

Hydro-Physical Parameters of Irrigation Zone Soils of the Khashuri Municipality in Shida Kartli Region of Georgia

Malkhaz Dolidze*, Olga Kharashvili**, Jemal Sadagashvili*

* Department of Agroengineering, Georgian Technical University, Tbilisi, Georgia

** Department of Irrigation and Drainage at the Tsotne Mirtskhulava Water Management Institute, Georgian Technical University, Tbilisi, Georgia

(Presented by Academy Member Avtandil Korakhashvili)

Abstract. The correct solution to the issue of crops irrigation agricultural irrigated areas is one of the main measures for obtaining high and solid harvest. During the correct selection of the irrigation mode, it is necessary to take into account the hydro-physical indicators of the soil, and apply both traditional and resource-saving measures. The Khashuri Municipality of Shida Kartli region belongs to the first agro-climatic zone. Precipitation starts to increase in spring, to decrease in July to August, and to increase in autumn. Determining the melioration indicators of the irrigation zone's soils of the Khashuri Municipality in Shida Kartli in order to clarify the irrigation regime is very relevant. The rise in world wheat prices created a perfectly logical motivation to increase wheat field. Considering hydro-physical and climatic conditions of the soil in the village of Vaka of the Khashuri Municipality, the early maturing spring wheat variety "Amikuri" was sown. The soils in the village include: Black soil: weakly flaky, cloddy, heavy clay soil formed on heavy calcareous clay; Sward forest brown-gray clay soil: diluvial loamy clay, heavy loam and light loam; Dark-gray heavy loam soil: sword forest formed on calcareous clay. It is worth noting that the 0.5-meter layer is characterized by a particularly high filterability, where the filtration coefficient ranges within 0.0011430-0.003637 cm/s. The filtration coefficient decreases from the depth of 0.5 m, but still represents the significant value (0.002135 cm/s). Based on appropriate experimental data, the soils of the area under consideration are grouped into three categories from the melioration point of view. For each category, the values of melioration indicators are given. Based on the received data, the irrigation norm is established and the minimum amount of soil moisture is determined, which determines time of start the next irrigation. © 2025 Bull. Georg. Natl. Acad. Sci.

Keywords: soil, volumetric mass, marginal water capacity, maximum molecular water capacity, irrigation rate, Amikus

Introduction

Climatic and agro-climatic resources of small-land Georgia are of vital importance. The variety of cli-

mate in the territory of Georgia is created by the common influence of the solar radiation. Caucasus Mountains, the Black and Caspian Seas, the trans-

formation of air masses, conditions of complex mountainous terrain and other climate-forming factors.

Human life, practical activities, and almost all farming activities are directly related to the soil and climatic conditions. Skillful use of soil-climatic conditions on the scientific basis is most important for agricultural production. Consideration of soil-climatic resources will help farmers to get a quality, guaranteed harvest of agricultural crops (Gubeladze & Kharaishvili, 2020).

In all developed countries, effective management of agriculture without irrigation regime is unthinkable. During the correct selection of the irrigation mode, it is necessary to take into account the hydro-physical indicators of the soil, as using traditional and resource-saving measures.

The Khashuri Municipality of Shida Kartli region belongs to the first agro-climatic zone. Precipitation starts to increase from spring, to decrease from July to August, and to increase in autumn. Relative air humidity is important for normal photosynthesis of agricultural crops, which is considered secondary supporting factor for plants, after the main agroclimatic resources (heat, light, moisture) (Gubeladze & Kharaishvili, 2018; Kharaishvili & Baidauri, 2022).

Approximately 70% of the world's water demand comes from irrigation, so the determination of water demand depends a lot on the study and correct determination of soil properties of irrigated areas.

The role of water in the agriculture remains irreplaceable. There is no doubt about the role of water in our well-being, the need and dependence on it is eternal.

The correct solution to the issue of irrigation of agricultural crops in irrigated areas is one of the main measures for obtaining high and solid harvest. The correct selection of irrigation mode and technique elements of agricultural crops mainly depend on the hydrophysical properties of soils. In this regard, the hydrophysical parameters of soils of the Khashuri Municipality were studied in the Agricul-

tural Reclamation Laboratory of the Faculty of Agricultural Sciences and Biosystems Engineering of Georgian Technical University (Kharaishvili, 2019).

Georgia is considered the epicenter of the origin and evolution of the wheat genus within the genetic center of Pre-Asia. It is believed that traditional Georgian crop varieties should be planted in places of historical origin, taking into account of appropriate soil and climatic conditions.

The method of Prof. G. T. Selyaninov is used to assess water supply of the Khashuri Municipality. According to the research, the sum of temperatures of three months of summer, reduced by ten times, is taken as an indicator of water consumption (Kharaishvili, 2019):

$$K = \frac{\sum p}{\sum t:10}. \quad (1)$$

According to G. T. Selyaninov, in Georgia, there were: Dry, especially irrigated zone, water balance at $K = \frac{\sum p}{\sum t:10} < 0.6$; Severe drought, water balance up to 0.6-0.8; Drought – water balance 0.8-1.0; Insufficient moisture – water balance 1.0-1.2; Moderately humid – water balance 1.2-1.6; Moist, water balance 1.6-2.0; Wetland water balance 2.0-2.4; Too moist, water balance >2.4 .

At the time when the sum water balance temperatures reaches 1002.8°C, atmospheric precipitation is 206 mm. $K = \frac{\sum p}{\sum t:10} = \frac{206}{1002.8} = 0.21$.

The Khashuri Municipality belongs to the dry especially irrigated zone, water balance <0.21 .

For the reclamation assessment of the soils of the Khashuri Municipality in terms of water-physical properties, marginal water capacity, bulk density, maximum molecular moisture and filtration coefficient necessary to clarify the reclamation measures were studied (Gubeladze & Kharaishvili, 2018; Kharaishvili, 2019).

In order to determine soil improvement indicators, soil samples were taken in the form of

monoliths in not dissolved state (height 16 cm, diameter 12 cm). Monoliths were taken in order at the following depths: 0-16 cm; 16-32 cm; 32-48 cm and 48-64 cm.

The soils of The Khashuri Municipality are divided according to their hydrophysical properties: Black soil: weakly flaky, cloddy, heavy clay soil on heavy calcareous clay; Sward forest brown gray clay soil: diluvial loamy clay, heavy loam and light loam; Dark gray heavy loam soil of sword forest on calcareous clay.

1. Black soil: weakly flaky cloddy, heavy clay soil on heavy calcareous clay is spread in the west of The Khashuri Municipality, in the village of Kvishkheta; To the north – the fields of Tezeri village and the main channel of the Tashiskari irrigation system; To the east there are fields of village of Vaka, to the south is the river Suramula to Khashuri, and then Tbilisi-Borjomi highway (Kharashvili et al., 2019).

According to the given data (Table 1), from the point of view of irrigation melioration, two soil areas can be distinguished from the mentioned group of soils according to their hydrophysical properties.

The first massif of the soil is characterized by the data of the cut. It is located west of Khashuri, occupies the area between Tbilisi-Batumi and Tbilisi-Borjomi railways. Soils are loose from the

surface. Their volumetric weight ranges from 0.92 to 1.12 g/cm³, the average value at the depth of 0-70 cm is equal to 1.04, according to the maximum molecular, marginal water capacity, the soils are characterized by quite good indicators, which is an indicator of the ability to retain a large amount of water. The marginal water capacity ranges from 47.34 to 54.83%, on all types of soil (the obtained data are included in Table 1). Irrigation rate was determined (according to Dependency 2)

$$m = 100 \cdot H \alpha (r_{\text{marg}} - r_{\text{marg}} 80\%) \text{ m}^3/\text{ha}, \quad (2)$$

where H is the active layer of the soil, where the main part of plant root system is spread. Usual depth of active layer is considered to be: for vegetables – 0.3-0.5 m; for field crops – 0.6-0.8 m; for perennial crops – 0.7-0.8 m; α – volumetric mass of soil, g/cm³; r_{marg} – marginal water capacity, %; $r_{\text{marg}} 80\%$ – the amount of moisture allowed in the soil before watering, % (Kharashvili, 2019; Meladze G. & Meladze M., 2010).

The value of marginal water capacity determines the need for high irrigation norm characteristic of these soils, which is $m = 100 \cdot 0.7 \cdot 1.04 (50.40 - 40.32 \cdot 80\%) = 733 \text{ m}^3/\text{ha}$; according to the data obtained, it is about 700 m³/ha is equal to the Data on the filtration coefficient of these soils are particularly noteworthy. As can be seen from these

Table 1. Black soil weakly flaky cloddy heavy clay soils' hydrophysical properties

Sampling location	Sampling depth, cm	Volume weight, g/cm ³	Marginal water capacity by weight, %	Maximum molecular moisture, %	Filtration coefficient	Watering norm, m ³ /ha
Village Vaka Cut 1	0-16	0.92	50.47	15.79	0.011430	734
	16-32	1.06	48.66	17.51	0.003637	
	32-48	1.07	54.83	22.01	0.006777	
	48-64	1.12	47.34	18.91	0.002135	
	0-70	1.04	50.40	18.55	-	
Village Vaka Cut 2	0-16	0.95	46.07	22.54	0.000019	776
	16-32	1.21	42.77	21.64	0.000006	
	32-48	1.17	45.83	24.80	0.000023	
	48-64	1.17	47.07	20.85	0.000001	
	0-70	1.12	45.43	22.46	-	
Village Vaka Cut 3	0-16	0.95	46.53	20.40	0.000077	738
	16-32	1.06	48.62	22.50	0.000047	
	32-48	1.21	42.55	22.63	0.000044	
	48-64	1.22	39.46	21.64	0.000151	
	0-70	1.11	44.29	21.74	-	

data, soils are characterized by the best filterability. The 0.5-meter layer is characterized by a particularly high filterability, where the filtration coefficient ranges within 0.0011430-0.003637 cm/s. The filtration coefficient decreases from the depth of 0.5 m, but still represents the significant value (0.002135 cm/s).

Special attention is needed when selecting watering method and elements of the irrigation technique. The elements of the irrigation technique should be selected in such a way that water given for irrigation does not have been to stay on the area for a long time, i.e., it will be necessary to increase the irrigation flow as much as possible, which will significantly reduce duration of irrigation per hectare (Meladze G. & Meladze M., 2010).

The second array of soil, which started from the north of river Suramula, extends to the fields of village Vaka is characterized by the data of the second and third cut. Compared to the first cut, it is characterized by quite different physical and water properties. The volumetric weight of these soils in the upper arable horizon is equal to 0.95, which increases with depth, but is still of small value. High maximum molecular humidity of soils (20.40-24.80%) is important, which is the indicator of presence a large amount of water unusable for plants in these soils. This situation can mislead us when determining the need for irrigation, especially if we visually assess the soil moisture supply, because soils characterized by high maximum molecular moisture may seem sufficiently moist

when most of the moisture in the soil is in a state that cannot be absorbed by plant. These soils, at the entire depth, are characterized by high rates of marginal water capacity – 39.46-47.07%. The irrigation norm was determined at 700 m³/ha. Water permeability of soils is given in the form of filtration coefficient (Table 1). In the case of cuts 1 and 2, it is characterized by a small value. In the case of 3rd cut, it is within 0.000019-0.000001 cm/s (Kharaishvili, 2019).

The presence of a low filtration coefficient in soils is caused by the sodium content in the soil's compacting complex and the absence of carbonate in the upper layers. As a result, soil structural aggregates are characterized by less resistance to water, breaking down upon contact with water, and becoming poor water conductors. This factor is worth attention during the selection of irrigation method and technical elements. Therefore, it is necessary to carry out irrigation with horizontal filtration, in the case of large slopes, by reducing the irrigation flow to the minimum, by using oblique channels, by increasing of irrigation flow in flat areas, by using deep compacted channels.

2. Dark gray heavy loam soil of sword forest on calcareous clay is spread: in the fields of villages Vaka and Tsromi, at a depth of 0.5 m, the soil is dark gray in color, in the lower part it has a crumb structure.

The volumetric weight of soils in the 0-16 cm layer (Table 2) ranges from 0.92 to 1.36 g/cm³. These soils are characterized by high values of

Table 2. Hydrophysical properties of dark gray heavy loam soil of sword forest's

Sampling location	Sampling depth, cm	Volume weight, g/cm ³	Marginal water capacity by weight, %	Maximum molecular moisture, %	Filtration coefficient	Watering norm, m ³ /ha
Village Vaka Cut 1	0-16	0.97	44.39	15.85	0.000362	643
	16-32	1.23	38.28	17.51	0.001535	
	32-48	1.32	36.78	20.90	0.000013	
	48-64	1.36	31.12	-	0.000005	
	0-70	1.22	37.64	-		
Village Tsromi Cut 2	0-16	0.92	46.41	19.56	0.002893	721
	16-32	1.26	46.04	-	0.000076	
	32-48	1.33	37.48	19.79	0.000005	
	48-64	1.20	44.98	19.15	0.000129	
	0-70	1.18	43.73			

maximum molecular moisture and marginal water capacity. Marginal water capacity in 0.64 m layer is 31.12-46.41%. Marginal water capacity data determines the need of high irrigation norm for these soils, which is 650 m³ per hectare based on the use of received data. According to the filtration properties, soil profile is varied throughout to the depth. The filtration coefficient of 0-16 cm layer of soils in the vicinity of Tsromi village decreases by 0.002893 cm/s, in the 16-32 cm layer by 0.000076 cm/s. It decreases more in the 32-48 cm layer and amounts to 0.000005 cm/s, and increases again in the 48-64 m layer. The picture is almost the same in other cases. Only difference is in the absolute index of filtering coefficient. Due to the obtained filterability, when irrigating these soils, it will be necessary to carry out irrigation in the manner of horizontal filtration, in the case of large slopes, using oblique cuttings, in flat areas, deep compacted cuttings, provided that the water has to stay in the cuttings for a long time, so that it is absorbed by the soil in sufficient quantity.

After determining hydrophysical parameters of the Khashuri Municipality soils, in the village of Vaka, at M. Noniashvili's farm has been sown Austrian wheat variety "Amikus. Crop's excellent standing ability qualifies as a prerequisite for high yield. The specific share of autumn wheat is much higher than spring forms. Winter wheat uses soil moisture better, develops strong root system, yields are more stable, and is a long-day plant. Flowering takes place intensively under the long lighting conditions. Duration of flowering is one week. Grain ripening depends on the variety and climatic conditions. Grain ripening ends earlier in dry hot conditions (Kharashvili & Baidauri, 2022).



Fig. 1. Agricultural fields of the village of Vaka.



Fig. 2. Wheat variety *amikus*.

The field is cultivated several months before sowing. Seed sowing depth is 5-8 cm. Germination begins at 3-4°C. Sowing dates are not the same in the different regions, because the regions have different climatic and natural conditions. In lowland regions, winter colds start late and sowing is later, from 01.10 to 30.10. In the highlands, sowing should start from 05-10.09 to 30.09 (Meladze G. & Meladze M., 2010).

In the village of Vaka, the Khashuri Municipality, taking into account the results of hydro-physical and climatic conditions of soil, the early-maturing spring wheat variety Amikuri is irrigated only once with the irrigation norm of 650 m³/ha, which is significantly different from the current one. It should be noted that wheat spike ripened well, no matter how surprising it may seem to us, more wheat arrived than expected, 5-6 tons per hectare, as a result of milling, 1st quality flour was obtained, which is quite a good result.

Conclusion

According to the obtained data, it can be concluded that for the meliorational characterization of the soil, in order to select irrigation melioration measures, main attention should be paid to the hydro-physical properties of soil – volumetric weight, maximum water capacity, maximum molecular moisture, filtration coefficient, knowledge of which is necessary for selection of irrigation melioration measures, specification of melioration measures, implementation in the case. The accepted irrigation norms are significantly different from the existing recommended norms, which will help to save irrigation water, to properly regulate irrigation regime of farmers to get abundant harvest.

აგროტექნოლოგია

საქართველოს შიდა ქართლის რეგიონის ხაშურის მუნიციპალიტეტის სარწყავი ზონის ნიადაგების ჰიდროფიზიკური მაჩვენებლები

მ. დოლიძე*, ო. ხარაიშვილი**, ჯ. სადალაშვილი*

* საქართველოს ტექნიკური უნივერსიტეტი, აგროინჟინერიის დეპარტამენტი, თბილისი, საქართველო

** საქართველოს ტექნიკური უნივერსიტეტი, ცოტნე მირცხულავას სახ. წყალთა მეურნეობის ინსტიტუტი, ირიგაციისა და დრენაჟის განყოფილება, თბილისი, საქართველო

(წარმოდგენილია აკადემიის წევრის ა. კორახაშვილის მიერ)

სტატია ეხება შიდა ქართლის ხაშურის მუნიციპალიტეტის სარწყავი ზონის ნიადაგების მელიორაციული მაჩვენებლების დადგენას მორწყვის რეჟიმის დაზუსტების მიზნით. მსოფლიოში ხორბლის ფასების ზრდამ გააჩინა ხორბლის ნათესების გაზრდის სრულიად ლოგიკური მოტივაცია. ხაშურის მუნიციპალიტეტის სოფელ ვაყაში ნიადაგის ჰიდროფიზიკური, კლიმატური პირობების შესწავლის გათვალისწინებით, დათესილია საადრეო სიმწიფის უფხო საშემოდგომო ხორბალი „ამიკური“. სათანადო ექსპერიმენტული მონაცემების საფუძველზე განსაზღვრული ზონის ნიადაგები, მელიორაციული თვალსაზრისით, დაჯგუფებულია სამ კატეგორიად. თითოეული კატეგორიისთვის მოყვანილია მელიორაციული მაჩვენებლების მნიშვნელობები. მიღებული მონაცემების მიხედვით, დადგენილია მორწყვის ნორმა, განსაზღვრულია ნიადაგის ტენის ის მინიმალური რაოდენობა, რომელიც განსაზღვრავს მორიგი რწყვის დაწყების დროს.

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