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Mathematical Modeling of Water Regimes on Drained Lands

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***Abstract*—The model of the dynamics of the ground water level (CWL) in the area between the drains during pressure regulation in the drains in the conditions of a three-layer soil structure is proposed and implemented. Having the connection between ground water level and humidity in the aeration zone established on the basis of the conducted experiments, the issue of ensuring the necessary humidity in the aeration zone within the root system is resolved.**

As a result of the regulation of GWL in different modes (passive reduction and humidification) taking into account natural conditions, in particular, based on the received database on the amount of precipitation, the necessary parameters were obtained that characterize the water regime in the aeration zone. The analysis of the obtained results allows for establishing and proposing more effective resource-saving modes of moistening under the condition of a sufficient supply of moisture to the root layer.

In the conducted experiments, the accumulated precipitation in the active layer (0-0.6 m) of the soil in the mode of passive reduction of GWL, when an accumulative capacity for moisture retention is formed in the upper layers of the soil, was used as efficiently as possible.

***Index Terms*—model, analysis, root layer, groundwater level, humidification mode, filtering, soil, aeration zone.**

I. INTRODUCTION

The complex conditions of the functioning of reclamation systems at the present stage necessitate the development and implementation of advanced, cost-effective, environmentally safe regimes and technologies that provide for the restoration of the ecological balance of natural landscapes and water ecosystems, the reproduction of soil fertility, as well as adaptation to new socio-economic conditions, advanced technologies of agricultural production, i.e. ensuring the conditions for the transition from extensive agriculture on the reclaimed lands to intensive on the basis of the use of the latest scientific achievements and best practices [1-4].

The purpose of the paper is the mathematical modeling of the groundwater level regime and the justification of resource-saving technological parameters of water regulation on drained lands, which take into account the peculiarities of the use of moisture by cultivated agricultural crops, which allows for ensuring their reliable moisture supply on drained lands.

II. METHODS AND TECHNIQUES

Well-known Ukrainian and foreign scientists studied various aspects of regulating the water regime on drained lands [3-6]. Regulation of the water regime on drained lands is based on two main approaches [7-11].

The first of them is water balance, the easiest to implement, but very close. In modern conditions, it does not satisfy the requirements of agricultural production on drained lands, since it does not allow to correct establish the amount of water exchange between soil layers in the aeration zone and practically does not provide information about the dynamic properties of the object (parameters and type of regulatory network, hydrogeological and geological conditions, hydrophysical soil parameters, etc.).

The second is based on the wide application of mathematical modeling methods, while the moisture transfer equation is used [12]. This approach makes it possible to take into account a complex of factors that determine the moisture regime in the root layer of the soil, including the intensity and distribution of moisture absorption by cultivated crops along the depth of the root zone.

The water-air regime of the soil, which is favorable for agricultural crops, is maintained thanks to the use of various regulation technologies, which must provide for such dynamics of the groundwater level (GWL), in which favorable soil moisture is maintained in the aeration zone, and at the same time, atmospheric precipitation can be accumulated in the root layer without harmful impact of flooding of the root system of cultivated crops.

Taking into account the modern requirements for the level of substantiation of technological schemes and melioration regimes, it becomes obvious that an important approach to solving the tasks is the use of mathematical modeling based on physically based models of hydrophysical processes, which will allow taking into account the complex of natural and technical factors that affect the quality functioning of reclamation systems.

Therefore, an extremely important component of research is the schematization of natural conditions and the construction of calculated filtration schemes that reflect the most important factors in the formation of water-physical processes in real conditions[10-14].

In the process of schematization, the form and structure of the groundwater movement area are established; the presence and intensity of pressurized power supply; the nature of water exchange between saturated-unsaturated zones and the atmosphere; significance, location, and nature of the action of the main elements of the drying-humidification system; the initial and final values of the flow characteristics, which must be calculated, and their relationship with other elements of the scheme. The method of schematizing natural conditions is described in detail in [6, 15-21].

III. RESULTS AND DISCUSSION

Analysis of engineering-geological studies, that according to the geological structure, the aquifer layer of the experimental area is heterogeneous and can be reduced to a three-layer structure with a horizontal water table. The aquifer is pressureless with a free surface.

After carrying out the schematization of natural conditions, an estimated filtration scheme was built (Fig. 1). We will conduct an analysis of the Groundwater level (GWL) regime in a three-layer foundation when it is moistened as a result of raising the level to the required depth, in which case the formation of the necessary moisture regime is substantiated in the root layer.

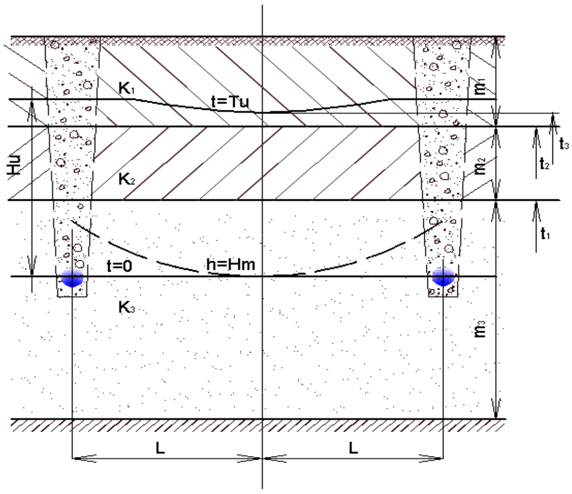


Fig. 1. Estimated filtering scheme

After the passive reduction of the GWL to the maximum depth h_m, the drainage system is switched to the humidification mode (Fig. 1). Water for humidification is supplied to the main and humidification network until a certain moment of time $t=T_u$, which must be calculated until the GWL in the middle between the drains reaches the mark $h = h_n$. In fact, the entire period of conditional release can be divided into three stages. During the first, preparatory stage, which is short in time (lasts, as a rule, several hours), the leading and regulating network is filled with water until the appropriate pressure H_u is established above the drain.

In the second stage, the level above the drain rises almost to a mark equal to the pressure in the H_u drain. At the same time, the pitted zone is saturated.

The third stage, the main one, is characterized by an intensive rise of GWL between the drains. As the results of long-term field observations in research and production conditions showed, its duration significantly exceeds the duration of the first two stages. In this regard, we assume that the level above the drain is established instantly. For the most general solution, we also assume that at the beginning of wetting, the GWL in the middle between the drains is in the third, lower layer, and the level of drainage backfill H_u=const is in the upper, first layer from the surface of the layer. The complexity of building a mathematical model of filtration in a three-layer is explained by the fact that when the GWL rises (decreases), the surface of the depression curve can be located in different layers, that is, the layer limits can be crossed at the interstices. Therefore, in the case of a three-layer base, for an approximate description of the change in GWL, we use the following level of the system, recorded with sufficient depth (Fig. 2):

$$\begin{cases} \mu_1 \frac{dh_1}{dt} = \frac{d^2 V_1}{dx^2}; \\ \mu_2 \frac{dh_2}{dt} = \frac{d^2 V_2}{dx^2}; \\ \mu_3 \frac{dh_3}{dt} = \frac{d^2 V_3}{dx^2}, \end{cases} \tag{1}$$

where

$$V_1 = \frac{k_{в_1}}{2} h_1^2;$$

$$V_2 = \frac{k_{в_2}}{2} h_2^2 + \alpha_2 h_2;$$

$$V_3 = \frac{k_{в_1}}{2} h_3^2 + \alpha_1 h_3.$$

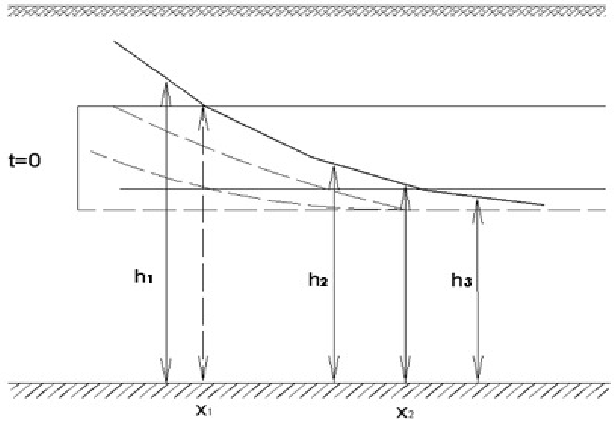


Fig. 2. Calculation scheme for determining the parameters of the humidification mode

The coefficients α_2 and α_1 (auxiliary parameters) are determined by the expressions:

$$\alpha_2 = (k_{в_3} - k_{в_2}) m_3; \quad \alpha_1 = k_{в_2} m_1 + k_{в_3} m_3 - k_{в_1}(m_2 + m_3).$$

In addition, in the written system of equations (1) h_i - the level of groundwater within the i-th layer of the soil (Fig. 2), and μ_i - the coefficients of the averaged total lack of saturation of the i-th layer.

The initial and limit conditions of the problem are as follows:

$$t = 0;\ h_1^0 = H_m \tag{2}$$

$$x = L;\ \frac{dh_1}{dx} = 0 \tag{3}$$

$$x = x_1;\ k_{в_1} \frac{dh_1}{dx} = k_{в_2} \frac{dh_2}{dx};\ h_1 = h_2 \tag{4}$$

$$x = x_2;\ k_{в_2} \frac{dh_2}{dx} = k_{в_3} \frac{dh_3}{dx};\ h_2 = h_3 \tag{5}$$

$$x = 0;\ V_3 - 2\phi \frac{dV_3}{dx} = \frac{k_{в_1}}{2} H_u + \alpha_1 H_u \tag{6}$$

In the limit condition (6), the value ϕ is the filtration resistance of the drain. Other parameter values not given are clear from the corresponding figures.

Using the results of works [3], in the first approximation, instead of the system of equations (1), we have the following system:

$$\begin{cases} \mu_1 \frac{dh_1^{(0)}}{dt} = \frac{d^2V_1}{dx^2}; \\ \mu_2 \frac{dh_2^{(0)}}{dt} = \frac{d^2V_2}{dx^2}; \\ \mu_3 \frac{dh_3^{(0)}}{dt} = \frac{d^2V_3}{dx^2}, \end{cases} \tag{7}$$

where

$$h_i^{(0)} = h_i(L, t).$$

After the transformations of equations (1) – (6), the problem is reduced to finding the change in the groundwater level between the drains, which is the main thing in solving the given problem. The solution to this problem allows establishing the dynamics of the GWL in the middle between the drain lines within each s -th layer:

$$t = \mu_3(L^2 + 4L\phi) R_s(h_1^{(0)}) \tag{8}$$

The variable parameter R_s is generally determined by the dependence:

$$\begin{cases} \frac{1}{\sqrt{\delta_s}}\left(\varphi_s - arctg \frac{k_{в_s} h_1^{(0)} + \alpha_s}{\sqrt{\delta_s}}\right) \\ at\ \delta_s = -k_{в_3} V_3 - \alpha_s^2 > 0; \\ \frac{1}{k_{в_s} h_1^{(0)} + \alpha_s} - \frac{1}{k_{в_s} m + \alpha_s} \\ at\ \delta_s = 0; \\ \frac{1}{2\sqrt{-\delta_s}} \ln\left(\Psi_s \frac{\alpha_s + \sqrt{-\delta_s} + k_{в_s} h_1^{(0)}}{\alpha_s - \sqrt{-\delta_s} + k_{в_s} h_1^{(0)}}\right) at\ \delta_s < 0, \end{cases} \tag{9}$$

where

$V_3 = k_{в_1} H_u^2 + 2\alpha_1 H_u + \sum_{i=s}^{2} (k_{в_{i-1}} - k_{в_i}) \mu_i^2$ - the layer with the number s will be completely saturated at the moment t^* of contact of the free surface between the drains on the limit s and $s-1$ the layers. The named point in time is defined by the expression:

$$t^* = \mu_s(L^2 + 4L\phi) R_s(\mu_s), \tag{10}$$

where $R_s(\mu_s)$ is determined by dependence (9) at :

$$h_1^{(0)} = \mu_2.$$

In the case of a three-layer layer, the time for the groundwater level to rise to the border of the second and third layers is determined by the dependence:

$$t_1 = \mu_3(L^2 + 4L\phi) R_1, \tag{11}$$

where $R_1 = \frac{1}{2\omega_1} ln \frac{k_{в_3} m - \omega_1}{k_{в_3} m + \omega_1} \cdot \frac{k_{в_3} m + \omega_1}{k_{в_3} m - \omega_1};$

$$\omega_1 = \sqrt{k_{в_3} \begin{bmatrix} k_{в_1} H_u^2 + 2\alpha_1 H_u + (k_{в_1} - k_{в_2}) * \\ * (m_2 + m_3)^2 + (k_{в_2} - k_{в_3}) m_3^2 \end{bmatrix}};$$

$$\alpha_1 = k_{в_2} m_2 + k_{в_3} m_3 - k_{в_1}(m_2 + m_3);$$

$$\mu_3 = \xi_1 \frac{(\mu - m)^{\xi_1+1} - (m_2 + m_3 - m)^{\xi_1+1} - (m_1 + m_2)^{\xi_1+1} + m_2^{\xi_1+1}}{m_3 - m} + \\ + \xi_2 \frac{(m_2 + m_3 - m)^{\xi_2+1} - (m_3 - m)^{\xi_2+1} - m_2^{\xi_2+1}}{m_3 - m} \\ + \xi_3 (m_3 - m)^{\xi_3}.$$

The coefficient of the lack of saturation μ_3 when the GWL rises to the border of the second and third layers (and for further calculations) is determined by the linear expression for the current lack of saturation:

$$\mu_i = \xi_i h^{\xi}, , \tag{12}$$

where for peat soils: $\xi = 0{,}116 k_в^{0{,}375}$, $\zeta = 0{,}75$ [8]; for mineral soils: $\xi = 0{,}056 k_в^{0{,}5}$, $\zeta = 0{,}33$ [7]; for the conditions of drained and irrigated lands of Ukraine $\zeta = 0{,}5$, ξ is determined depending on the type of soil [6].

The duration of the GWL rise from the lower boundary of the layer interface (third and second) to the upper boundary of the layer interface (second and first) t_2 is determined by the expression:

$$t_2 = \mu_2(L^2 + 4L\phi) R_2, \tag{13}$$

where

$$R_2 = \frac{1}{2\omega_2} \ln\left(\frac{k_{в_2} m_3 - \omega_2 + \alpha_2}{k_{в_2} m_3 + \omega_2 + \alpha_2} \cdot \frac{k_{в_2}(m_2 + m_3) + \omega_2 + \alpha_2}{k_{в_2}(m_2 + m_3) - \omega_2 + \alpha_2}\right),$$

$$\omega_2 \sqrt{k_{в_2} \beta + \alpha_2^2},$$

$$\beta = k_{в_1} H_u^2 + 2\alpha_1 H_u + (k_{в_1} - k_{в_2})(m_1 + m_2)^2,$$

$$\alpha_2 = (k_{в_3} - k_{в_2}) m_3,$$

$$\mu_2 = \xi_1 \frac{(m_1 + m_2)^{\xi_1+1} - m_2^{\xi_1+1} - m_1^{\xi_1+1}}{m_2 - m_1} + \xi_2 m_2^{\xi_2}.$$

The duration of the rise of GWL in the upper layer of the soil to the mark is determined by the expression:

$$t_3 = \mu_1(L^2 + 4L\phi)R_1, \quad (14)$$

where

$$R_1 = \frac{1}{2T_2^*}\ln\left(\frac{H_u - m_2 - m_3}{T + T_2^*} \cdot \frac{T_2 + T_2^* - k_{в_1}H_N}{H_u - m_1 - m_2 - m_3 + H_N}\right);$$

$$T = k_{в_1}m_3 + k_{в_2}m_3 + k_{в_3}m_3;$$

$$T_2^* = k_{в_1}(H_u + m_2 - m_3) + k_{в_2}m_2 + k_{в_3}m_3;$$

$$T_2 = k_{в_1}m_1 + k_{в_2}m_2 + k_{в_3}m_3;$$

$$\mu_1 = \xi_1\frac{m_1^{\xi_1+1} - H_N^{\xi_1+1}}{m_1 - H_N}.$$

The total duration of the rise of GWL T_u is determined as the sum according to the expression:

$$T_u = t_1 + t_2 + t_3 \quad (15)$$

Thus, the obtained expressions (11) - (15) allow calculating the duration of the rise of the GWL T_u to a given mark during humidification, upon reaching which the supply of water to the conducting and regulating network is stopped. The drying-humidification network is switched to passive mode, which excludes, except for the urgent need during the period of torrential rains, the discharge of water outside the reclamation area.

According to functional characteristics, information support is divided into six blocks. In the first three blocks (meteorological, soil, biological) regulatory and reference information is formed. Filtration and hydrophysical characteristics, including total and minimum moisture capacity, which are formed in the soil block, are determined based on existing reference data and, if necessary, supplemented with field determinations. The necessary data for calculations related to the growth characteristics of specific crops and their water consumption are contained in the biological block. In particular, in this block, averaged data from the leaf index, the power of the root system of cultivated crops according to the phases of their development, and the function of the distribution of moisture absorption by the depth of the aeration zone is formed.

Operational information (the next three blocks) about the actual parameters of water regime regulation (actual GWL for the previous decade and soil moisture), plant growth parameters, and current meteorological parameters are formed based on the results of monitoring the production process on the reclaimed field.

Implementation of the obtained results of theoretical studies of the experimental site of the "Ikva" polder system

Analyzing the weather conditions of the growing season of 2022, it is possible to note a fairly uneven distribution of precipitation, the presence of long periods without rain with extreme values of temperature and air humidity deficit, and unfavorable conditions for growing crops, which also confirm the results of observations of biometric characteristics.

To determine the optimal modes of moistening, taking into account the patterns of moisture absorption by the root system, we used data obtained in the conditions of the experimental site with the help of a field tensiometry device.

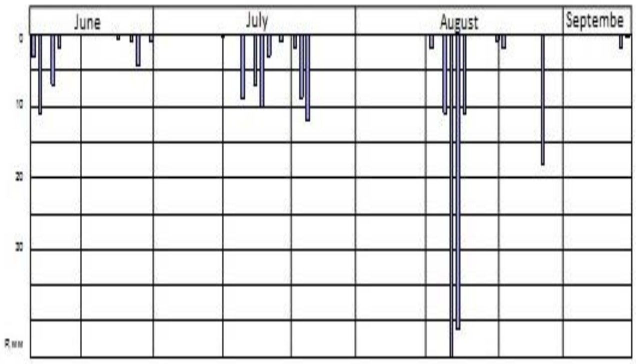
The technological parameters that characterize the process of subsoil moistening (draining) and all characteristics related to the regulation of the water regime are listed in Table 1.

TABLE I. INITIAL TECHNOLOGICAL PARAMETERS DURING THE IMPLEMENTATION OF RESOURCE-SAVING MODES OF HUMIDIFICATION IN THE EXPERIMENTAL AREA OF THE POLDER SYSTEM "IKVA"

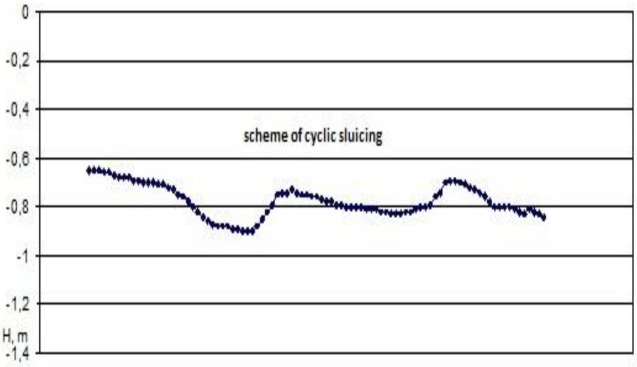
<table>
<tr><td colspan="7">Remedial regime</td></tr>
<tr><td colspan="2">Start of passive reduction of GWL</td><td colspan="3">Transition from drying mode to humidification mode</td><td colspan="2">End of humidification mode</td></tr>
<tr><td colspan="7">Implementation date</td></tr>
<tr><td colspan="2">19.06.2022</td><td colspan="3">12.08.2022</td><td colspan="2">4.09.2022</td></tr>
<tr><td colspan="4">The duration of GWL reduction - 53 days</td><td colspan="3">The duration of hydration - 23 days</td></tr>
<tr><td colspan="7">Amount of precipitation, mm</td></tr>
<tr><td colspan="4">73.1</td><td colspan="3">117.9</td></tr>
<tr><td colspan="7">Groundwater level, m</td></tr>
<tr><td colspan="2">Initial</td><td colspan="3">Maximum</td><td colspan="2">Final</td></tr>
<tr><td colspan="2">0.94</td><td colspan="3">1.26</td><td colspan="2">0.91</td></tr>
<tr><td colspan="7">Soil moisture, in parts by volume</td></tr>
<tr><td>In the layer</td><td colspan="2">19.06.2022</td><td colspan="2">12.08.2022</td><td colspan="2">4.09.2022</td></tr>
<tr><td>0 – 0.1 м</td><td colspan="2">0.43</td><td colspan="2">0.41</td><td colspan="2">0.43</td></tr>
<tr><td>0.1 – 0.2</td><td colspan="2">0.44</td><td colspan="2">0.41</td><td colspan="2">0.42</td></tr>
<tr><td>0.2 – 0.3</td><td colspan="2">0.40</td><td colspan="2">0.38</td><td colspan="2">0.40</td></tr>
<tr><td>0.3 – 0.4</td><td colspan="2">0.40</td><td colspan="2">0.38</td><td colspan="2">0.40</td></tr>
<tr><td>0.4 – 0.5</td><td colspan="2">0.40</td><td colspan="2">0.38</td><td colspan="2">0.41</td></tr>
<tr><td>0.5 – 0.6</td><td colspan="2">0.41</td><td colspan="2">0.40</td><td colspan="2">0.41</td></tr>
<tr><td colspan="7">Soil moisture in the zone of maximum moisture absorption by the root system, in fractions of the volume</td></tr>
<tr><td colspan="2">0.42</td><td colspan="3">0.40</td><td colspan="2">0.42</td></tr>
<tr><td colspan="7">Leaf surface index / grass stand height, m</td></tr>
<tr><td colspan="2">0.82/0.15</td><td colspan="3">2.98/0.50</td><td colspan="2">5.4/0.65</td></tr>
<tr><td colspan="7">Average long-term experimental values of total evaporation (E, mm) for perennial grasses and atmospheric precipitation (P, mm)</td></tr>
<tr><td rowspan="3">Month</td><td colspan="6">Decade</td></tr>
<tr><td colspan="2">1</td><td colspan="2">2</td><td colspan="2">3</td></tr>
<tr><td>E</td><td>P</td><td>E</td><td>P</td><td>E</td><td>P</td></tr>
<tr><td>June</td><td>28.5</td><td>79.5</td><td>25.9</td><td>20.0</td><td>18.1</td><td>7.0</td></tr>
<tr><td>July</td><td>24.5</td><td>0.30</td><td>36.2</td><td>32.0</td><td>45.7</td><td>20.8</td></tr>
<tr><td>August</td><td>27.6</td><td>2.00</td><td>15.6</td><td>108.9</td><td>33.7</td><td>20.0</td></tr>
<tr><td>September</td><td>19.9</td><td>2.30</td><td>19.4</td><td>35.0</td><td>15.5</td><td>13.0</td></tr>
</table>

Perennial grasses were grown on the experimental site of the "Ikva" polder system. The first cut was made on June 18. The height of the grasses on the first slope was 0.66 m, and the leaf index was 3.66. As can be seen from the table, the growth dynamics of perennial grasses of the second slope are characterized by the following indicators of the leaf index:

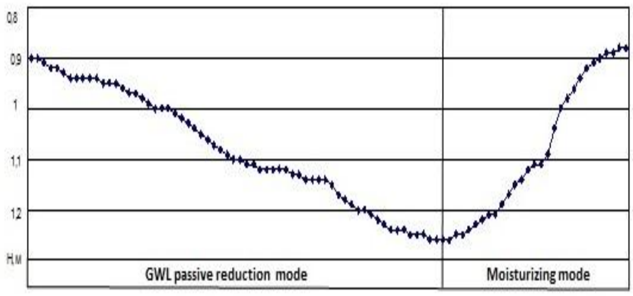
0.82 – for the first decade of growth; 2.98 – at the end of the cycle of passive reduction of GWL and 5.4 – at the moment of the second slope. In 2012, the herb yield of the second cutting was higher compared to the first cutting (18.5 and 27.5 t/ha, respectively).



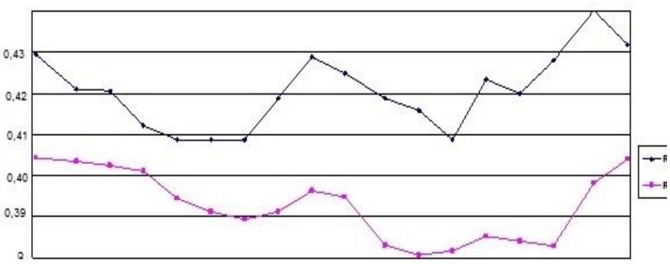
a)



b)



c)



d)

Fig. 3. Rainfall dynamics (a); groundwater level in the case of the cyclic sluicing scheme and the implementation of the developed regimes (b, c); average soil moisture by pentads, in fractions of the soil volume (Row 1 – in the layer of maximum moisture absorption (0–0.2 m), Row 2 – in the layer 0.3–0.6 m) in the growing season of 2012, "Ikva" polder system (d).

The initial GWL (for the period of approbation) was at a depth of 0.7 m, and the soil moisture in the zone of the most intense absorption of moisture by the root system (at a depth of 0.15–0.25 m) was 0.42 (in fractions of the soil volume).

The period of field research on the dynamics of GWL and soil moisture is divided into two stages. The first stage corresponds to the cycle of passive reduction of GWL, when due to a small amount of precipitation for 53 days, as well as evaporation and transpiration of cultivated perennial grasses, GWL decreases to the maximum possible - 1.26 m (Fig. 3). This period continued until August 12.

The end of the cycle of passive reduction of GWL under the action of evaporation and transpiration and the beginning of moistening was determined by soil moisture in the zone of its maximum absorption by the root system of perennial grasses at a depth of 0.15 - 0.25 m. When the moisture in a given soil layer decreases to the lower limit of its optimal value, which is established according to the recommendations [8], the first cycle (passive reduction of GWL ended and the drainage system was switched to the humidification mode. The value of groundwater pressure, respectively, was 3.23 kPa, which corresponds to the lowest soil moisture content of 0.38 (in parts of the soil volume). The position of the 1.26 m water well corresponds to the mentioned moment. According to traditional technology, the water wells were maintained at a depth of 0.7 - 0.9m.

The dynamics of the average humidity by pentads in the layer 0 - 0.2 m (Row 1), where the maximum absorption of moisture by the roots of cultivated perennial grasses is observed, and in the layer, 0.3 - 0.6 m (Row 2) during the growing season of 2022 is given in Fig. 3. Obtained plots of moisture distribution in the root zone during the experiment (Fig. 3).

The results of the analysis showed that during the implementation of the developed moistening regimes on the experimental site of the Ikva polder system throughout the cycle of passive reduction of GWL, the soil moisture in the root layer was within the optimal range. At the same time, the criterion of a sufficient supply of moisture was the condition of its maintenance within the necessary limits in the zone of maximum absorption of moisture by the roots of perennial grasses. The maximum efficiency of this technological scheme of water regulation was achieved precisely in the mode of passive reduction of GWL, when an accumulative capacity was formed in the upper layers of the soil to retain moisture from precipitation.

On August 12 (Fig. 4), the second cycle of implementation of the developed water regulation regimes began, when the drainage system was transferred to the humidification mode by supplying water to the collector and drainage network to ensure the necessary pressure. A significant amount of precipitation (117.9 mm) falls during this period, which is 30% of the total amount of precipitation during the growing season.

In the process of moistening, the soil moisture gradually increased. During the periods of rainfall, a sharp increase was observed, especially rapidly in the upper layer (0-0.20 cm). Atmospheric precipitation contributed to the acceleration of soil moisture equalization to its initial values in the depth of the aeration zone.

The analysis of field studies of the dynamics of soil moisture and GWL in the experimental area during the implementation of the developed water regulation regimes showed that even in the presence of a long dry period, which occurred during a passive decrease of GWL, soil moisture in the zone of its maximum absorption and in general in the active layer was maintained in the recommended range is long enough (53 days) even with a relatively small amount of precipitation (73.1 mm). Accumulated precipitation in the active layer (0-0.6 m) of the soil was used as efficiently as possible.

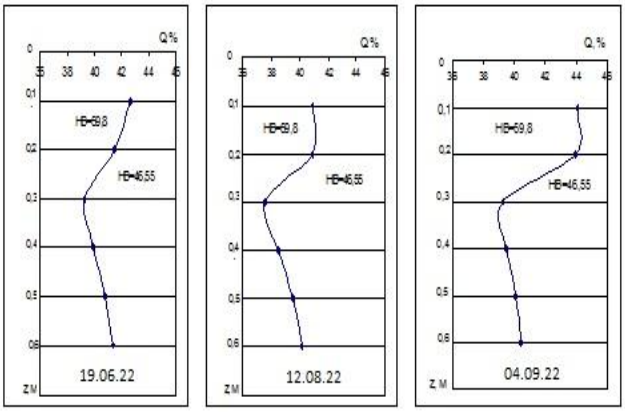


Fig.4. Plots of moisture distribution in the aeration zone during water regulation under experimental conditions at the experimental site of the “Ikva” polder system.

CONCLUSIONS

A mathematical model of the dynamics of GWL in the area between the drains during pressure regulation in the drains in the conditions of a three-layer soil structure is proposed and implemented. Having the connection between GWL and humidity in the aeration zone established based on the conducted experiments, the issue of ensuring the necessary humidity in the aeration zone within the root system is resolved.

As a result of the regulation of GWL in different modes (passive reduction and humidification) taking into account natural conditions, in particular, based on the received database on the amount of precipitation, the necessary parameters were obtained that characterize the water regime in the aeration zone. The analysis of the obtained results allows for establishing and proposing more effective resource-saving modes of moistening under the condition of a sufficient supply of moisture to the root layer. In the conducted experiments, the accumulated precipitation in the active layer (0-0.6 m) of the soil in the mode of passive reduction of GWL, when an accumulative capacity for moisture retention is formed in the upper layers of the soil, was used as efficiently as possible.

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