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Estimation of Applicability of Technical Facilities for Irrigation of Agricultural Crops in Rugged Relief Conditions of the Zhambyl Region

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Abstract

In the face of the growing scarcity of water and mineral resources and environmental stress, for the formation of small farms and peasant farms, new technologies and irrigation techniques for crops are needed that would ensure: environmental safety; uniformity of water distribution over the irrigation area; favorable phytoclimatic conditions of the plant development habitat; irrigation in rugged relief conditions; protection from negative impacts; introduction of nutrients with irrigation water; reduction of metal consumption of systems and automation of the irrigation process. The increase in the productivity of crops is affected not only by the method of irrigation used, the humidity and temperature of soil and air, but also by the conditions in which the plant grows during the season. Along with the need to regulate the soil moisture and the temperature of the near-earth layer of air, protection from unfavorable factors of the habitat is needed in order to create optimal conditions for the development of plants, which indicates the advisability of developing a technology and technical facilities to solve this problem. The paper covers various methods of irrigation and their application in conditions that are not favorable for plants, provision of foliar water supply to plants due to dispersion of the water jet via sprinkler nozzles, influence of various irrigation technologies on the microclimate, substantiation of the choice of parameters for technical facilities of misting, empirical formula for specifying the range of sprinkler nozzles, effect of rugged relief on the development of technologies and technical facilities for irrigation of crops, as well as results of the experimental studies of various sprays/nozzles developed by KazSRIWE LLP (Kazakh scientific research institute of water economy).

Keywords: irrigation methods, misting, watering, spray, nozzle, rain intensity, irrigation coefficients.

Introduction

Irrigated agriculture throughout the world is one of the main factors for ensuring the stability of agricultural yield and food security.

The development of irrigation contributes to obtaining guaranteed yield, reducing the economic risks associated with crop losses due to instability in weather conditions, creating jobs for the rural population, settling settlements and a number of other factors that ensure the growth of living standards.

The analysis of the natural and geographical conditions of cultivation of agricultural crops in the Zhambyl Region shows that part of the irrigated land is located on the slopes of the mountains and in the upper sections of greatly sloping foothill plains and rugged relief represented by soils with poor permeability. The climate of the region is subject to: late spring and early autumnal frosts, dry winds, droughts, hurricanes, high temperature, low relative humidity, and hail precipitation. These adverse factors have a significant impact on crop losses.

Methods

The applicability of technical facilities for irrigation of agricultural crops was assessed taking into account the study and analysis of the present technologies of misting, drip and subsoil irrigation of agricultural crops used in the Republic of Kazakhstan and the global practice and in-situ studies in peasants' and farmers' farms of the Zhambyl Region.

The basis for experimental and theoretical studies was the work on assessing the applicability of technical irrigation tools by Shtepa, Nosenko, Danilchenko, and Lebedev. The assessment was done using several indicators characterizing the natural and economic conditions, and was based on accounting for technical and operational characteristics of the irrigation facilities, such as consumption, pressure, intensity, size of drops, range of irrigation, etc. To achieve this goal and solve the tasks set, the system approach was used based on the principle of considering both the system as a whole and its individual components. The parameters of irrigation were identified by selecting the existing types and modifications of sprinkling devices.

The field studies and data processing were carried out using Dospekhov's field method, taking into account the specific tasks and conditions of the Zhambyl Region. All the field studies comply with the requirements of standards, norms and rules of technological and environmental safety, contained in the regulations of the Republic of Kazakhstan, and were carried out in compliance with GOSTs and sector standards.

Results

Cultivation of crops in conditions with unfavorable factors requires careful selection of irrigation techniques [1-6].

For all types of irrigation technology, agrotechnical requirements were developed and approved, the duration of which is limited, as the technology is continuously improving, and, consequently, the related requirements are also enhancing. The following main groups of requirements of the agricultural sector to the irrigation technique are standing out: agrobiological, soil-meliorative and ecological, organizational-economic. These requirements for the irrigation technology must meet the respective purpose (7). To meet the requirements for the irrigation technology, according to the international classification, the following methods of irrigation are distinguished: aerosol humidification, sprinkling, surface irrigation, subsoil (including drip) irrigation, and subterranean irrigation (subirrigation). As the experience shows, none of these methods of irrigation can be recommended as universal and uniquely possible for all conditions (8). The main purpose of various methods of irrigation is given in Table 1.

Natural, climatic and economic conditions determine the technique of irrigation. A perspective irrigation technique should not only be created taking into account the shortage of water and other resources, but also be ecologically safe. In view of the foregoing, the most promising watering method is sprinkling [9-11].

The existing sprinkling technique, along with agrotechnical requirements, must fit organically into the existing system of farming. For example, the multilevel frontal sprinkler made by *Valley* (USA) ensures the watering of 98% of the area of rectangular sites, and the drum type sprinklers (Italy) have become an ideal technique for irrigation and watering for many small and medium-sized farms.

However, the assessment of the applicability of various irrigation methods, with a change in the state of the environment (Table 2), shows that the aerosol method, in comparison with other methods of irrigation, is more universal for its use in difficult climatic conditions [12-14].

The combination of common irrigation methods, for example, irrigation with aerosol sprinkling, is most effective in the zone of unstable moistening.

The expediency of using aerosol irrigation depends on many factors. The main of them are natural climatic (climate, relief, water supply, irrigation water quality, water-physical properties of soil, groundwater salinity and mineralization, etc.) and economic conditions (composition and characteristics of agricultural crops, their physiological needs, conditions of cultivation, and resource availability).

The main disadvantages of aerosol irrigation can be attributed to the high cost of the equipment, plants and machinery used, as well as the dependence of the efficiency of this irrigation method on wind speed.

The essence of the aerosol (misting) method of irrigation consists in periodic (once each 1-1.5 hours) dispersion (spraying) of water over the irrigated area at thermally intense times of the day. Dispersed water is transported over the area of the site due to the use of its kinetic energy and air flow (wind speed). In this method, the sprayed water acts on the watering of the leaf tissue in such a way that drops are retained on the leaf surface before they are absorbed by the plants. The size of the drops affects the absorbing capacity of plants. The optimal diameter is 100-800 μm. Reducing the diameter of drops contributes to their more intense evaporation, but smaller drops are strongly influenced by the wind, so being less than 50 μm, they cannot settle at all. Thus, out-root water nutrition of plants is carried out. It is established that the root system of agricultural crops during aerosol moistening penetrates deeper layers of the soil, contributing to more powerful development of the root system, increasing soil fertility. The loss of water by physical evaporation during evapotranspiration is also significantly reduced. The fundamental difference between aerosol and other irrigation methods is that the soil does not humidify due to watering, and the water reserves in the soil do not increase, but are rationally preserved. The optimum water regime of agricultural crops is provided by the initial water reserves in the soil, natural precipitation falling during the vegetation period, and foliar plant water supply [11, 15]. Such watering raises the humidity of the air near the soil, helps reduce air temperature and the leaf surface of plants (by 6-12 °C), and, consequently, eliminate the conditions of photosynthetic depression, increasing the productivity of agricultural crops.

The main methods of water dispersion are hydrodynamic, hydromechanical and pneumohydrodynamic. To do this, nozzles of various designs are used, which are provided on misting machines or devices as seen on Figure 1 (16).

Table 1 – The main purpose of various methods of irrigation

Parameters	Irrigation methods				
	Aerosol	Sprinkling	Surface	Subsoil	Subterranean
Moistening of soil	no	yes	yes	yes	yes
Moistening of air	yes	yes	partly	no	no
Moisture supply	no	partly	yes	partly	partly
Desalination	no	partly	yes	no	no
Application of fertilizers and herbicides	partly	yes	partly	yes	no
Sewage irrigation	no	yes	yes	yes	no
Antifreeze irrigation	yes	yes	no	no	no
Provocative watering for weed growth	no	yes	yes	no	no

Table 2 – Application of various methods of irrigation under unfavorable conditions for plants and extreme conditions of the environment

Factor	Irrigation methods				
	Aerosol	Sprinkling	Surface	Subsoil	Subterranean
Salinized soil	partly	partly	yes	no	no
Light sandy soils	yes	yes	partly	partly	no
Heavy soils	yes	no	yes	yes	yes
Rugged relief	yes	yes	partly	partly	no
Great slopes	yes	yes	partly	yes	no
Mineralized subsoil waters nearby	partly	partly	partly	no	no
Deficiency of water resources	yes	yes	partly	yes	partly
Mineralized irrigation water	partly	no	partly	no	no
Strong wind	yes	no	yes	yes	yes
Air droughts and hot winds	yes	partly	no	no	no
Antifreeze protection	yes	yes	no	no	no

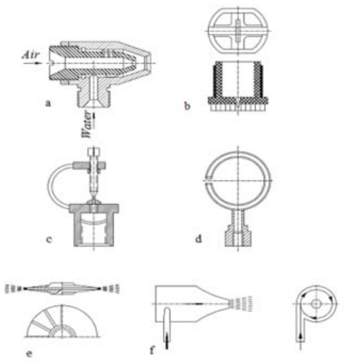

Figure 1 – Schemes of nozzles of various designs: a – pneumatic spray gun OP-1; b – irrigator PFP-180; c – sprinkler of colliding jets (AFI); d – slit sprinkler; e – rotating disc sprinkler; f – centrifugal spray with vortex chamber

On stationary systems, for over-tree misting in gardens, the equipment, comprising a mast 9-12 m high and a rotary bar with dispersants (nozzles), is used. The bar is self-aligned perpendicular to the direction of the wind in accordance with Figure 2. The equipment operates according to the principle of hydrodynamic water dispersion. At a wind speed of 3-6 m/s, the average rain intensity is not less than 0.06 mm/h.

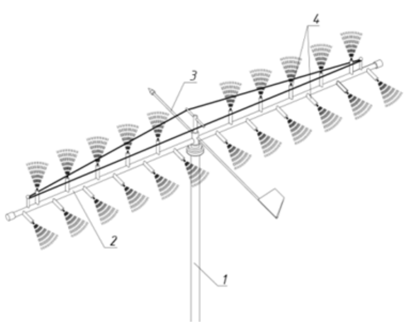

Figure 2 – Aerosol sprinkling system's rod: 1 – mast; 2 – rotary bar; 3 – weathercock; 4 – dispenser

The main specifications of existing stationary systems of misting by VNPO Raduga and UkrNIIOS are shown in Table 3.

Table 3 – Key specifications

Specification	VNPO Raduga	UkrNIIOS
Type of the basic working tool	Centrifugal sprinkler	Nozzle
Rate of the working tool, l/s	0.08-0.11	0.008
Pressure at the working tool, MPa	0.3-0.4	0.15-0.4
Number of working tools per ha	5-7	1000
Rain intensity, mm/min at wind speed 3-6 m/s	not over 0.001	–
Area covered by one operator, ha	100	50
Specific length of piping, m/ha	300	2213

Sprinkling, according to the applicability in unfavorable natural and climatic conditions, takes the second place after the aerosol moistening method due to high rain intensity of mass-scale sprinkler machines and devices causing water erosion on heavy soils.

The permissible rain intensity on soils (heavy loams and clays) with a slope up to 0.12 ranges from 0.07 to 0.034 mm/min without a crop, and from 0.09 to 0.05 mm/min with a crop. Therefore, the designed sprinkler should, by moistening of the surface air layer, exclude surface runoff in the irrigated area as well [13-17].

KazSRIWE LLP developed and tested prototype spray nozzles (Figure 3) [18].

The results of tests of simultaneously operating two, three, four and eight misting modules with 12 spray nozzles and 6 carousel nozzles in each module, which worked 220 and 240 hours, respectively, are given in Table 4.

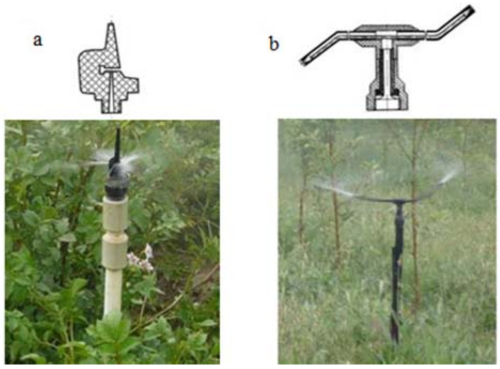

Figure 3 – Sprinkling nozzles designed by KazSRIWE LLP (a – spray nozzle; b – carousel nozzle)

Table 4 – Technical characteristics of the operation of misting modules with various types of nozzles (average)

Specifications	Sprinkling nozzles					
	Spray nozzle			Carousel nozzle		
	Piping pressure, MPa					
	0.15	0.20	0.25	0.15	0.20	0.25
Sprinkling area, ha	0.0037	0.0040	0.0043	0.049	0.058	0.062
Network rate, l/s	0.017	0.019	0.022	0.49	0.58	0.62
Piping diameter, mm	15	15	15	20	20	20
Nozzle rate, l/s	0.0014	0.0016	0.0018	0.082	0.096	0.107
Sprinkling range, m	1.22	1.26	1.31	6.3	6.9	7.1
Number of nozzles, pcs.	12	12	12	6	6	6
Average rain intensity, mm/min	0.028	0.030	0.032	0.055	0.058	0.065
Coefficient of effective irrigation, K_{ef}	0.82	0.84	0.83	0.81	0.84	0.82

Table 5 – Degree of impact of different irrigation technologies on the microclimate

Irrigation technology	Degree of impact on the microclimate	Result on microclimate		
		Air humidity increase, %	Decrease in air temperature in hot hours of the day, °C	Increase in crop yield, %
Drip, subsoil, surface	Very insignificant (microclimatic factor 0.05-0.2)			
Periodical sprinkling	Intensive but short (microclimatic factor 0.25-0.5)	Short within watering period up to 15-35	Short within watering period 4-10	Apple orchard. Compared to surface, 15-30
Intermittent and simultaneous impulse sprinkling	Low-intensity long impact (microclimatic factor 0.55-0.75)	10-30	2-8	Tea gardens by 30-40 Fruit plants by 25-50 Grain crops by 15-20
Aerosol	Long, almost fully controlled (microclimatic factor ≅ 0.9)	10-20	6-12	Tea gardens by 20-30 Grain crops by 15-20
Misting	Long, almost fully controlled (microclimatic factor 0.82-0.89)	8-10	5-7	Apple orchard by 15-30

The average watering rate for sprinkling duration of 6-8 hours is 20.0-30.0 mm with the use of carousel nozzles and 10.0-15.0 mm with misting nozzles.

Monitoring of the moisture content of the root zone of the soil during misting showed that the irrigation water in the testing of modular systems is fully accumulated by the soil in the 0-60 cm layer, which indicates the absence of a deep discharge. Misting, moistening the surface air layer and the top soil layers, reduces their temperature to optimum values. The comparison of climatic conditions (apple-trees' habitat) during misting and ordinary irrigation (by furrows) showed that the air temperature decreases by 5-7 °C in the daytime, and its humidity rises by 8-10%. The values of the microclimatic coefficient over the ten days' time intervals vary from 0.82 to 0.89, the average for the observation period being 0.85. The analysis of Table 4 shows that the spray nozzle has an average rain intensity of half that of the carousel one. According to this index, the spray nozzle was selected (for misting), in which the average rain intensity was less than the permissible in heavy soils (0.028-0.030 < 0.07-0.034) without a crop.

DISCUSSION

Based on the results of the studies conducted, it is necessary to establish the effectiveness of the impact of misting on the microclimate of plants. A comparative assessment of the impact on the microclimate of the existing irrigation and misting technologies is given in Table 5.

From Table 5 it can be seen that misting by the effectiveness of the impact on the microclimate of plants is practically inferior to aerosol, while misting has an advantage over aerosol, since it allows moistening the soil, including heavy soils without a surface runoff of water (its intensity is less than permissible). Misting eliminates the danger of raising groundwater, since there is no deep filtration, the structure and physical properties of the soil are preserved, that is, it is an environmentally safe irrigation technology.

According to the indexes considered in the context of the irrigation technology, misting is more promising, and it is recommended for introduction into farming enterprises of the agroindustrial complex of Kazakhstan, mainly in severe and unfavorable conditions of vegetation.

The main parameters that determine the operation of sprinkler nozzles for the misting system are its range of irrigation and the rain intensity, which depend on the head, the passage diameter and the height of the flat deflector (circular slit nozzle) above the nozzle outlet. The irrigation range of the circular slit nozzle (jet) was determined by the empirical formula by B. Shtep (formula 1) [7] and was adjusted according to the empirical formulas proposed by KazSRIWE LLP (formulas 4-5).

1. $R = H/0.43 + 0.0014(H/d), m$ (1)
2. $R = H/2.6 + 0.0014(H/d), m$ (2)
3. $R = H/2.3 + 0.0007\left(H/F_{H \cdot h_s}\right), m$ (3)

where:

H - was the water head, m;
d - was the diameter of the outlet, m;
F_H - was the cross-sectional area of the passage, m^2;
h_s - was the distance from the outlet to the flat deflector, m. Experimental h_s = 3 mm.

The ranges of sprinklers, determined by calculation in accordance with the above formulas, and their comparison with the experimental data (Table 6) show that formula 1, which takes into account the distance from the outlet to the flat deflector (the height of the slit), is more approximate to experimental, and was accepted as the basic formula for subsequent calculations.

The irrigation ranges of the slit sprinkler nozzle and its dependence on the height of the circular slit are given in Table 7.

Table 6 – Calculated and experimental data of the irrigation range of the slit misting nozzle

Calculation formulae	H – head, m, d = 0.002 m		
	15	20	25
	R – irrigation range of the nozzle, m		
$R = H/0.43 + 0.0014(H/d)$, m	1.37	1.38	1.39
$R = H/2.6 + 0.0014(H/d)$, m	1.14	1.2	1.24
$R = H/2.3 + 0.0007\,(H/F_{H \cdot h_s})$, m	1.215	1.275	1.314
Experimental data	1.22	1.26	1.31

Table 7 – Calculated values of irrigation range of the circular slit sprinkler nozzle as a function of the slit height

Type		h_s – height of the slit nozzle, mm									
		1	2	3	4	5	6	7	8	9	10
Water head, m	Outlet diameter, m	R – irrigation range of the sprinkler nozzle, m									
15	0.001	0.97	0.52	0.35	0.27	0.22	0.18	0.16	0.14	0.12	0.11
20	0.001	1.01	0.53	0.36	0.27	0.22	0.18	0.16	0.14	0.12	0.11
25	0.001	1.03	0.54	0.36	0.27	0.22	0.18	0.16	0.14	0.12	0.11
15	0.002	2.81	1.73	1.215	0.97	0.8	0.68	0.59	0.52	0.47	0.42
20	0.002	3.09	1.83	1.275	1.01	0.82	0.69	0.6	0.53	0.47	0.43
25	0.002	3.3	1.9	1.314	1.03	0.84	0.7	0.61	0.54	0.48	0.43
15	0.003	4.3	3.02	2.32	1.89	1.59	1.37	1.2	1.08	0.97	0.89
20	0.003	5.02	3.35	2.51	2.01	1.68	1.44	1.26	1.12	1.01	0.92
25	0.003	5.58	3.59	2.65	2.1	1.74	1.48	1.29	1.14	1.03	0.93

The results of experimental bench and field studies showed that they are close enough to the calculations. The experimental studies also found that sprinkler nozzles having outlet diameters less than 2 mm and circular slit height less than 3 mm have low operational reliability due to clogging of the outlets and the circular slit. In this regard, the size of the outlet diameter was taken equal to 2 mm and the height of the circular slit – 3 mm. Further studies showed that the parameters adopted provided high operational reliability of the slit nozzle's operation.

The irrigation range of the carousel nozzle was determined by the formula by F. Pikalov (7) adjusted according to the empirical formula (8) developed by KazSRIWE LLP for the far-watering sprinkling nozzle and the empirical formula (9) for the near-watering sprinkling nozzle.

$$R = 0.42H + 1000d, \text{ m} \quad (4)$$

$$R = \frac{H}{0.4} + 0.00025(H/d), \text{ m} \quad (5)$$

$$R = \frac{H}{0.6} + 0.00035(H/d), \text{ m} \quad (6)$$

where:
H - was the water head, m;
d - was the outlet diameter, m.

Table 8 gives the comparative data of the radius of irrigation of the carousel nozzle, obtained by calculation and experimentation.

The empirical formula by KazSRIWE, which has been used to determine the irrigation range of the carousel nozzle, is in good compliance with the experimental data. The outlet diameter of the carousel nozzle is the same as that of the 2.0 mm slit nozzle. The reason is the same: high clogging of the nozzle outlet and low operational reliability.

Table 8 – Finding the irrigation range of the carousel nozzle

Formula	H – water head, m, d = 0.002 m		
	15	20	25
	R – irrigation range, m		
$R = 0.42H + 1000d$	8.3	10	12.5
$R = H/0.4 + 0.00025(H/d)$(far-watering nozzle) $R = H/0.6 + 0.00035(H/d)$(near-watering nozzle)	6.59 4.65	6.89 4.88	7.092 5.025
Experiment: 1) far-watering 2) near-watering	 6.3 4.55	 6.9 4.75	 7.1 4.99

The theoretical average rain intensity in slit-type sprinklers was found using the formula (10):

$$I = 60q/\pi R^2, \text{ mm/min} \quad (7)$$

where:

q - was the nozzle water rate, l/s;

R - was the nozzle irrigation range, m.

The water rate of the circular slit sprinkler nozzle was found according to the empirical formula (11) by KazSRIWE as follows:

$$q = E_{ttl}\, \omega\sqrt{2gH}, \text{ l/s}, \quad (8)$$

where:

E_{ttl} - was the total coefficient of water rate, which is the product of the coefficients: jet compression (0.6), fluid flow resistance through the hole (0.064), velocity (0.97), and flow rate (0.7). The averaged values of these coefficients were used. The product of these coefficients was 0.0256 (19). Consequently, E_{ttl} = 0.0256;

ω - was the outlet passage area, m^2;

g - was the gravity acceleration (9.8 m/s^2);

H - was the water head, m.

The rain intensity of the carousel nozzle was determined by the empirical formula by KazSRIWE, since the existing standard formulae had been suitable for sprinklers having 1 sprinkler jet ($I = 60q/\pi R^2 n$).

The standard formula was adjusted, indicating the presence of 2 sprinkling jets in the carousel nozzle.

$$I = 60q/\, 3.14(R_1 + R_2)n, \text{ mm/min}, \quad (9)$$

where:

R_1 - was the irrigation range of 1 jet of sprinkling nozzle;

R_2 - was the irrigation range of 2 jets of sprinkling nozzle, m;

n - was the rotation rate of sprinkling nozzle, min^{-1}, n = 0.44.

$$q = 2\mu\, \omega\sqrt{2gH}, \text{ l/s} \quad (10)$$

where:

μ - was the consumption rate (0.76);

ω - was the outlet passage area, m^2.

Table 9 displays the theoretical and experimental rain intensities of sprinkling nozzles: slit and carousel.

Table 9 shows that the calculated and experimental values are actually very close. This means the correctness of the accepted empirical formulas.

The influence of rugged relief on the development of technologies and technical facilities of irrigation of agricultural crops is examined in the case study of the Zhambyl Region.

The characteristic features of the climate of the Zhambyl Region are significant aridity and continentality. The continentality of the climate is manifested in sharp day/night and winter/summer temperature contrasts, rapid transition from winter to summer. In the southern mountain part of the region, the features of continentality are attenuated: the winter is milder and the precipitation is better.

Desert plains of the northern and central regions of the region are especially arid. The summer is hot there, the average July temperature is the same as in the tropics (25-26 °C), on some days the air temperature reaches 45-47 °C (absolute maximum). Meantime, the winter in its severity does not correspond to geographical latitude. The coldest month is January, the average temperature being -11 – 14 °C in the north of the region and -5 – 9 °C in the south. Cold arctic air in winter, penetrating to the south of the region, causes severe frosts, reaching -35 – 46 °C (absolute minimum).

The period with an average daily air temperature above 0 °C is quite long. In the north of the region it is 225-240 days, in the central regions – 245-260 days, and in the mountains and foothills – 225-245 days.

The frost-free period on the plains lasts 5-6 months, in the foothills and mountains 4-6 months.

In general, there is little precipitation in the region, especially in its flat area (less than 250 mm per year). A non-significant amount of precipitation (100-130 mm per year) is recorded in the northeast of the region off the coast of the Balkhash Lake. In northern and central regions, rains are very rare in summer. In the foothill areas, the amount of precipitation increases to 300-350 mm, which allows using part of the land for rainfed farming. In the Kirghiz Alatau mountains, 500-600 mm of precipitation falls. By the seasons of the year, the precipitation is extremely uneven, mostly falling during the winter-spring period. A brief analysis of the climatic features of the Zhambyl Region shows that with a sufficient number of heat-provided days for cultivation of crops, there is not enough atmospheric precipitation, especially in the flat area, not evenly distributed during the year. In addition, in the process of plant development, they are also affected by anomalous natural phenomena: frost, dry wind, high air temperature, etc.

Table 9 – Comparative rain intensities of sprinklers

Name	Water head, m, d = 0.002 m					
	15	20	25	15	20	25
Nozzle	Slit			Carousel		
Rain intensity formulae	$I = 60q/\pi R^2$			$I = 60q/\, 3.14(R_1 + R_2)n$		
Designed rain intensity	0.018	0.0192	0.0198	0.0546	0.0575	0.060
Experimental rain intensity	0.018	0.0192	0.020	0.055	0.058	0.065
Formulae to calculate water consumption by nozzles	$q = E_{ttl}\omega\sqrt{2gH}$			$q = 2\mu\,\omega\sqrt{2gH}$		
Designed water rates of nozzles	0.00138	0.00159	0.00178	0.0814	0.094	0.105
Experimental water rates of nozzles	0.0014	0.0016	0.0018	0.082	0.096	0.107

The irrigated lands of the foothill zone of the Zhambyl Region are usually small-sized with a rugged configuration and great slopes. The use of the existing irrigation technique, which would satisfy the agrotechnical requirements to crop cultivation in the foothill zone, is problematic [20-23].

The analysis of the irrigation technique used in the foothill zone showed that the most promising method was still sprinkling. However, the existing sprinkler devices have high rain intensity and cannot be used because of the occurrence of water erosion of the soil. Therefore, the solution of this problem is connected with the development of new technical facilities. The analysis of the irrigation technology methods showed that the lowest rain intensity occurred during the aerosol moistening method, which moistened the surface air layer, but not the soil. The device to be developed should combine the positive features of the aerosol irrigation method (humidification of the air) and moistening of the soil. Such a device can be a misting sprinkler that simultaneously moistens air and soil [17, 23-27].

CONCLUSION

1. The Zhambyl Region belongs, according to the conditions of cultivation of crops in the growing season, to the category of severe and unfavorable areas. Part of the irrigated land is located on the mountain slopes and the upper sections of sloping foothill plains with significant terrain slopes and rugged relief, having mostly weak water permeability. During the growing season, the plants can be affected by high air temperature, freezing, dry wind, drought, strong wind, etc., which adversely affect the yield of crops.
2. The irrigated lands of the Zhambyl Region are predisposed to the development of water erosion of soils, especially foothill areas, therefore irrigation techniques should provide watering without water runoff on the soil surface. This means that when sprinkling the rain intensity should correspond to non-pressure soaking by the soil.
3. The analysis of the applicability of the irrigation technique in rugged relief conditions showed that the most promising among the existing methods of irrigation was misting, which combined aerosol humidification of air and soil. Creating a microclimate in the surface layer, misting is a kind of regulator of plant photosynthesis.
4. The parameters of misting nozzles (irrigation range, water rate, average rain intensity, outlet nozzle diameter, working water head), found by calculation, were compared with the experimental data obtained during bench and field tests. Some empirical formulas have been developed to determine the parameters of sprinkler nozzles. Comparative research results have shown that the calculated numerical values of the operation parameters and the experimental data practically coincide. This means that the empirical formulas are correct.

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