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Hydromodule zoning of irrigated lands in South Karakalpakstan and the optimal mode of cotton irrigation”

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Abstract. One of the main directions for the further development of irrigated agriculture in the basin of the Aral Sea rivers is to increase the productivity of scarce irrigation water through the development and implementation of water-saving regimes and technologies for irrigation of agricultural crops that meet environmental requirements, contributing to an increase in the fertility of irrigated lands, obtaining a high early ripening crop yield. The article presents the results of research on hydromodular zoning of irrigated lands based on GIS technologies, as well as cotton irrigation regimes in the conditions of South Karakalpakstan.
Keywords: Irrigation regime, soil, water-physical properties of soil, groundwater, salt regime, reclamation, efficiency and water conservation.

Introduction. Water resources management requires a deep understanding of the special value of water for humans, the principles of human interaction with nature and the importance of water resources for the development of society. Only with knowledge of the numerous interrelationships that are formed in water management in ensuring the vital activity of society and natural balance, food production and economic development, as well as the role of water in the evolutionary processes on earth, can we take on water resources management [1]. In the context of climate change and increasing water scarcity, a decrease in water consumption of agricultural crops is of great importance in solving the problem of water conservation in the arid zone [2,3].

As a result of global climate change, the area of glaciers in Central Asia has shrunk by about 30 percent over the last 50-60 years. It is estimated that the volume of glaciers decreases by 50 percent when the temperature rises to 20C and by 78 percent when heated to 40C. Climate change will lead to 10-15% evaporation of water from water surfaces, and 10-20% more water consumption due to increased plant transpiration and irrigation standards. This leads to an average 18% increase in non-renewable water consumption. This will undoubtedly complicate the further growth of agricultural production [4,5].

Methods. Soil analysis, observations, measurements and analysis of cotton, cotton selection, "Methods of studying agrophysical, agrochemical and microbiological properties of soil in cotton fields" adopted at the Scientific Research Institute of Seed Agrotechnology [12], "], the accuracy and reliability of the obtained data were analyzed mathematically and statistically on the basis of the generally accepted method of VP Peregudov. Hydromodule zoning was carried out on the basis of the method of N.F. Bespalov [6].

Results and Discussion. Scientific research to determine the irrigation regime of cotton was carried out on the irrigated lands of the farm "Reimbay boshliq" in Beruni district of southern Karakalpakstan in the following experimental system (Table 1).

Table 1. Field experiment implementation system

№	Pre-irrigation soil moisture, in% relative to the limited field moisture capacity	Irrigation rate, m^3/ha
1	Production control	Actual measurements
2	70-70-60	On the moisture deficit in the layer of 70–100–70 cm
3	70-80-60	On the moisture deficit in the layer of 70–100–70 cm
4	70-80-60	Moisture deficit in the 70-100-70 cm layer was increased by 30%.

Volume-2
Issue-1
DOI 10.5281/zenodo.6557583
On the lands of the farm there are collector-drainage networks, irrigation networks are of engineering nature. To irrigate agricultural crops, water is delivered to the fields through horns and temporary ditches, and the crops are irrigated side by side. The soil of the farm is weak and moderately saline. The mechanical composition of the experimental field soil, according to N. Kachinsky's description, is a layer of medium sand with a depth of 0-85 cm and a layer of light sand with a depth of 85-118 cm.
While plant development and productivity are related to soil fertility, plants also affect soil composition. Depending on the farming culture, its fertility will also change after the soil begins to develop from its natural state through the cultivation of agricultural crops. Improving soil fertility depends on 4 main factors: reclamation regime, mechanical treatment, fertilization schedule and the type of plant to be planted. The plant improves as much water-air and nutrient regimes as possible in the soil during the growing season and leaves behind it a certain amount of organic matter in the soil. However, chronic planting of one crop in a given area does not have a positive effect, on the contrary, it reduces soil fertility, so intensive farming should be used in the cultivation of each crop based on crop rotation, irrigation and optimal use of fertilizers [14].
In the cultivation of agricultural crops, the order of irrigation is necessary to ensure a water regime for each plant species, in specific climatic conditions. Agricultural crops react differently to water supply conditions depending on the biological properties of cotton. However, usually when the demand for water is continuously met throughout the entire period of growth and development, all plants are provided with maximum yields.
Irrigation rate was determined according to the following formula [15].

$$m = 100 \cdot h \cdot J \cdot (W_{lfmc} - W_{ah}) + K \quad m^3/ha$$

Cotton planted in the experimental field was irrigated on the basis of the specified humidity. During the growing season, the number of irrigations in each variant of cotton, its duration, and the total amount of water supplied varied significantly (Table 3).

In option 3, where the pre-irrigation soil moisture was 70-80-60% relative to the limited field moisture capacity, the cotton was irrigated three times during the flowering-harvesting period according to the 0-3-0 scheme with 714-766 m^3/ha irrigation norms. Seasonal irrigation norms were 2203-2250 m^3/ha or 1428-1632 m^3/ha less water than the control. Depending on the pre-irrigation moisture of the soil, the period between irrigations was 18-22 days.

In variant 1 of the experiment, cotton was irrigated once during the growing season according to the 1-2-1 scheme once before the flowering-yield period, 2 times during the flowering-fruiting period and once during the ripening period, a total of 4 times, at 1112-1291 m^3/ha. The seasonal irrigation rate was 4638-4744 m^3/ha. The period between irrigations was 25-26 days.

Table 3. Irrigation regime of cotton

Options	Indicators	Irrigation, m^3/ha						Irrigation scheme	Seasonal Irrigation norm, m^3/ha
		1	2	3	4	5	6		
2018									
1	Irrigation period	18.06	13.07	08.08	3.09			1-2-1	4678
	Irrigation interval, days		25	26	26				
	Irrigation rate, m^3/ha	1247	1126	1164	1141				
2	Irrigation period	20.06	14.07	06.08	03.09			1-2-1	3335
	Irrigation interval, days		24	23	27				
	Irrigation rate, m^3/ha	650	891	921	873				
3	Irrigation period	19.06	07.07	24.07	17.08			1-2-1	2854

Volume-2
Issue-1
DOI 10.5281/zenodo.6557583

	Irrigation interval, days		18	17	24				
	Irrigation rate, m^3/ha	643	663	693	855				
4	Irrigation period	18.06	08.07	30.07	25.08			1-2-1	3731
	Irrigation interval, days		20	22	26				
	Irrigation rate, m^3/ha	823	883	901	1124				
2019									
1	Irrigation period	19.06	14.07	09.08	4.09			1-2-1	4744
	Irrigation interval, days		25	26	26				
	Irrigation rate, m^3/ha	1276	1159	1142	1167				
2	Irrigation period	22.06	15.07	05.08	02.09			1-2-1	3422
	Irrigation interval, days		23	23	26				
	Irrigation rate, m^3/ha	664	926	956	876				
3	Irrigation period	21.06	09.07	26.07	18.08			1-2-1	2789
	Irrigation interval, days		18	17	23				
	Irrigation rate, m^3/ha	633	623	668	865				
4	Irrigation period	20.06	11.07	02.08	29.08			1-2-1	3711
	Irrigation interval, days		21	22	27				
	Irrigation rate, m^3/ha	836	848	888	1139				
2020									
1	Irrigation period	19.06	14.07	09.08	4.09			1-2-1	4738
	Irrigation interval, days		25	26	26				
	Irrigation rate, m^3/ha	1291	1214	1112	1121				
2	Irrigation period	06.07	29.07	21.08				1-2-1	3432
	Irrigation interval, days		23	23					
	Irrigation rate, m^3/ha	680	933	948	871				
3	Irrigation period	20.06	08.07	25.07	18.08			1-2-1	2867
	Irrigation interval, days		18	17	24				
	Irrigation rate, m^3/ha	638	658	689	882				
4	Irrigation period	19.06	11.07	03.08	30.08			1-2-1	3772
	Irrigation interval, days		20	23	27				
	Irrigation rate, m^3/ha	871	855	914	1132				

To determine changes in the depth and mineralization of groundwater levels in the experimental fields, observation wells were installed in all options, where groundwater levels were measured every 10 days and chemical samples were chemically analyzed (Figure 1).

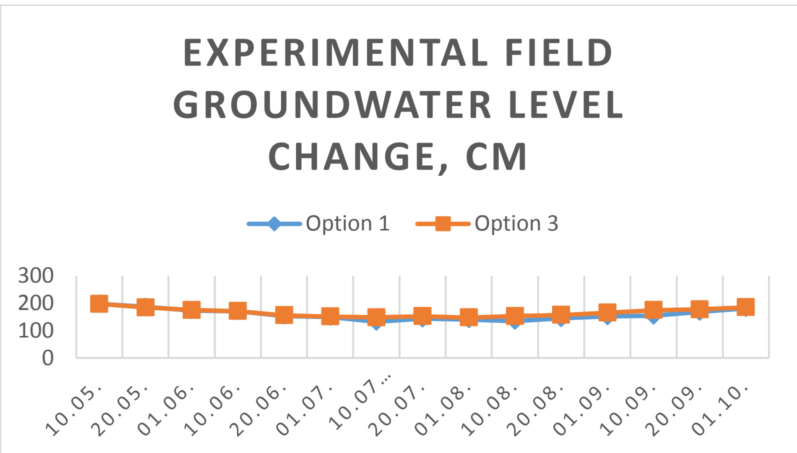

Figure 1. Changes in the average groundwater level for 2018-2020, cm

Volume-2
Issue-1
DOI 10.5281/zenodo.6557583

The study of the salt regime of the soil showed that the amount of chlorine ions relative to the weight of the soil at the beginning of the growing season in the topsoil (0-30 cm) is 0.010-0.012%, in the active layer of the soil (0-100 cm) 0.009-0.011%. At the end of the growing season in the tillage layer (0-30 cm) the amount of chloride ion relative to the weight of the soil was 0.023-0.024%, in the active layer of the soil (0-100 cm) 0.017-0.020%. The dry residue at the beginning of the vegetation in the plowing layer was 0.192-1.96%, and in the active layer of the soil was 0.167-1.72%. The dry residue at the end of the growing season in the tillage layer was 0.401-0.412%, and in the active layer of the soil was 0.352-0.362%. The coefficient of seasonal salt accumulation in the driving layer was 2.0-2.40 on the chloride ion and 2.01-2.15 on the dry residue. In the active 0–100 cm layer of soil was 1.82–1.90 and 2.05–2.18, respectively.

Phenological observations on the growth and development of cotton show that maintaining an optimal water regime in the root spreading layers of the plant in saline or saline soils depends on the composition and amount of water-soluble salts in the soil, which determines the direction of physiological processes in plant bodies. In such areas, the main period of cotton cultivation is the flowering and fruiting phase of cotton.

In experiments, the effect of irrigation regimes on the growth and development of cotton was studied through phenological observations (Table 2).

Table 2. The effect of irrigation regimes on the growth and development of cotton

Options	Seedling thickness, thousand pieces	Real sheet, cm	Cotton height, cm				Number of harvested branches, pieces		Number of pieces, pcs			Seedling thickness, thousand pieces
	1.06	1.06	1.06	1.07	1.08	1.09	1.07	1.08	1.08	1.09	1.09 opening	1.09
2018												
1	100,6	3,5	10,1	34,6	80,9	95,3	6,6	10,4	6,1	10,2	2,1	98,5
2	100,8	3,6	11,0	30,7	72,8	81,8	7,2	10,9	6,3	10,7	2,2	99,1
3	100,8	3,7	11,0	32,7	78,8	87,8	7,2	11,3	6,8	11,2	2,8	99,7
4	100,3	3,4	10,6	33,3	79,9	91,1	7,2	10,7	6,6	10,4	2,3	99,3
2019												
1	97,4	3,2	9,1	36,5	82,6	98,7	6,3	10,1	5,7	9,7	2,0	95,2
2	98,6	3,4	9,0	36,4	70,2	82,5	6,2	10,4	5,6	10,0	2,1	96,4
3	98,4	3,5	9,1	36,4	76,4	88,9	6,4	10,9	6,3	10,5	2,6	96,9
4	97,9	3,3	9,2	37,1	78,3	92,5	6,3	10,5	6,1	10,3	2,2	95,5
2020												
1	100,0	3,7	10,3	38,2	92,4	98,9	6,1	10,3	5,4	9,8	2,1	96,5
2	100,5	3,8	11,1	40,5	71,6	82,8	6,2	10,6	5,7	10,1	2,2	97,2
3	100,6	3,6	11,2	42,4	77,2	90,4	6,5	10,8	6,0	10,4	2,5	98,7
4	100,4	3,5	10,6	40,6	77,4	93,7	6,4	10,7	5,9	10,2	2,3	97,8

According to Table 4, in the 3rd variant of the experiment, as of September 1, the length of the cotton was 87.8-90.4 cm, the number of branches was 10.8-11.3, the number of pods was 10.4-11.2, and the number of open buds The number of branches was 0.5-0.9, the number of pods was 0.5-0.8, and the number of pods opened on September 1 was 0.4-0. There were 7 more.

Volume-2
Issue-1
DOI 10.5281/zenodo.6557583

The thickness, mechanical composition and current state of the groundwater table in the aeration layer of irrigated lands of South Karakalpakstan were analyzed according to the data of the Amelioration Expedition under the Lower Amudarya Irrigation Basin Department. The map of the administrative territories of Amudarya, Ellikkala, Turtkul and Beruni districts of South Karakalpakstan (scale 1: 50000) and observation wells of the expedition included in it were used. According to the data of soil-lithological sections from the "passport" of observation wells and the average perennial indicators of groundwater level in the vegetation period for each observation well of the reclamation expedition, irrigated lands of Amudarya, Ellikkala, Turtkul and Beruni districts are mainly 6: IV, V, VI, Hydromodule VII, VIII and IX belong to the regions. (Table 3)

Table 3. Distribution of irrigated lands of South Karakalpakstan districts by hydromodular regions, ha.

stricts	Irrigated area, thousand ha,	Observation wells, pcs	Observation area, thousand ha	Hydromodule regions								
				I	II	III	IV	V	VI	VII	VIII	IX
runiy	33,32	318	33,10	0,51	0,99	0,00	2,13	2,28	1,29	34,18	27,79	30,82

Digital map of the distribution of 3 types of soils (light, medium and heavy sand) with a mechanical composition in the Amudarya basin, based on passports of observation wells installed to monitor the dynamics of groundwater in each district and the results of field research, ArcGIS program [19,20] Electronic maps of hydromodule zoning of irrigated lands of Beruni districts of South Karakalpakstan were created (Figures 2,).

Volume-2
Issue-1
DOI 10.5281/zenodo.6557583

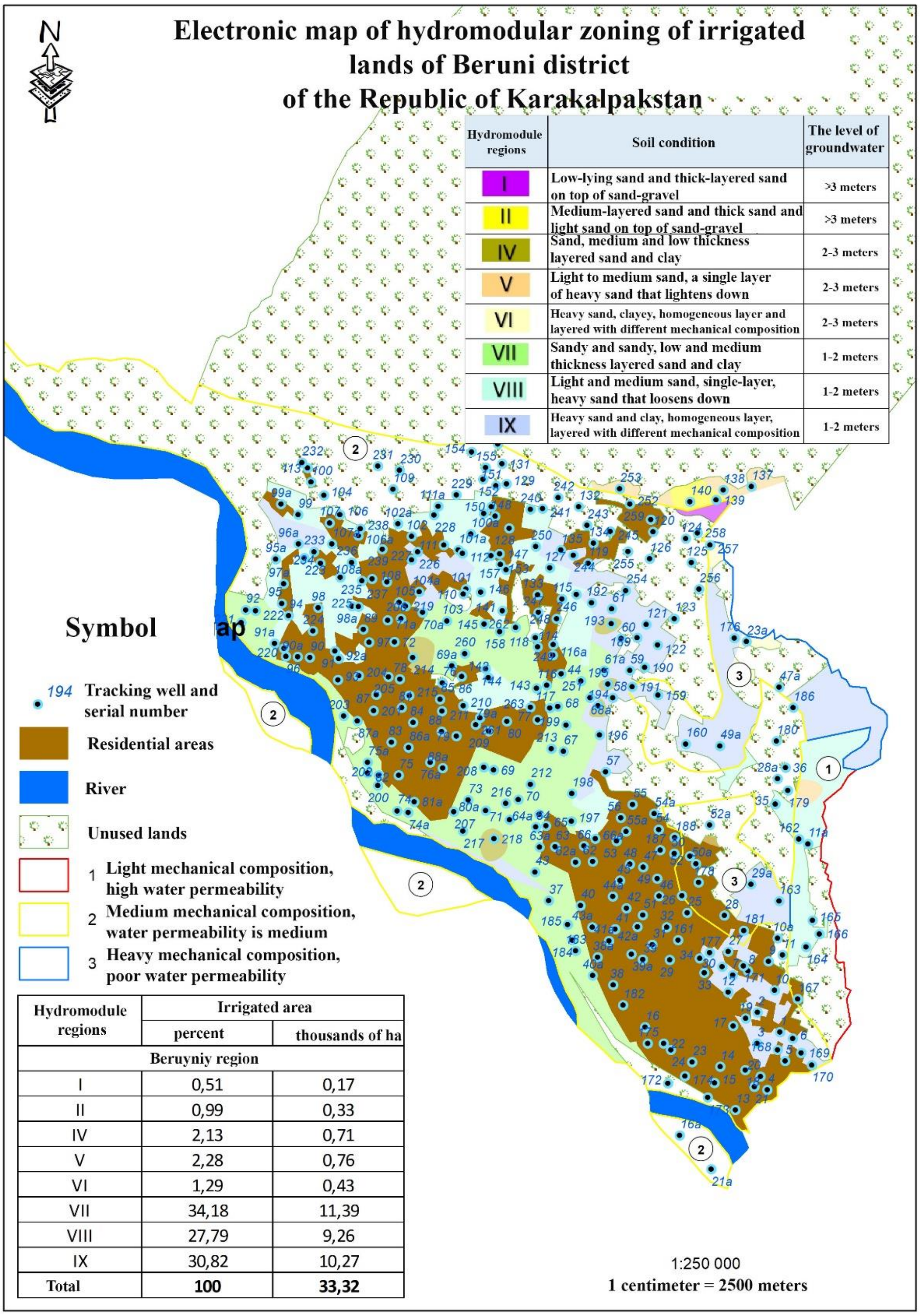

Figure 2. Electronic map of hydromodular zoning of irrigated lands of Beruni district of the Republic of Karakalpakstan.

Conclusions. The following conclusions can be drawn from field experiments on the development of scientifically based irrigation procedures for cotton in alluvial soils of irrigated meadows, which have long been irrigated:

1. At the beginning of the experiments, the volumetric weight of the soil was 1.35-1.37 g/cm^3 in the 0-30 cm layer and 1.37-1.39 g/cm^3 in the 0-100 cm layer. At the end of the growing season, the

Volume-2
Issue-1
DOI 10.5281/zenodo.6557583
volumetric weight of the soil increased in all experiments under the influence of cotton care and various irrigation regimes. The minimum soil compaction was 0.01-0.02 g/cm^3.

2. At the beginning of the experiments, the water permeability of the soil for 6 hours was 1258-1300 m3 / ha or 0.349-0.361 mm / min. By the end of the growing season, the water permeability of the soil decreased in all variants due to the increase in soil volume, but in the case of cotton, the pre-irrigation soil moisture was limited to 70-80-60% of the field moisture capacity of 126-130 m3 / ha, 0.035-0.036 mm / min. was found to be less.

3. In terms of cotton yield, the best results were recorded in option 3: the yield was 38.2-38.9 t/ha, ie 3.8-4.1 t/ha higher than the control and the minimum for 1 quintal of cotton: 71, 7-74.7 m^3 of river water was consumed.

4. Irrigated lands of the southern districts of the Republic of Karakalpakstan belong to one soil-climatic zone - desert zone, within three soil-ameliorative oblasts within this zone. Irrigated lands of the southern districts of the Republic of Karakalpakstan are divided into 25.78% - VII, 34.37% - VIII and 21.86% - IX hydromodular zones in the aeration layer according to the thickness of the soil, mechanical composition, location and groundwater level.

5. Electronic maps of irrigated lands of the southern districts of the Republic of Karakalpakstan were created using GAT technology and ArcGIS program.

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Volume-2
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