SIMULATION OF WATER-SALT DYNAMICS OF SOIL ROOTS, SUBSOIL AND SUBSOIL LAYERS

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Annotation

In the article, the creation of a mathematical model of the process of water-salt exchange during the cultivation of cotton on soils prone to salinization due to the growing shortage of irrigation water.

Key words: Water deficit, water resources, technology, water conservation, water-salt, mathematical model.

One of the unique aspects of the 21st century is the rapid growth of water consumption in various aspects of the national economy. Irrigated farming is taking the first place in this field. Moisture resources, soil fertility, and applied agrotechnics determine the natural biological productivity in different natural and climatic conditions of the world.« The introduction of computer technology as a tool for rapid calculation of physical processes occurring in the "soil-water-plant" system allows to predict the productivity of agro-ecosystems in a short period of time based on mathematical modeling.

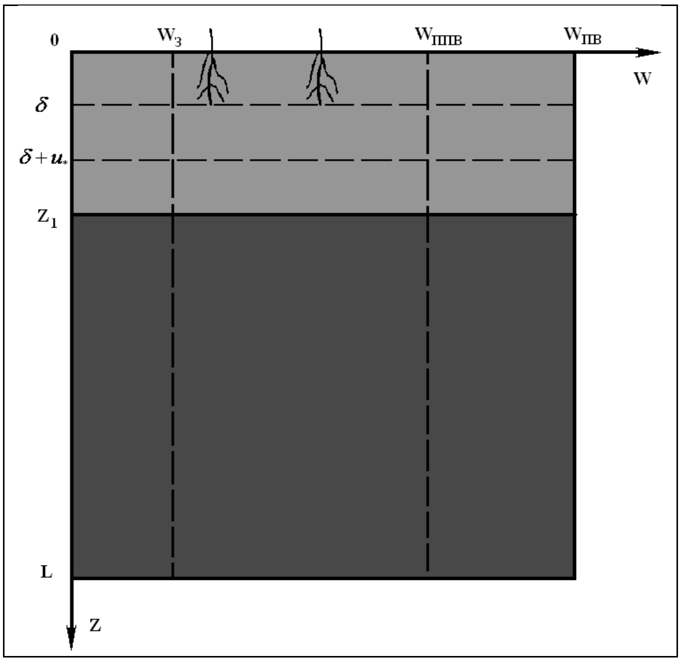

Figure 1 Schematic section of soil $0 \leq Z \leq \delta+u$ – root layer; $0 \leq Z \leq Z_1$ – arable layer; $Z_1 \leq Z \leq L$ - plowed sub-layer

The limitation of water resources is increasingly demanding science-based methods that predict changes in humidity, taking into account the applied agrotechnical and reclamation measures. The summation of works aimed at prevention of irrigation water deficiency and drought prevention and the accuracy of external countermeasures depend on accurate and reliable prediction of moisture dynamics of the irrigated area. In this article, WZ humidity to WPV. changes in volumetric humidity up to relative absolute humidity were calculated. If the cross-section of the medium under consideration (Fig. 1) consists of three layers: the root layer, the arable layer and the arable sub-layer, the moisture migration is expressed by the following equation[1, 2, 3]:

$$\begin{cases} \dfrac{d}{dz}\left[D_1(W_1)\dfrac{dW_1}{dz}\right]-\dfrac{dK_1}{dz}-\dfrac{12E_T}{7(\delta+u_*)}\left[1-\dfrac{z}{2(\delta+u_*)}-\dfrac{z^2}{2(\delta+u_*)^2}\right]=0, & (0\le z\le\delta+u_*) \\ \dfrac{d}{dz}\left[D_1^*(W_1^*)\dfrac{dW_1^*}{dz}\right]-\dfrac{dK_1^*}{dz}=0, & (\delta+u_*\le z\le z_1) \\ \dfrac{d}{dz}\left[D_2(W_2)\dfrac{dW_2}{dz}\right]-\dfrac{dK_2}{dz}=0, & (z_1\le z\le L) \end{cases}$$

(1.1)

$$W_1(z)\big|_{Z=0}=W_{IIP}=const\;; \qquad (1.2)$$

$$W_1(\delta+u_*)=W_1^*(\delta+u_*);$$

$$\left[K_1(W_1)-D_1(W_1)\frac{dW_1}{dz}\right]_{Z=\delta+u_*}=\left[K_1^*(W_1^*)-D_1^*(W_1^*)\frac{dW_1^*}{dz}\right]_{Z=\delta+u_*}; \qquad (1.3)$$

$$W_1^*(z_1)=W_2(z_1) \qquad (1.4)$$

$$\left[K_1^*(W_1^*)-D_1^*(W_1^*)\frac{dW_1^*}{dz}\right]_{Z=Z_1}=\left[K_2(W_2)-D_2(W_2)\frac{dW_2}{dz}\right]_{Z=Z_1} \qquad (1.5)$$

$$W_2(L)=W_{IIB}=const \qquad (1.6)$$

W_1, W_2 – volumetric humidity; moisture transfer coefficients are accepted in the following form:

$$K_1(W_1)=A_1e^{A_2z};\qquad K_1^*(W_1^*)=A_1^*e^{A_1^*z};\qquad K_2(W_2)=B_1e^{B_2z};$$

Instead of diffusivity coefficients, their average values were used

$$D_1(W_1)=D_1=const\qquad D_1^*(W_1^*)=D_1^*=const\qquad D_2(W_2)=D_2=const\,;$$

δ– the depth of the root system; δ +u* is the depth at which plant roots can absorb moisture; Z_1- granitic medu pahotnym and subpahotnym layer; W_{pr} - some intermediate moisture content between the moisture content of W_3 and the boundary moisture content Wppv, i.e.

$$W_3<W_{pr}<Wppv\;;$$

L - the depth of the underground water level; Wpv - total moisture capacity; Z - a vertical coordinate pointing down from the earth's surface [4].

Here the following condition is fulfilled

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$$\frac{12E_T}{7(\delta+u_*)}\int_0^{\delta+u_*}\left[1-\frac{z}{2(\delta+u_*)}-\frac{z^2}{2(\delta+u_*)^2}\right]dz=E_T$$

In this case, it should be taken into account that the volumetric moisture in the plowed layer can only be in the following inequality

$W_3 \le W \le W_{ppv}$,

here, e W_3 – humidity; W_{PPV} – the limit of field humidity.(1) Integrating each equation of the system of equations twice, we form the following expression:

$$\frac{dW_1}{dz}-\frac{A_1}{D_1}e^{A_2Z}-\frac{A_5}{D_1}\left[z-\frac{z^2}{4(\delta+u_*)}-\frac{z^3}{6(\delta+u_*)^2}\right]=C_5\,, \qquad (1.7)$$

here $$A_5=\frac{12E_T}{7D_1(\delta+u_*)},$$

$$W_1(z)=\frac{A_1}{A_2D_1}e^{A_2Z}-\frac{A_5}{D_1}\left[\frac{z^2}{2}-\frac{z^3}{12(\delta+u_*)}-\frac{z^4}{24(\delta+u_*)^2}\right]+C_5z+C_6 \qquad (1.8)$$

(1) Interpolating the second and third equations of the system of equations, we form the following expression:

$$\frac{dW_1^*}{dz}-\frac{A_1^*}{D_1^*}e^{A_2^*Z}=C_7 \quad \text{или} \quad W_1^*(z)=\frac{A_1^*}{A_2^*D_1^*}e^{A_2^*Z}+C_7z+C_8 \qquad (1.9)$$

$$\frac{dW_2}{dz}=\frac{B_1}{D_2}e^{B_2Z}+C_9\,, \qquad W_2(z)=\frac{B_1}{B_2D_2}e^{B_2Z}+C_9z+C_{10} \qquad (1.10)$$

Given the boundary conditions, we determine S5, S6, S7, S8, S9 and S10:

$$C_5=\frac{D_1^*D_2\Phi}{P} \qquad C_6=W_{\varPi P}-\frac{A_1}{A_2D_1} \qquad C_7=\frac{D_1D_2\Phi}{P}+\frac{7A_5U}{12D_1^*},$$

$$C_8=W_{\varPi P}+\frac{A_1}{A_2D_1}\left[e^{A_2U}-1\right]-\frac{3A_5U^2}{8D_1}-\frac{A_1^*}{A_2^*D_1^*}e^{A_2^*U}+U\left[D_2\left(D_1^*-D_1\right)\frac{\Phi}{P}-\frac{7A_5U}{12D_1^*}\right]$$

$$C_9=\frac{D_1D_1^*\Phi}{P}+\frac{7A_5U}{12D_2} \qquad C_{10}=W_{\varPi B}-\frac{B_1}{B_2D_2}e^{B_2L}-L\left[D_1D_1^*\frac{\Phi}{P}+\frac{7A_5U}{12D_2}\right] \qquad (1.11)$$

here $U=\delta+u_*$ $\qquad$ $P=D_1D_2\left(z_1-U\right)+D_1^*D_2U+D_1^*D_1\left(L-z_1\right)$

$$\Phi=W_{\varPi B}-W_{\varPi P}-\frac{B_1}{B_2D_2}\left[e^{B_2L}-e^{B_2Z_1}\right]-\frac{A_1^*}{A_2^*D_1^*}\left[e^{A_2^*Z_1}-e^{A_2^*U}\right]-\frac{A_1}{A_2D_1}\left[e^{A_2U}-1\right]+$$
$$+\frac{3A_5U^2}{8D_1}-\frac{7A_5U}{12D_1}\left[\frac{z_1-U}{D_1^*}-\frac{L-z_1}{D_2}\right] \qquad (1.12)$$

Substituting all the derivative constants found into $C_j=\left(j=\overline{5,10}\right)$, we determine the volume moisture distribution as a function of depth:

$$W_1(z)=W_{\varPi P}+\frac{A_1}{A_2D_1}\left[e^{A_2Z}-1\right]+\frac{A_5z^2}{D_1}\left[\frac{1}{2}-\frac{z}{12U}-\frac{z^2}{24U^2}\right]+D_1^*D_2\frac{\Phi}{P}z$$

$0 \le z \le \delta + u_*$

$$W_1^*(z) = \frac{A_1^*}{A_2^* D_1^*}\left[e^{A_2^* Z} - e^{A_2^*(\delta+u_*)}\right] + z\left[D_1 D_2 \frac{\Phi}{P} + \frac{7A_5(\delta+u_*)}{12D_1^*}\right] + \frac{A_1}{A_2 D_1}\left(e^{A_2(\delta+u_*)} - 1\right) +$$

$$+W_{\Pi P} - \frac{3A_5}{8D_1}(\delta+u_*)^2 + \left[\left(D_1^* - D_1\right)D_2 \frac{\Phi}{P} - \frac{7A_5(\delta+u_*)}{12D_1^*}\right](\delta+u_*) \quad ; \quad (1.13)$$

$\delta + u_* \le z \le z_1$

$$W_2(z) = W_{\Pi B} - \frac{B_1}{B_2 D_2}\left(e^{B_2 L} - e^{B_2 Z}\right) + (L-z)\left[D_1 D_1^* \frac{\Phi}{P} + \frac{7A_5(\delta+u_*)}{12D_2}\right]$$

$z_1 \le z \le L$

Figure 2 shows the above equation graphically

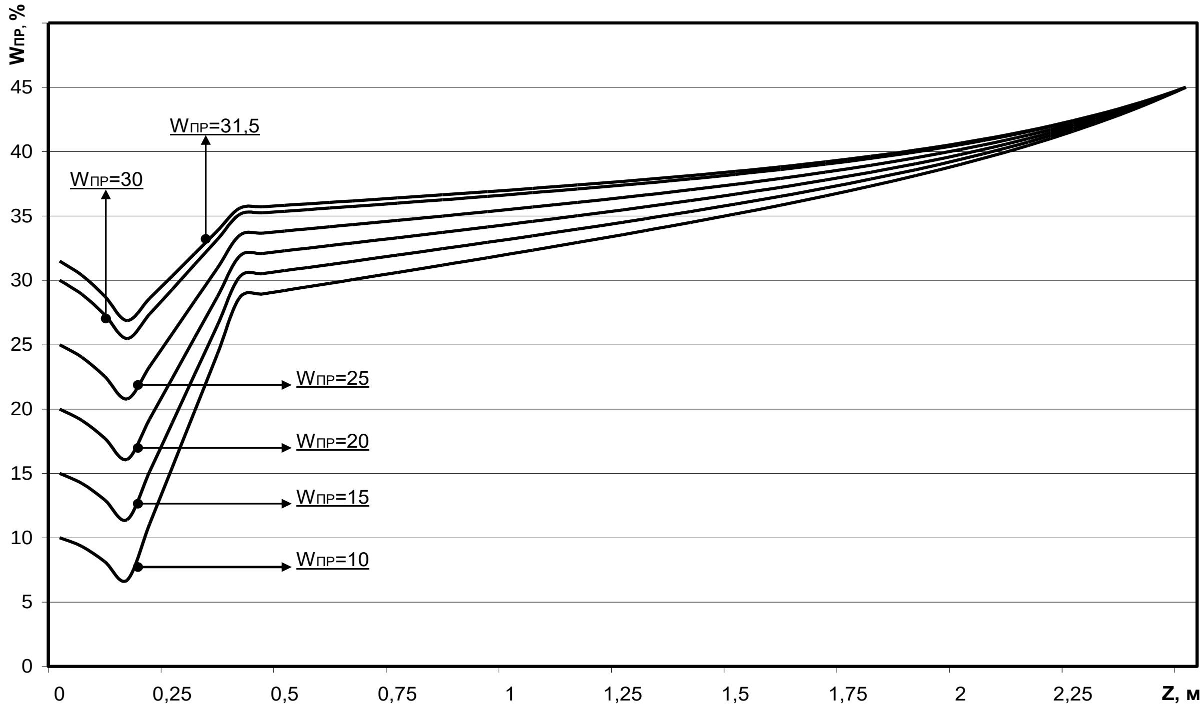

Figure 2. Graph of the equation $W_{PR} = f(z)$ for desert conditions (Syrdarya region, Mirzaabad district) $(\delta + u_*)$ =0.15 m, Z_1=0.4 m.

As the analysis of graph indicators shows, the conducted theoretical studies have reliable similarities with the natural data of these processes. The developed moisture transport models are suitable for three-layered environments and take into account soil porosity, groundwater level, and infiltration and transpiration. Authors' comparison of theoretical results with experimental data made it possible to clarify the parameters of equations (1,3). The results are presented in the table below.

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coefficients of mathematical models.

1.1- Table

The location of the object		Lower Chirchik region	Zomin	Mirzaabad district	Kattakorgon	Nishan district	Kumkorgon district	Kuva District	Sardoba District
SIU		Sayram water	Winner water	Yangi abad	Madatsuv-JRK	Triangle	N. Mirzaev	Akbarabad	G'. Ghulam
Mechanical composition		Sandy	Heavy sand	Heavy sand	Heavy sand	Medium grainy	Medium grainy	Lightly creamy	Lightly creamy
Equation coefficients	A_1	$9.39 \cdot 10^{-4}$	$3.29 \cdot 10^{-4}$	$2.18 \cdot 10^{-4}$	$2.023 \cdot 10^{-4}$	$5.44 \cdot 10^{-4}$	$2.31 \cdot 10^{-4}$	$3.64 \cdot 10^{-3}$	$3.32 \cdot 10^{-3}$
	A_1^*	$7.83 \cdot 10^{-4}$	$4.51 \cdot 10^{-4}$	$7.34 \cdot 10^{-5}$	$2.21 \cdot 10^{-4}$	$1.08 \cdot 10^{-4}$	$9.28 \cdot 10^{-5}$	$4.28 \cdot 10^{-3}$	$3.68 \cdot 10^{-3}$
	A_2	1,94	2.01	1.73	1.56	2,23	2,4	2,31	2,2
	A_2^*	1,94	1.49	1.57	1.84	2,73	2,65	2,44	2,1
	B_1	$2.7 \cdot 10^{-3}$	$4.6 \cdot 10^{-4}$	$3.44 \cdot 10^{-4}$	$1.66 \cdot 10^{-4}$	$2.27 \cdot 10^{-4}$	$1.52 \cdot 10^{-4}$	$5.17 \cdot 10^{-3}$	$3.71 \cdot 10^{-3}$
	B_2	1,562	2.31	2.517	2.44	2,43	2,65	1,828	2,088
	D_1	0.005	0.0037	0.0044	0.0052	$6.85 \cdot 10^{-3}$	$5.5 \cdot 10^{-3}$	$3.98 \cdot 10^{-3}$	0.003
	D_1^*	0.0011	0.00086	0.00093	0.0012	$1{,}05 \cdot 10^{-3}$	$9{,}5 \cdot 10^{-4}$	$4.81 \cdot 10^{-4}$	0.0005
	D_2	0.022	0.01	0.017	0.023	$12{,}4 \cdot 10^{-3}$	$19{,}1 \cdot 10^{-3}$	$6.84 \cdot 10^{-3}$	0.008

The obtained information provides the means of optimal determination of the completeness of the soil step by step. direct, complete. The information in the table shows that volume reduction affects settlement, horizontal renaissance, and access to the mechanical structure of the soil. The large difference between the coefficients of the same type of soil is explained by both chemical composition and climatic conditions.

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