indicator against which to carry out the moisture optimisation process. In this case, in order to confirm the hypothesis, it is necessary to fulfil the condition that the variant with maximum CO_2 production must have maximum:

1. Agricultural crop productivity.
2. Potential soil fertility, and be superior to all possible variants according to the current methodology.

In order to see the development trends of the soil microbiological system in which different moisture levels are maintained, based on the information obtained from the measurements, graphs were constructed that illustrate very well the relationships of the influence of soil moisture on soil microbiological activity. (figure 2).

From these graphs we can see, that alongside with increasing soil moisture the CO_2 production increases up to a certain moisture level. Further increases in humidity lead to an inhibition of microbial activity, a statistically proven trend. This allows us to choose the most optimal variant. We observe that the regime with maximum production is the variant 2((0.7-0.9) CC) in both cases.

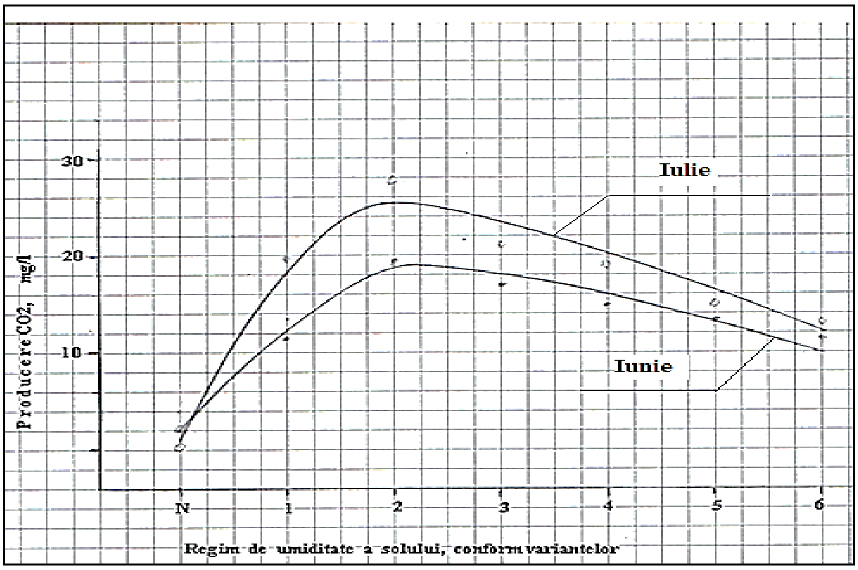
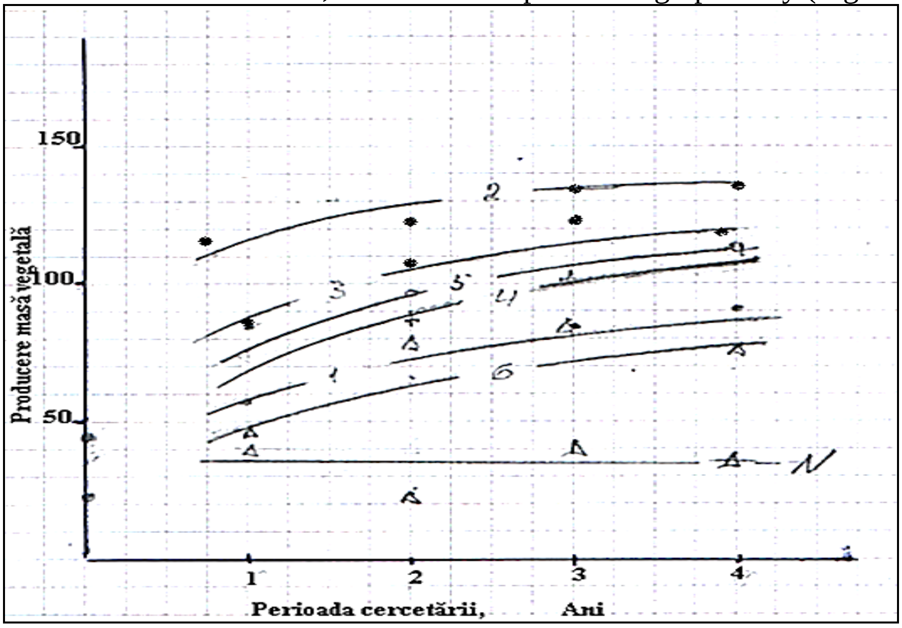


Figure 2. Dependence of CO_2 production on humidity regime

$DL_{05} = 2,23 * 0,03 = 0,07$ month 06
$DL_{05} = 2,18 * 1,8 = 3,9$ month 07

Organic mass production, according to the hypothesis, should have a maximum level in the variant with maximum activity of the soil microbial system. The results of experimental investigations of the influence of soil moisture regimes on organic mass production are presented in Table 1. For the identification of the hypothesis, the results of the investigations were statistically processed (Table 1). The table shows the cumulative experimental results after four years of research. In order to illustrate this, the results are presented graphically (Figure 3).



For regimes (A), - LED05 = 9, 3g
For time (B), - LED05 = 7, 6g

Figure 3. Trends in organic mass production as a function of moisture regime and time

In which: 1,2, are soil moisture regimes according to methods; N - natural hydrothermal regime. This figure can show us that in all the variants investigated, the production of organic mass has essentially increased in each year, with the exception of the last year where it remained at the level of the penultimate year.

The highest level of organic mass produced in moisture regime 2 - ((0.7-0.9) CC) can be observed. This regime also creates the best conditions for the development of the soil microbial system. The lowest production is observed in regimes 1 and 6, which indicate yields of the same level although regime 1 is drier and regime 6 is the wettest of all the variants.

As in the case of CO_2 production, the maximum yield is produced under the humid conditions of variant 2. Thus, under the conditions of this experiment we find that the effective fertility is higher where microbial activity is maximum (Part 2 of the identified hypothesis). But, according to the hypothesis, it is also required to establish the tendency of humus accumulation (potential fertility) depending on the moisture regimes accepted in the research.

For clarity, the results of the experiment are illustrated in graphical form (Figure 4). From the figure shown we observe the same development trend of the solification processes as in the other two cases investigated.

We observe that the humus content in the soil increases annually. The highest humus increase was identified in the moisture regime corresponding to variant 2 - ((0.7-0.9) CC). The lowest increase - regimes 4,6,1, which from a statistical point of view are at the same level (DL 05 = 0.06% according to the value determined in percentages).

An intermediate place is occupied by regime 5 ((0.8-1.0) CC). The ecosystem conditions created as a result of maintaining moisture regime 3 (currently recommended) led to a total increase in humus of about 0.31% compared to the initial level. At the same time this level is 0.49% lower than regime 2 ((0.7-0.9) CC).

For a generalization of the results in Table 1 a classification of the variants is made according to the maximum level reached as a consequence of their influence on the solification processes.

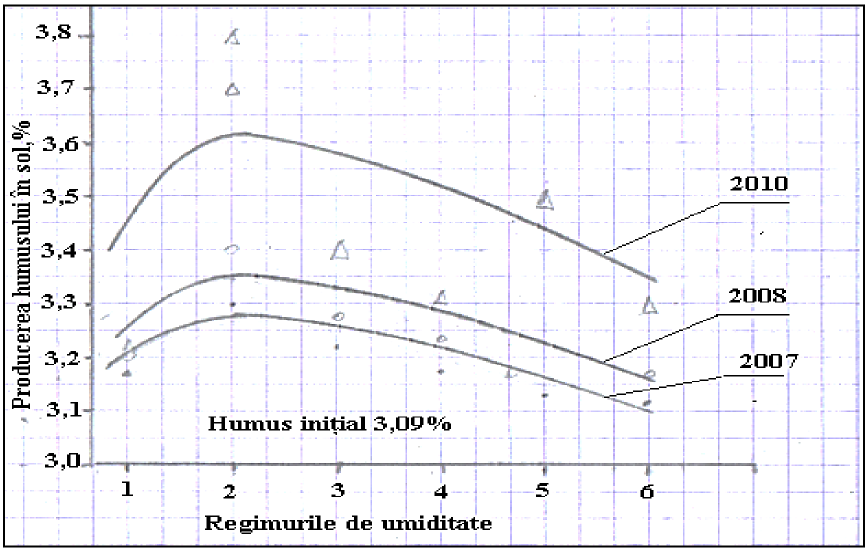


Figure 4. Dependence of humus accumulation on soil moisture regimes

The results of the experimental research from the last year are presented, in which the solification processes reached the highest level for the 4-year period. In the result of the analysis performed (Table 1) we see that the initial condition on the validity of the hypothesis is confirmed.

Table 1

Differentiation of variants according to the criteria listed for validating the new hypothesis

Variants	**CO_2 emission, mg/l DL = 3,9**	**Differentiation of variants**	**Organic matter making, g/liz DL = 9,3**	**Differentiation of variants**	**Humus making, % DL = 0,06%**	**Differentiation of variants**
(0,7-0,8)CC	19,9	II	75,6	IV	3,21	III
(0,7-0,9)CC	27,9	I	132,8	I	3,80	I
(0,7-1,0)CC	21,4	II	106,9	II	3,40	II
(0,8-0,9)CC	18,6	II	94,1	III	3,31	III
(0,8-1,0)CC	14,8	III	100,9	II	3,51	II
(0,9-1,0)CC	12,7	IV	68,9	IV	3,30	III

Conclusions

1. The initial hypothesis that CO_2 emission can be accepted as a biological indicator for optimising soil moisture regimes during irrigation is confirmed.

2. The current methodology for soil moisture research and optimisation does not meet the existing ecological requirements and diminishes the possibilities of researching the whole field of soil moisture that can be maintained in the soil.

3. It can be observed that the difference between the soil moisture variants decreases with increasing soil moisture level.

4. This method allows us to obtain:

- information on the response of micro-organisms to anthropogenic impacts, as biota react to even the smallest changes in the environment;
- regulating the burden on the ecosystem;

- the tendency for solification processes to develop, in which micro-organisms play one of the main roles.

Establishing the trend of development of solification processes by physico-chemical methods is difficult and requires long-term research because cernozomes, due to their natural specificity, have a relatively high capacity to resist changes (buffering capacity) imposed by anthropogenic impact.

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