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Study of soil watering processes in aeration zone with lysimeters in irrigation

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ABSTRACT: The article presents the results of lysimetric experiments on moderately saline soils with medium and light mechanical composition. The optimal irrigation regime and the total water consumption of cotton variety "Bukhara-6" were established on the basis of measurements of humidity in the aeration zone, the balance equation in the process of irrigation on lysimeters. The methods of managing the water-salt regime of the soil are substantiated.

KEY WORDS: salinity, irrigation regime, chemical ameliorants, humidity, water consumption, transpiration

I. INTRODUCTION

The main method of irrigation in the arid zone is the technology of surface irrigation, especially irrigation through furrows. However, traditional methods of irrigated irrigation have, first of all, significant shortcomings in the uniformity of soil moisture along the length of the irrigated. Although the scientific basis of irrigation technology has improved, many other aspects of this scientific problem have not been solved. One of them is to determine the infiltration properties of irrigation and the properties of soils in different irrigation regimes

In the context of sustainable economic development in Kashkadarya region, the most pressing issue is the rational use of water resources, the development of scientifically based use of available water resources, the effective use of them in irrigated areas. Resolutions of the President of the Republic of Uzbekistan No. PF-4947 of February 7, 2017, "Strategy for further development of the Republic of Uzbekistan", No. PP-4499 of October 25, 2019 "On measures to expand mechanisms to encourage the introduction of water-saving technologies in agriculture" are designed to solve these problems.

The main purpose of establishing the order of irrigation of crops is to establish the optimal amount of irrigation, the number and timing of irrigation required for it, taking into account the natural-climatic, soil-ameliorative, hydrogeological and many other conditions of the area during its growth.

Under the conditions of plant life, it receives nutrients in a dilute solution with an osmotic pressure of 1-2 atmospheres. In any case, the pre-irrigation soil moisture should not be less than 65–70% of the limited field moisture capacity. In order to reduce the concentration of soil solution in saline and saline soils, it is recommended that the moisture content should not be less than 75% of the limited field moisture capacity. Accordingly, the physiological minimum (or maximum molecular moisture capacity) of the soil is 30-35 percent relative to the limited field moisture capacity [2].

For a particular climate, soil, and hydrogeological conditions, it is important to determine the total water consumption of agricultural crops, including cotton. For this purpose, a lysimetric complex was created on the territory at Karshi Engineering-Economics Institute.

II. MATERIALS AND METHODS

Lysimeter is an engineer-technical structure used to monitor the dynamics of moisture inflow and movement in the soil cover under natural conditions, changes in the chemical composition of the soil solution, including various factors (mineral and organic fertilizers, type and method of irrigation, the nature of photosynthesis). The lysimeter is the main structure of agro-ameliorative research complexes. The lysimeter (in Greek "lysos" – melting) was first used by the French scientist La Hira in 1688 to study the rate of absorption of atmospheric precipitation into the soil. For agrochemical

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research, it was first used by British scientists John Dalton to study the role of atmospheric precipitation in groundwater saturation (1795) and Way in 1850 to observe the chemical composition of a solution leached through the soil.

III. RESULTS AND DISCUSSION

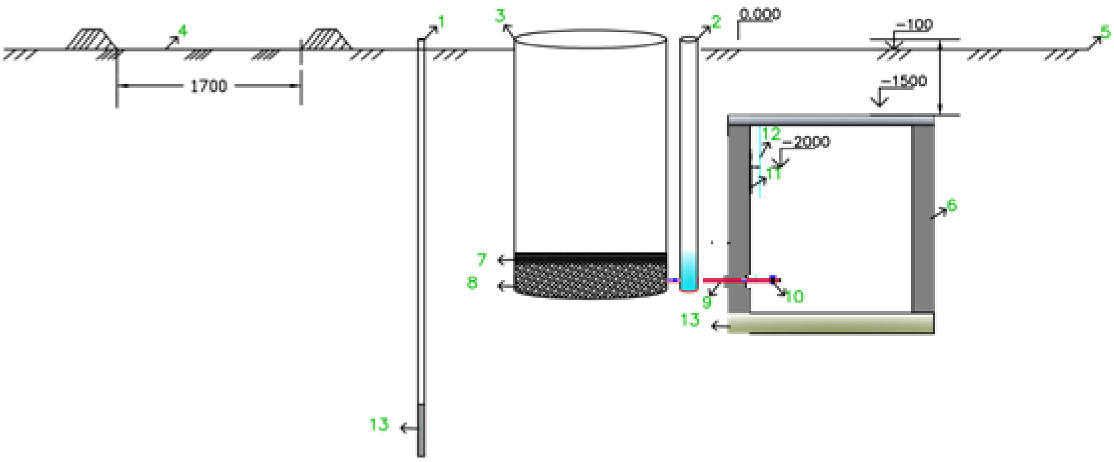
In 2017–2020, a lysimetric complex was built at the Karshi Engineering - Economics Institute on the basis of a fundamental project VA-QXF-5-003- “Laws of the dynamics of soil moisture processes in the irrigation of agricultural crops”. In the lysimetric complex, a 2.4-meter-long metal pipe with a diameter of 1400 mm was inserted into the ground under pressure, while maintaining the monolithicity of the ground (soil). The bottom part was filled with 10 cm of sand and 30 cm of gravel to have filtration processes, and the bottom part was covered with iron.

Figure 1. The process of building a lysimetric complex on the territory of the Karshi Engineering-Economics Institute.

In order to keep the level of groundwater at the same level, a steel pipe with a diameter of 159 mm was connected to the main pipe at a depth of 2-3 meters above the ground at the bottom of the steel pipe, and then connected to the pesometer.

Thus, two more 3.4-meter-long and 3.0-meter-long metal tube lysimeters with a diameter of 1000 mm were built.

Observation of all components of the water balance during the growing season of cotton allowed one to determine the amount of evapotranspiration directly for each lysimeter, taking into account the seasonal irrigation norm in 2019: 7.0; 9.6 and 10.6 thousand m^3/ha formed. The amount of evapotranspiration was determined on the basis of equilibrium, the difference in soil moisture reserves in spring and autumn, the volume of groundwater filling and the amount of drainage flow [1,3].



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1	Control well (d = 40 mm, N = 4.00 m)	8	Gravel
2	Installation of groundwater saturation (d = 159 mm, H = 2.50 m)	9	Piezometer tube (d = 25 mm)
3	Lysimeters (d = 1000 mm, N = 2.5 m)	10	Drain lock
4	Control area (10 m2)	11	Piezometer reading
5	Ground level	12	The ruler
6	Trench wall	13	Trench basement
7	Sand	14	Filter

Figure 2. Cross-sectional view of the lysimetric complex.

By pouring water through a pesometric pipe mounted next to the lysimeter, the appropriate depth of groundwater in each lysimeter was formed according to the following scheme:

- In the 1st lysimeter (1.53 m^2) – groundwater level is 2.0 m;
- In lysimeter 2 (0.785 m^2) – groundwater level is 2.5 m;
- In the 3rd lysimeter (0.785 m^2) – groundwater level is 3.0 m.

Evapotranspiration from crops can be determined by studying the soil moisture balance determined on a lysimeter.

Plant evapotranspiration is determined by meteorological data as well as data on agricultural crops using the Penman-Monteith equation. Aerodynamics albedo and crop body resistance can also be used to directly determine the amount of evapotranspiration through the growth description of the crop itself. Albedo and crop body resistance are difficult to determine because they can change continuously during the growing season depending on climatic conditions, plant development, and soil moisture. The moisture capacity of the soil also affects the resistance of the crop body, and when the plant is exposed to water shortages, it increases sharply [4,5].

Since the generalized data on aerodynamics and crop body resistance of the various surfaces occupied by crops are significantly less, the Penman-Montith equation is used only to determine Eto-evapotranspiration from the hypothetical grass surface at plant height, albedo and well-moisture plant.

$$ET_c = K_c ET_o \ , \quad (1)$$

where ET_c is single crop coefficient (K_c)

Crop growth or water consumption is affected by groundwater, salinity, plant number, pests and diseases, weeds, or low soil fertility.

Etc is determined by the method of yield coefficient, in which the effect of different weather conditions is included in Eto, the characteristics of the crop are included in the coefficient K_c.

The effects of crop transpiration and soil evaporation are combined into a single yield coefficient. The K_c coefficient includes the characteristics of the crops and the average effect of soil evaporation. For standard irrigation planning and management, for the development of basic irrigation schemes, and for large-scale hydrological water balance studies, the average crop yields are appropriate and convenient relative to K_c, which is continuously calculated using a single crop and soil factor. The individual transpiration and evaporation coefficients ($K_b + K_c$) should be taken into account only for certain crop areas and when K_c values are required daily in certain years.

Calculation of crop evapotranspiration using ET_c includes:

1. identifying the growth phases of crops, determining their duration and selecting the appropriate K_c coefficients;
2. comparison of selected K_c coefficients with humidification or climatic frequency.

Evapotranspiration can also be determined by measuring various components of soil water balance. This method involves estimating the flow of water entering and leaving the root zone at the same time (Figure 3). Water is added to the root zone through irrigation (I) and precipitation (R).

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Part of I and R can be wasted by surface runoff (PO) and depth filtration (DP) and it replenishes groundwater. When the groundwater level is close, it can rise above the water level through the capillary rise (CR) towards the root zone or be lost horizontally through the groundwater flow (SF_{fin}) or out of the root zone (SF_{aut}).

However, in many cases, in addition to steep hills, the amount of SF_{fin} and SF^{aut} is very small and can be ignored. Evaporation from the soil and transpiration of plants reduce moisture in the root zone. Taking into account all currents except evapotranspiration (ET), its amount can be determined based on changes in soil moisture (DSW) over a period of time:

$$ET = I + P - RO - DP + CR \pm \Delta SF \pm SW \qquad (2)$$

Some flows, such as groundwater flow, depth filming, and capillary rise from the water surface, are difficult to detect and sometimes impossible to account for in a short period of time. The soil water balance method allows the determination of ET values only over a long period of time, a week or ten days.

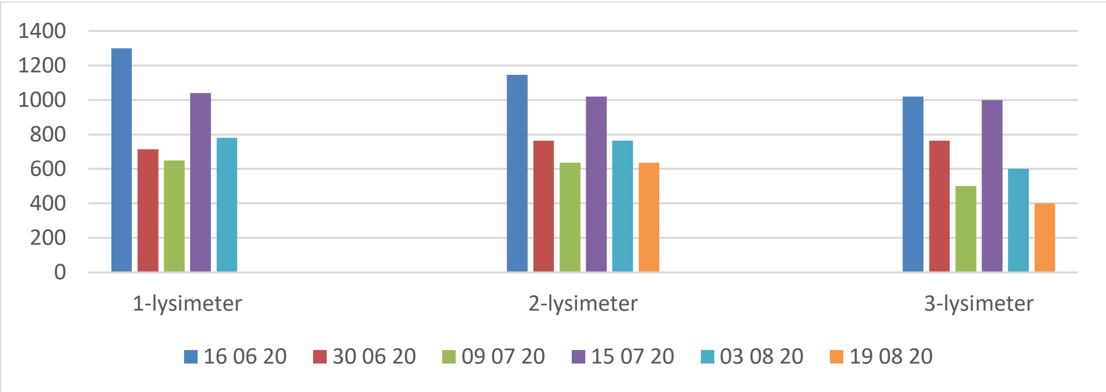

Figure 3. Schedule of water supply to cotton during the growing season of 2020.

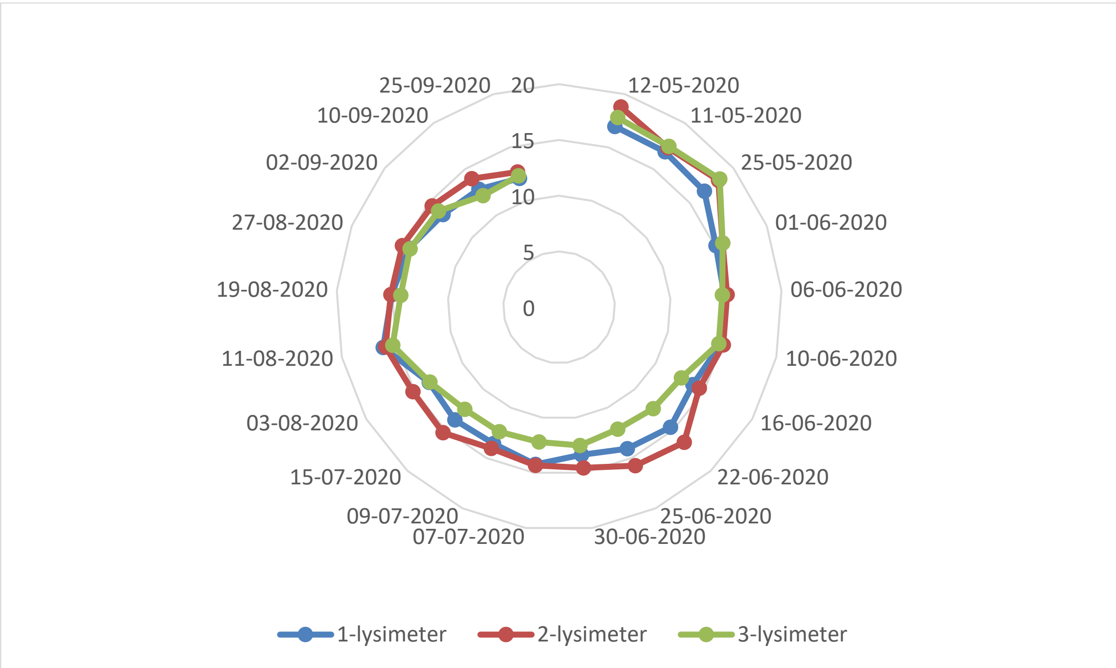

Figure 4. Graph of soil moisture change during the growing season of 2020.

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Despite the high level of soil salinity in lysimeters, due to the maintenance of osmotic pressure by irrigation, cotton was formed at the following values: from the 1st lysimeter – 46.27 centner/ha, from the second – 38.46 centner/ha, 27.40 c/ha from the third and 22.48 c/ha from the control option. The reason for the difference in yield in lysimeters is the different levels of salinity of the soils in the lysimeters during the growing season.

IV.CONCLUSION

Using the amount of water absorbed and its chemical composition, it is possible to determine the possible loss of nutrients from different horizons of the soil. It should be noted that any research using lysimeters requires the correct choice of the type of lysimeter and the improvement of a particular design, usually for the purpose of a particular scientific experiment. Even there is no single scheme for conducting certain types of constructions and lysimetric studies, each experiment has its own characteristics. This is especially true for the construction of lysimetric stations and long-term experiments.

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