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INTRODUCTION OF WATER-SAVING EQUIPMENT AND IRRIGATION TECHNOLOGY IN AZERBAIJAN

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Abstract

The final level of agricultural plants productivity is determined by optimum of plants' moisture ensuring. In the conditions of irrigated agriculture the intensity of water supply, the uniformity of water distribution over surface and within some period directly forms the final impact. In this article suggest using such concepts as "readiness of system for work" and "system reliability" for irrigation systems design. It is obviously shown, that by implementation of suggested formulas it is possible to calculate the influence coefficients of mentioned factors for additional yields data and respectively the final production. To use the notion of technique downtime during the operation of irrigation equipment is recommended.

Key words: the water preserving equipment, the water preserving technology of an irrigation, the water mode of the soil, hydrological factors of formation of a crop, uniform distribution of moisture, intensity of water giving, an availability quotient, durability of the equipment, average value of refusals.

1. Introduction

It is known that food, water, air, heat are one of the main criteria for creating aeration for plant life [1-4]. Lack of moisture in soil has a great influence on its air, heat and microbiological levels, as well as on its nutrient regime, and, consequently, on soil fertility and the direction of soil formation process. It should also be noted that the processes of accumulation and destruction of organic matter largely depend on soil water regime. The natural water and nutrient regime of soil and land masses in many cases do not coincide with the necessary regime for the best agricultural use of land. In some cases crops experience lack of moisture, in others, on the contrary, obtaining the necessary yields is hampered by excess moisture and lack of air and food assimilated by plants in the soil. Thus, the excess or lack of moisture and related phenomena are caused by the action of either general climatic and hydrological factors, or local causes: relief and hydrographic position, soil properties, the nature of economic use of the territory, and often the influence of both factors together.

Azerbaijan differs from all other regions of the former Soviet Union in terms of climatic conditions, as 9 out of 11 climatic belts existing in nature take place in our republic. It should also be noted that precipitation in the territory is very uneven, and in some regions is insufficient to meet the needs of agricultural crops during their growing season, i.e. there is an acute water deficit.

Under such conditions, water-saving technique and safe irrigation technology used for irrigation of agricultural crops in different soil and climatic zones of the republic are of great national and economic importance.

The advantage of water-saving technique and technology is that when supplying water in accordance with the needs of crops, they create conditions for uniform distribution of moisture over the entire irrigated area, form humidification centers for more intensive plant development, hence, significantly increase crop yields.

At the same time, application of new water-saving irrigation techniques and technology leads to irrigation water saving by 2-2.5 times and yield increase by 1.3-1.5 times. In addition, there is a possibility of rational application of fertilizers together with irrigation water, as well as convenience for implementation of appropriate agro-technical measures for growing crops.

It should be noted that application of water-saving irrigation technique and technology create conditions for maximum beneficial use of natural precipitation by regulating the operation mode of irrigation technique in accordance with natural conditions of different regions of Azerbaijan.

Introduction of water-saving irrigation technique and technology is one of the most difficult scientific and technical tasks of irrigated agriculture today. This is, first of all, the need to establish biologically optimal conditions of soil moisture and surface air layer, as well as environmentally acceptable level of soil moisture and aeration to preserve and increase its fertility under irrigation against the background of natural, poorly predictable precipitation.

When implementing water-saving irrigation technique and technology, the following parameters should be considered:

- water supply intensity and water consumption,

- ratio of parts of water supply used for creation of soil and air moisture;
- correspondence of water supply intensity and natural precipitation to accumulating capacity of active soil moisture exchange layer.

2. Problem statement

The main task of application of new irrigation technique and technology is to find solutions for optimal dispersal and uniform distribution of water runoff in the process of its conversion into the state of soil and air moisture. The higher is the irrigation efficiency coefficient, the higher is the crop yield.

It should be noted that if we compare water supply intensity and evapotranspiration intensity, their ratio for different irrigation technologies and means varies from 1 to 1000, with lower values corresponding to low-intensity irrigation techniques (slow and intermittent sprinkling, synchronous-pulse sprinkling, aerosol humidification, drip and pulse-drip irrigation).

When solving the issue of irrigation technology, it is necessary to take into account optimization problems. The problem of optimization of irrigation technological process should organically include agrobiological, ecological and socio-economic assessment. These factors are requirements of agricultural production. Agrobiological requirements stipulate optimal water supply to plants. For this purpose, irrigation technique should provide water supply in the required quantity, quality and timing in accordance with the biological phases of plant development uniform distribution of water on the field and soil horizons in accordance with the placement of the root system of plants, positive impact of irrigation on the environment surrounding the plant and the creation of the required air thermal and nutritional regimes in the soil and microclimate that corresponds to the physiological characteristics of plant development, the exclusion of mechanical damage plants and the negative effects of water currents and raindrops on them.

Ecological requirement is reduced to preservation and improvement of microrelief, mechanical composition of soil and ameliorative condition of lands. For this purpose, irrigation technique and irrigation technology should not allow water erosion of soil: destruction of soil structure and compaction, water losses for deep filtration and discharge, secondary salinization and waterlogging of irrigated lands.

Socio-economic requirements are reduced to rational and highly efficient use of irrigation equipment, water and labor on the irrigated area. At that, irrigation technique should provide highly efficient and rational use of irrigation equipment, and operational reliability should be higher compared to the previously used technique.

Theoretical prerequisite for solving the above requirements is rational use of water factors and their influence on crop yield.

3. Problem solution

The influence of factors on the value of yield is expressed by the following relationship:

$$Y=A\cdot \prod_{l-1}^{n}[1-(1-f')^2] \quad (1)$$

where A is the maximum yield increase at optimal supply of all factors;

f' – relative value of i-th factor;

n – number of factors influencing yield.

Consider that during the growing season (o, T) 1 irrigation is carried out at the time τ, τ_2 <………< τ_i <T. Let's assume τ_{i+1} =T.

Then, taking into account the time dependence of factor values and assuming that yield increases in different interirrigation periods are independent, expression (1) will take the form (1):

$$Y=\sum_{j=1}^{1}\left\{\frac{Aj}{\tau_j+1-\tau_j}\int_{\tau_j}^{\tau_{j+1}}\prod_{j=1}^{n}[1-(1-f'(t))^2]cH\right\} \quad (2)$$

where Aj – yield increment for the j-th irrigation cycle (τ_j , τ_{j+1}) under optimal supply of all factors during the inter-irrigation period and in the process of irrigation.

Factors change in different degrees, having different influence on yield formation. Characteristic changes of factors and their influence on yield during the inter-irrigation period are shown above

It is obvious from the diagrams that the variety of factors affecting the yield makes it difficult to directly use this dependence (or others similar to it). The greatest influence on yield is exerted by the factor whose absolute value of the value varies most maximally relative to one. Yield reduction in fractions of one can be expressed in the following form

$$\Delta Y = 1 - (1 - Y_B/Y_0) \cdot (1 - K_e/2)^2 \quad (3)$$

Here $\Delta У$ is an indicator of yield reduction in fractions of one unit.

When planning water use, it is necessary to take into account the impact of reliability indicators of irrigation machinery and equipment of irrigation systems on the operational irrigation regime and on crop yields. Irrigation systems with stationary and mobile elements, as well as other technical systems, in the process of active functioning fail and do not provide water supply to the whole command area.

Equipment failure or reduction of water distribution quality disrupts the planned water supply regime, which negatively affects the value of yield. For an irrigation system characterized by a certain availability factor, equipment durability and average value of failures, the damage from under-watering and, therefore, the value of yield shortfall can reach up to 30%.

Reliability of operation of technological equipment of the irrigation system is assessed by a complex indicator of availability coefficient K, which characterizes the probability of serviceability of the object in any time interval, except for the periods during which the use of the object for its intended purpose is not provided.

The availability coefficient of the system has a direct impact on obtaining maximum yields of crops.

To confirm the above, it is necessary to consider some theoretical aspects of crop yield forecasting. Yield depending on irrigation rate is determined by the following formula:

$$Y = Y_0 + (Y_m - Y_0)\frac{M}{\overline{\overline{M}}} \quad (4)$$

Here $У_0$ – yield without irrigation; $У_м$ – maximum possible yield at rate M.

If we denote the yield $У_1$, at rate M_1, the following expression can be obtained from (4):

$$Y_1 = Y_0 + (Y_m - Y_0)\frac{M}{\overline{\overline{M}}} \quad (5)$$

At the norm M=*M* we have:

$$У_2=У_м \quad (6)$$

From (4) and (6) we have the yield loss due to idle time of system elements:

$$\Delta Y=Y_2-Y_1=Y_m-Y_0-(Y_m-Y_0)\frac{M_1}{M} \text{ or } \Delta Y= (Y_m-Y_0)\left(1-\frac{M_1}{M}\right) \quad (7)$$

If the mean time to failure is T_0 and the mean time to recovery is $T_в$, the system element will stand idle for the time:

$$T_{M}=\frac{T_B}{T_0}\cdot t \quad (8)$$

Then the net operating time will be equal to

$$T_p=t-t_{pr}=t\left(1-\frac{T_B}{T_0}\right) \quad (9)$$

If there are *n* such elements in the device, then

$$t_p= t\left(1- \sum_{i=1}^{n}\frac{Tbi}{Toi}\right) \quad (10)$$

If we assume that t=T irrigation period, then the time of network for the irrigation period will be:

$$T_p=T\left(1- \sum_{i=1}^{n}\frac{Tbi}{Toi}\right) \quad (11)$$

The irrigation rate corresponding to this time is equal to

$$M_i =QT\left(1-\sum_{i=1}^{n}\frac{Tbi}{Toi}\right) \quad (12)$$

If the system was failing, then

$$M=QT \quad (13)$$

From (12) and (13) we have:

$$M_1 = M\,(1-\sum_{i=1}^{n}\frac{Tbi}{Toi}) \quad (14)$$

Due to failures of system elements, the value of irrigation norm decreases from M to M_1.

Thus, when designing a system to maximize yield, it is necessary to increase the duration of irrigation or the flow rate of water applied to the system if possible.

The expression $Q=q^1\cdot S$ used so far does not take into account the reliability of the system, i.e. the technique is assumed to be absolutely reliable.

In view of the above, it becomes obvious that the expression enclosed in brackets in formula (14) is nothing but the coefficient of system readiness to work, i.e.

$$K_p = 1-\sum_{i=1}^{n}\frac{Tbi}{Toi} \quad (15)$$

Thus, the influence of availability factor on the value of crop yield becomes obvious. Failure of the device requires additional costs to restore its operability. The required reliability of operation of technological equipment of the system should be high.

For water-saving irrigation system technique and technology the availability coefficient is taken as 0,98, power unit pump – 0,99, pipeline network and fittings – 0,99, on-farm irrigation systems 0,83-0,95. The irrigation efficiency coefficient K_e is used as a criterion of uniformity of rain layer distribution. For water-saving technique and technology K_e should not be less than 0,95.

4. Conclusion

The above theoretical premises and formulas are deduced by the authors and the necessity of taking into account the above factors in the development and design, as well as implementation of water-saving irrigation system technique and technology is proved. It should also be noted that these indicators reflect the quality and reliability of technological processes of water intake, irrigation water distribution, as well as the degree of water, labor, energy and material resources use.

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