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Determination of Wheat Water Requirements in the Lomtagora Region (Kvemo Kartli) Considering Soil and Climatic Conditions

Malkhaz Dolidze Georgian Technical University, Faculty of Agrarian Sciences and Chemical Technologies, Professor, Georgia
E-mail: pmkavshiri@gmail.com

Maia Lomishvili Georgian Technical University, Faculty of Agrarian Sciences and Chemical Technologies, Associate Professor, Georgia
E-mail: m.lomishvili@gtu.ge

Shorena Kupreishvili Georgian Technical University, Faculty of Agrarian Sciences and Chemical Technologies, Associate Professor, Georgia
E-mail: Sh.Kupreishvili@gtu.ge

Aleksandre Tsitsagi Georgian Technical University, Faculty of Agrarian Sciences and Chemical Technologies, Associate Professor, Georgia
E-mail: alex.tsitsagi@gmail.com

Reviewers:

T. Odilavadze, Georgian Technical University, Faculty of chemical technologies, Associate Professor
E-mail: alex.tsitsagi@gmail.com

T. Supatashvili, Georgian Technical University, Faculty of chemical technologies, Associate Professor
E-mail: tamunasupatashvili@gmail.com

Abstract.

One of the main tasks of intensification of agricultural production is to increase the yield of grain and technical crops, through the introduction of modern agrotechnical measures, in irrigation farming. At this time, it is necessary to assess the impact of various agrotechnical measures on the background of hydrometeorological conditions throughout the entire period of vegetation of agricultural crops. From the numerous hydrometeorological factors on the dynamic process of growth and development of agricultural crops, special importance is acquired by such complex characteristics as evapotransporation, Because it is the main expenditure component of the water balance of growth and development of the plant. The study of the process of evapotransporation and its contributing factors for different climatic conditions is the main indicator for the optimal distribution of water resources and the water supply of agricultural crops.

In the conditions of irrigation farming, there are many mathematical models of the theoretical nature of determining the watering regime of agricultural crops, but most accurately the parameters of the watering regime can be determined using empirical dependencies that rely on direct observations. Based on the above, the specification of the parameters of the Watering mode considering the characteristics of evapotranspiration and soil-grounding is relevant.

The diversity and complexity of the processes during the targeted regulation of the properties of the test polygon Lomtagora soil-ground leads to the diversity and multipurpose of related studies. The methodology of the studies included both laboratory, experimental and field-based experience - analysis of weather data and calculation of the intensity of evapotranspiration, drought rates and periods of excess water according to the possible need for irrigation to detect plowing and harvesting days;

The paper proposes a reporting dependence on the determination of control evapotranspiration on the example of Autumn wheat of Marneuli district; As a result of the analysis of numerous dependencies in the determination of evapotranspiration, the feasibility of using the Penman-Montein method for its quantitative evaluation is substantiated, the FAO recommends that based on the results of the study conducted by the European Union Research Institutes, As the only standard way to define evapotranspiration is to perfectly reflect a multifactor event; The determination of evapotranspiration on a specific example is carried out, from which it is established that excess water at the beginning of the season can delay the sowing of wheat or cause disease; Water shortages in the middle of the season reduce growth and yield; Reduced evapotranspiration inhibits the ripening of wheat, harvesting.

The data obtained will provide great assistance to agricultural specialists with information on the consequences of expected droughts and the impact on vulnerable crops in particular, wheat.

Keywords: Agroclimate parameters; Climate change; Evapotranspiration; Period of vegetation.

Introduction

In the conditions of irrigation farming, there are many mathematical models of the theoretical nature of determining the watering regime of agricultural crops, but most accurately the parameters of the watering regime can be determined using empirical dependencies that rely on direct observations. Based on the above, the specification of the parameters of the Watering mode considering the characteristics of evapotranspiration and soil-grounding is relevant.

Main Part

Agricultural production is closely related to climate change, which increases the risks and negatively affects the yield of agricultural crops as well as on economic and social prosperity.

To do this, it is important to promote reasonable climatic agriculture, adaptation to climate change and promoting climate change mitigation.

In modern conditions, the problems caused by global climate change were presented with special clarity. Ecosystems formed over millennia, under altered temperature and non-favourable moisture-regimes, have begun to rupture. The new ecological environment, changes in the boundaries of agroclimate areas, required new approaches to agricultural production, the need for a new vision for established stereotypes.

Climate change for the agricultural sector has led to changes in the following agroclimate parameters: The sum of the active temperatures, the amount of precipitation that came during the vegetation period and the average value of the absolute minimum of temperature. On the conditions of the farming/agricultural irrigation, both the number of crops and the rate of stability are increasing. As a result of perfect irrigation, the yield of autumn wheat can be increased by 2-3 times, such an increase means an average yield of 6-8 t/ha [1,2].

In Georgia, the area of wheat fields is almost non irrigated, due to which its yield falls significantly in droughty years. The choice of waterless wheat crops is extremely scarce. That is why it is necessary to develop such an integrated model of the water irrigations mode that will allow us to take into account agroclimate data when determining the parameters of the irrigation and soil-ground characteristics with maximum reliability of environmental software harvesting and maximum preservation of the ecological equilibrium of the environment [3].

Based on the search for information, after consulting with the farmer Kakha Lashkhi, who runs the firm "Lomtagora", we selected the test polygon "Plot - 1.2". The main direction of the enterprise activity is the selection-seedling of wheat and corn and the production of meadow crops .

If the global warming process continues, temperatures can rise further and reach +2°C and even more after three to four decades. Therefore, the temperatures in question are taken into account and they need to be known in advance what effect they will have on the agrarian sector of the country. an increase in temperature at such a pace can have a negative impact on currently existing, adapted plants, especially in lowland areas to an altitude of 300-600 m above sea level, because, in such places greater amount of heat accumulates. Therefore, susceptibility to high temperatures supposed to complicate productivity of such vulnerable crops as cereals, fruit trees, vegetables [4].

Based on the above agricultural specialists are necessary to know in advance about the expected droughts in order to get prepared for the forthcoming challenges.

As a result of our observations, table #1 provides data on the soil moisture of the test polygon (from 01/09/2022 to 20/09/2022), temperature and atmospheric precipitation data, according these data prepared suitable graphs (Figure 1, 2).

The numbers of relative humidity, wind speed, cloudy, sunny and rainy days were processed and corresponding graphs were constructed (Figure 3).

Table 1.

the soil moisture of the test polygon (from 01//2022 to 20/09/2022), temperature and atmospheric precipitation data.

number, month, year	soil moisture, 0–70,0 mm	soil moisture,7 0,0–280,0 mm	soil moisture, 280,0-1000,0 mm	Average air temperature, °C	Minimum air temperature, °C	Maximum air temperature, °C	Precipitations, mm	Snow thickness, mm
2021/10	72	67	46	11,5	8,3	16	2,6	0
2021/11	66	62	50	8,7	5,3	14	0,69	0
2021/12	61	60	50	4,4	1,1	9,7	0,27	0
2022/01	52	54	49	3,1	-1	9	0,1	0
2022/02	46	47	47	6	1,4	12	0,14	0
2022/03	61	50	44	4	0,3	8,1	5	6,5
2022/04	50	43	36	14	9	21	0,86	0

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2022/05	54	51	39	16	11	22	1,7	0
2022/06	48	41	37	23	18	29	2,3	0
2022/07	35	39	39	25	18	32	0,12	0
2022/08	32	35	35	26	20	32	0,1	0
2022/09	38	33	31	22	16	27	0,6	0
sum	416	393	357	139,1	92,7	192,1	10,92	6,5

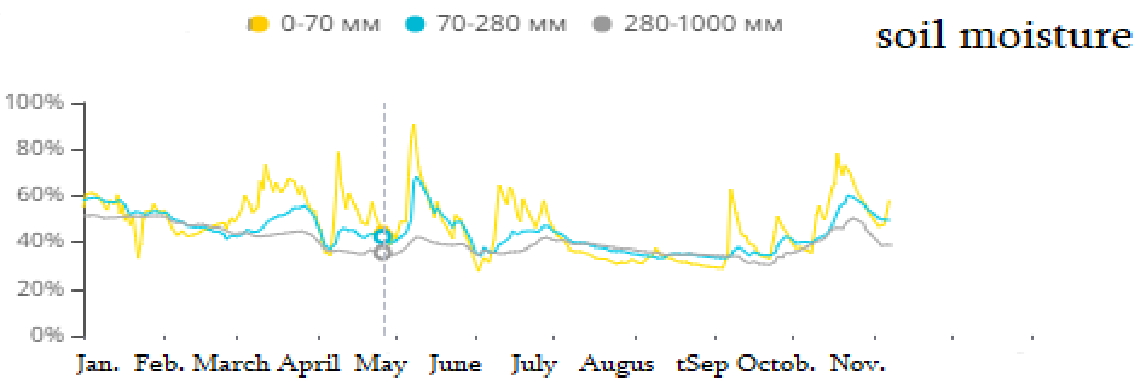

Figure 1. Schedule depicting soil moisture, according to table #1 data, 2022.

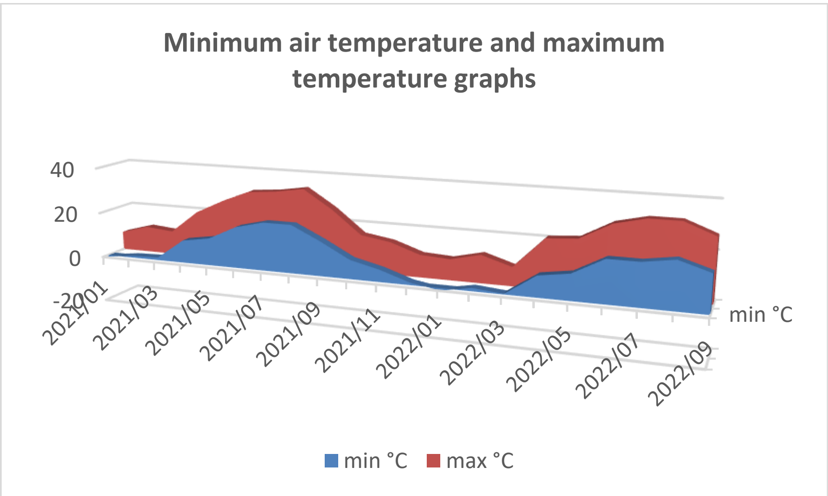

Figure 2. Minimum air temperature and maximum temperature graphs.

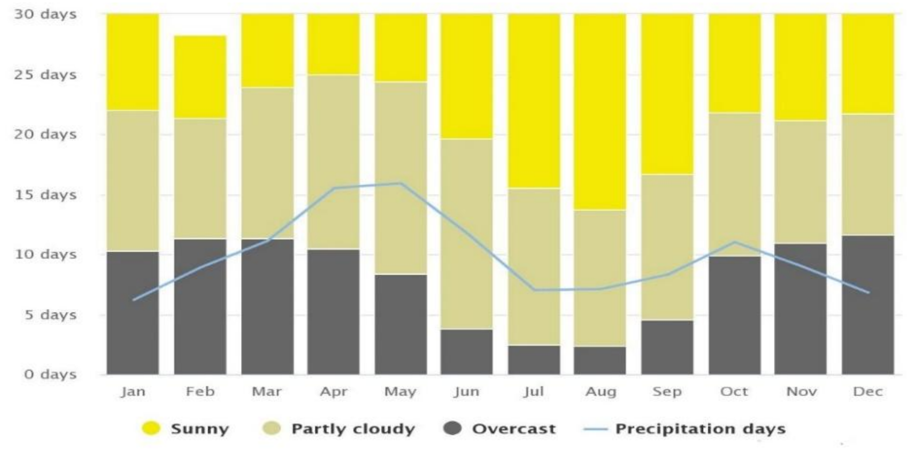

Figure 3. Cloudy, sunny, and precipitation days.

Based on the results of the study carried out by the European Research Institutes, the FAO recommended the Penman-Montein method as the only standard way to determine evapotranspiration, the reporting attitude of which has the following look:

$$ET_0 = \frac{0.408 \cdot \Delta \cdot (Rn - G) + \gamma \cdot \frac{900}{T + 273} \cdot U_2 \cdot (e_s - e_a)}{\Delta + \gamma \cdot (1 + 0.34 \cdot u_2)}$$

where: ET_0 is a control evapotranspiration (mm.day-1); Rn - culture surface radiation neto (MJм-2 days-1); G - the density of the heat flow of the soil (MJм-2 days-1); T - medium day-night temperature (0C); u_2 - wind speed up to 2 m in height (ms-1); Δ - saturated steam pressure curve rock (kPa oC-1); γ - psychometric constant (kPa oC-1); e_s - actual vapor pressure (kPa); e_a- saturated vapor pressure (kPa); (e_s - e_a) - saturated vapor pressure deficiency (kPa).

Monthly evapotranspiration is calculated by the Penman-Montein method [5, 6]:

Table 2.

Determination of ETo with mean monthly data Given the monthly average climatic data of April of of the Lomtagora (region of Kvemo Kartli).

Determination of ETo with mean monthly data Given the monthly average climatic data of April of of the Lomtagora (region of Kvemo Kartli) located at 41⁰28' N and at an elevation of 2 m:	
Measured at 2 m For April For March	Monthly average daily maximum temperature (T_{max}) =21⁰ C Monthly average daily minimum temperature (T_{min}) =9⁰ C Monthly average daily vapour pressure (e_a) =1.6 kPa Monthly average daily wind speed (u_2) =14 m/s Monthly average sunshine duration (n) =8.5 hours/day Mean monthly average temperature (Tmonth,i) =14⁰ C Mean monthly average temperature (Tmonth, i-1) =13⁰C

Parameters			
From Slope of vapour pressure curve (Δ) for different temperatures (T)	$T_{mean} = \frac{(Tmax+Tmin)}{2}$= Δ=0.110 kPa/°C	15	^{0}C
From Atmospheric pressure (P) for different altitudes (z) Psychrometric constant (γ) for different altitudes (z)	Altitude =2 m P =105 kPa γ =0,064 kPa/°C		
	$(1 + 0.34u_2)$= $\frac{\Delta}{[\Delta + \gamma(1 + 0.34u_2)]} =$ $\frac{\gamma}{[\Delta + \gamma(1 + 0.34u_2)]} =$ $\frac{900}{(T_{mean} + 273)} \cdot u_2 =$	5,76 0.23 0.13 44	
Vapour pressure deficit			
Saturation vapour pressure (e° (T)) for different temperatures (T)	e°(Tmax) =2,487 kPa e°(Tmin) =1.148 kPa		
- Given	e_s = (2,487+ 1.148)/2 =2 kPa e_a=1.6 Vapour pressure deficit $(e_s - e_a)$=(2 - 1,6) =0.4 kPa		
	Radiation (for month = April)		
J = (for 15 April)	Latitude = 41⁰28'N = (41⁰ +28'/60)=41.47 R_a	41.5 34.1	- °N
- -	$\frac{n}{N} = \frac{6}{13.2}$=0.45 Rs = = $\left(0.25 + 0.50\frac{n}{N}\right)R_a =$ [0.25 + 0.50 (0.45)] 34.1= $R_{so} = \left[(0.75 + \frac{2(otmetka)}{100\ 000}\right]R_a$ $= \left(0,75 + \frac{406}{100000}\right)34.1 =25.58$ $\frac{R_s}{R_{so}} = \frac{16.3}{25.58}$ =0.64 $R_{ns} = 0.77R_s = 0.77 \cdot 16.3$=12.55 T_{max}, K^4=36,71 $\sigma T_{min}, K^4 = 31.08$	16.3	- MJ m-2 day-1 MJ m-2 day-1 MJ m-2 day-1
	$\frac{\sigma T_{max}, K^4 + \sigma T_{min}, K^4}{2}$	32.49	MJ m-2 day-1
	e_a =1,148 $(0.34 - 0.14\sqrt{e_a})$	1.6 0.16	kPa
	$\frac{R_s}{R_{so}}$ =0.64 (1.35$\frac{R_s}{R_{so}}$ – 0.35)= 0.51		

	$R_{nl} = (\frac{\sigma T_{max},K^4 + \sigma T_{min},K^4}{2}) \cdot (0.34 - 0.14\sqrt{e_a})(1.35\frac{R_s}{R_{so}} - 0.35)$= 32.49 · 0.16 · 0.51	2.65	MJ m-2 day-1
	$R_n = R_{ns} - R_{nl} = 12.55 - 2.65 =$	9.9	MJ m-2 day-1
$T_{month-1}$	$G == 0.14(T_{month} - T_{month-1})$=(14-13) · 0,14 $R_n - G = 12.55 - 0,14$ $0.408(R_n - G)$	0.14 12.41 5	MJ m-2 day-1 MJ m-2 day-1 mm/day
Grass reference evapotranspiration			
-	$\left[\frac{\Delta}{\Delta+\gamma(1+0.34u_2)}\right][0.408(R_n - G]$=0.23 · 5 $\left[\frac{\gamma}{\Delta+\gamma(1+0.34u_2)}\right]\left[\frac{900}{T+273}\right]u_2[e_s - e_a)]$=0.13 · 44 ·0,4	1.15 1.3	mm/day mm/day
-	$ET_0 = \frac{0.408(R_n-G)+\gamma\frac{900}{T+273}u_2(e_s-e_a)}{\Delta+\gamma(1+0.34u_2)}$=1.15+1.3	2.45	mm/day

Table 3.

Monthly reference evapotranspiration Penman Monteith

Weather Station: Marneuli (Lomtagora)Height sea level 406 m. Baro metric pressure 970 HPA					Country: Georgia Coordinates: Latitude 41⁰28' Longitude 44⁰49'				
Months	T_{min} ⁰C	T_{max} ⁰C	Relative humidity %	Wind speed	Sunlight Hour	Radiation Kilo Vt – Hour/m2 per month	ET_0 mm.	K_C (mm)	Evapotranspiration of agricultural culture $ET_c = ET_0 \cdot K_C$ (მმ)
October	8.3	16	74	29	10.8	21.4	3.0	0.4	1.2
November	5.3	14	78	32	9.6	15.1	2.7	0.4	1.08
December	1.1	9,7	77	36	9.0	12.4	2.2	1.15	2.53
January	-1	9	75	35	9.3	13.8	1.85	1.15	2.13
February	1.4	12	72	40	10.4	19.2	2.01	1.15	2.31
March	0.3	8.1	70	45	11.7	26.3	2.2	1.15	2.53
April	9	21	66	14	13.2	34.1	2.45	0.8	2.0
May	11	22	67	25	14.4	39.5	3.9	0.8	3.0
June	18	29	64	12	15.0	41.9	5.1	1	5.1
July	18	32	60	27	14.8	40.8	5.4	1	5.4

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Based on the studies conducted, it is reasonable that evapotranspiration is the main spending component of water balance, the "soil-plant-atmosphere" in the system, which ensures the rational use of water resources and optimization of seed rotation on the shears. As a result of the analysis of numerous attitudes for determining evapotranspiration, the feasibility of using the Penman-Montein method for its quantitative assessment is substantiated for its quantitative assessment to perfectly reflect the multifactor event. The reporting attitude of determining control evapotranspiration is given; The determination of evapotranspiration on a particular example is carried out.

Conclusion

Based on the search for information, after consulting with the farmer Kakha Lashkhi, who runs the firm "Lomtagora", we selected the test polygon "Plot - 1.2". The main direction of the enterprise activity is the selection-seedling of wheat and corn and the production of meadow crops .

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მალხაზ დოლიძე საქართველოს ტექნიკური უნივერსიტეტის აგრარული მეცნიერებებისა და ქიმიური ტექნოლოგიების ფაკულტეტის პროფესორი, საქართველო
E-mail: pmkavshiri@gmail.com

მაია ლომიშვილი საქართველოს ტექნიკური უნივერსიტეტის აგრარული მეცნიერებებისა და ქიმიური ტექნოლოგიების ფაკულტეტის ასოცირებული პროფესორი, საქართველო
E-mail: m.lomishvili@gtu.ge

შორენა კუპრეიშვილი საქართველოს ტექნიკური უნივერსიტეტის სამთო გეოლოგიისა და მთის მდგრადი განვითარების ფაკულტეტის ასოცირებული პროფესორი, საქართველო
E-mail: Sh.Kupreishvili@gtu.ge

ალექსანდრე ციცაგი საქართველოს ტექნიკური უნივერსიტეტის აგრარული მეცნიერებებისა და ქიმიური ტექნოლოგიების ფაკულტეტის მაგისტრანტი, საქართველო
E-mail: alex.tsitsagi@gmail.com

რეცენზენტები:

თ. ოდილავაძე, საქართველოს ტექნიკური უნივერსიტეტის აგრარული მეცნიერებებისა და ქიმიური ტექნოლოგიების ფაკულტეტის ასოცირებული პროფესორი
E-mail: alex.tsitsagi@gmail.com

თ. სუპატაშვილი, საქართველოს ტექნიკური უნივერსიტეტის ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის უფროსი მეცნიერი თანამშრომელი
E-mail: tamunasupatashvili@gmail.com

ანოტაცია. სასოფლო-სამეურნეო წარმოების ინტენსიფიკაციის ერთ-ერთი ძირითადი ამოცანაა მარცვლოვანი და ტექნიკური კულტურების მოსავლიანობის გაზრდა თანამედროვე აგროტექნიკური ღონისძიებების დანერგვის გზით, განსაკუთრებით სარწყავი მიწათმოქმედების პირობებში. აუცილებელია აგროტექნიკური ღონისძიებების ეფექტის შეფასება ჰიდრომეტეოროლოგიური პირობების ფონზე ვეგეტაციის მთელს პერიოდში. ამ პროცესში განსაკუთრებული მნიშვნელობა ენიჭება ევაპოტრანსპირაციას, როგორც წყლის ბალანსის ძირითად ხარჯვით კომპონენტს, რომლის კვლევა მნიშვნელოვანია წყლის რესურსების ოპტიმალური მართვისათვის.

რწყვის რეჟიმის განსაზღვრის მრავალი მოდელის მიუხედავად, ყველაზე ზუსტი შედეგები ემპირიულ დამოკიდებულებებს ეფუძნება, რაც განაპირობებს ევაპოტრანსპირაციისა და ნიადაგ-გრუნტების მახასიათებლების გათვალისწინების აქტუალობას. კვლევა განხორციელდა ლომთაგორის საცდელ პოლიგონზე, ლაბორატორიული, საველე და ექსპერიმენტული მეთოდების გამოყენებით.

სტატიაში დასაბუთებულია პენმან-მონტეინის მეთოდის გამოყენება, რომელიც ევროკავშირის კვლევითი ინსტიტუტების მიერ განხორციელებულ კვლევის შედეგებზე დაყრდნობით FAO-ს მიერ არის რეკომენდებული, როგორც სტანდარტული მიდგომა. შედეგებმა აჩვენა, რომ წყლის დეფიციტი ამცირებს მოსავლიანობას, ხოლო ჭარბტენიანობა აფერხებს კულტურის განვითარებას. მიღებული მონაცემები მნიშვნელოვანია პრაქტიკული გამოყენებისთვის

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