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ASSESSMENT OF THE HEAT SUPPLY OF THE GROWING SEASON IN THE ALMATY REGION

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Modern climate norms for the main indicators of heat supply during the growing season in the Almaty region have been established for the period from 1991 to 2021. By comparing the sum of daily air temperatures above 10 °C and 15 °C with 90 % reliability to the heat demand of agricultural crops, the types of agricultural crops that are fully provided with heat were determined based on meteorological stations. The longest growing season (190…200 days) is observed in the central part of the region in the foothill semi-desert zone. The highest heat supply during the growing season (3800…4000 °C) is noted in the central part of the region in the foothill semi-desert zone. In the northern and central parts of the Almaty region, crops with moderate heat demand and heat-loving crops are provided with heat. In the foothill zone, heat-loving crops are not provided with heat, and in the mountainous agricultural areas, late spring crops are also not provided with heat. Maps of the duration and heat supply of the growing season were constructed. The obtained results will be useful in solving practical and scientific problems in agriculture, such as the rational placement of crops, planning the development of the region, ensuring food security.

Keywords: temperature, precipitation, vegetation, duration of the period, heat supply.

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INTRODUCTION

Climatic conditions are a determining factor in the development of agricultural sectors. In recent decades, the analysis of modern climatic conditions, including agro-climatic conditions, has become particularly relevant in addressing the sustainable development of the regions in Kazakhstan.

The combination of climatic factors that enable the production of agricultural products is called agro-climatic resources. Quantitative characteristics of climate and weather elements, their combinations and ratios that affect the yield and quality of agricultural products are called agro-climatic indicators. The agro-climatic resources of the territory are characterized by indicators such as solar radiation resources, thermal regime, and humidification regime of the growing season, among others.

The aim of the study is to assess the current climatic norms of heat supply during the growing season in the Almaty region in order to determine the influence of temperature conditions on agricultural production.

Methods for assessing heat resources in agro-climatology are used: dates of a steady transition of air temperature through 5 °, 10°, 15 ° C, the duration of the growing season with temperatures above 5 °, 10°, 15 °C.

Accordingly, the subject of the study is the heat supply of the growing season, which is one of the important agro-climatic indicators. After all, the possibility of cultivating an agricultural crop is primarily determined by the provision of its heat, i.e. the correspondence of the temperature regime of the area to the heat demand of the crop.

The object of research - Almaty region is located in the south-east of the Republic of Kazakhstan and borders on the east with the People's Republic of China, in the south – the Republic of Kyrgyzstan, in the west – Zhambyl region, in the north – Zhetysu region. The administrative center of the region is located in Konaev, located on the western coast of the Kapshagai reservoir. Since June 8, 2022, the region has been divided into 9 districts and 1 city of regional subordination (Figure 1).

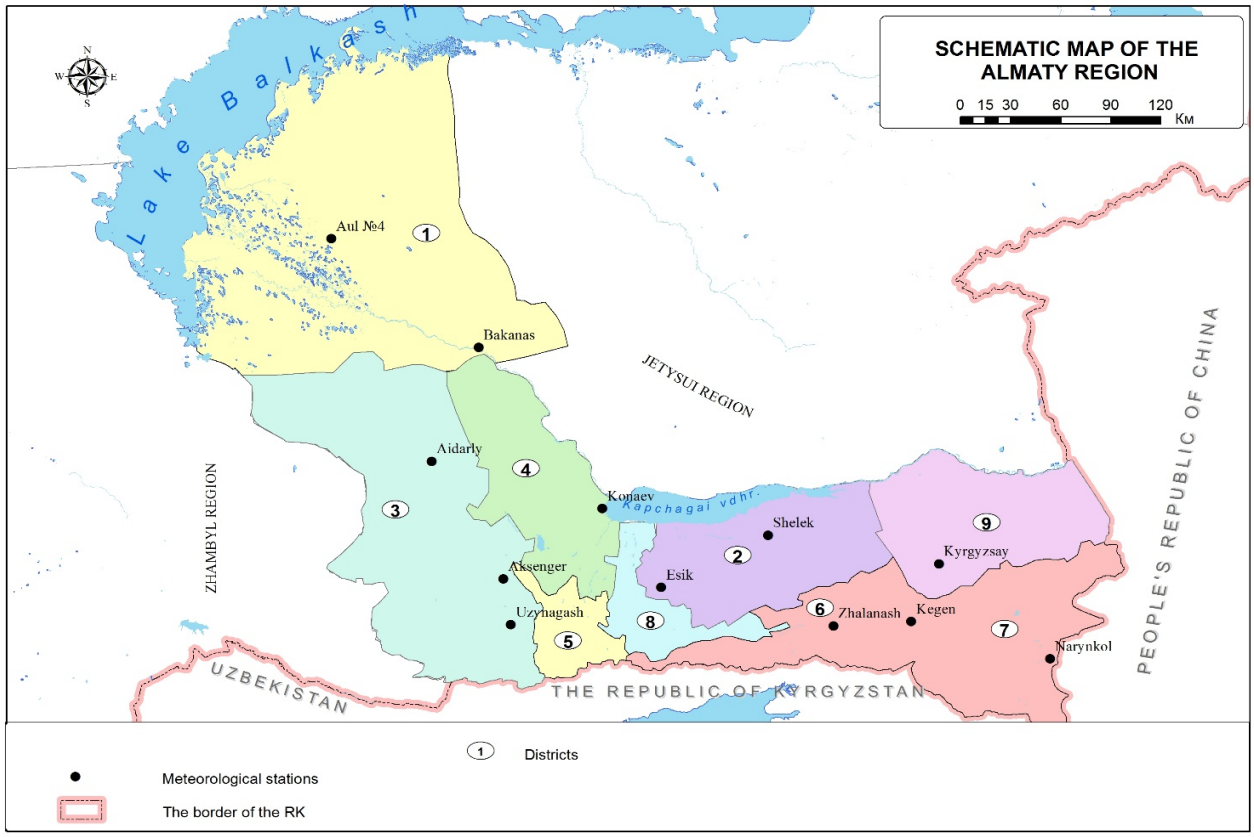

Fig. 1. *Schematic map of the Almaty region (https://www.gov.kz/)*

The region is located between the ridges of the Northern Tien Shan in the south, Lake Balkhash in the northwest and the Ile River in the northeast. The territory of the region has a difficult terrain. The northwestern part of the region is a semi-desert plain, slightly inclined to Lake Balkhash and indented by ancient riverbeds of Ile, Karatal, Aksu, Koksu, Lepsy, Ayagoz, the most significant of which is Bakanas river. Two separate massifs – in the south and east – extend the mountain ranges: the Ileysky Alatau and the Zhungar Alatau (Tien Shan Mountain system). The middle channel of the Ile River is located at the junction of their gradually decreasing slopes. The slopes themselves abound with cones of outflow of its tributaries (Sharyn, Shelek, Bolshaya and Malaya Almatinki, Kurty, etc.) (Uteshev, 1959).

The Almaty region is exposed to threats related to climate change. Here, climatic changes have already led to such consequences as changes in the water regime of mountain rivers, degradation of glaciers, depletion of water resources, an increase in abnormal weather events: extreme heat, droughts, dust storms, etc. This region is also at increased risk of extreme hydrometeorological situations such as avalanches, mudslides, floods, etc. (https://qazaqgeography.kz/).

It should be noted that in the study, a certain difficulty was caused by the complex relief of the region (the hypsometric difference between the flat part and the towering mountains reaches 4,600 m) and the sparsity of the meteorological observation network.

The results of the study showed that in the northern and central part of the Almaty region, moderate heat demand and heat-loving crops are provided with heat. In the foothill zone, thermophilic crops are not provided with heat, and in mountainous agricultural territories, late spring crops are also not provided with heat.

In Kazakhstan, the first scientific work on agro-climatic resources and zoning of agricultural crops «Agro-climatic zoning of Kazakhstan» was published by P.I. Koloskov in 1947 (Koloskov, 1947). In the light of modern information coverage, in 2017 S.S. Baisholanov prepared scientific and applied agro-climatic reference books for the northern and western 6 regions of Kazakhstan.

The agro-climatic reference books for the southern regions of Kazakhstan have not yet been updated. The agro-climatic reference book for the Almaty region under study was published in 1978 (Agro-climatic resources of the Alma-Ata region, 1978).

Similar studies on the northern regions of Kazakhstan are highlighted in the works, which provide estimates of the agrometeorological conditions of the growing season and their relationship with the yield of spring wheat in North Kazakhstan and Akmola regions. (Baisholanov et al. 2023).

This paper the agro-climatic resources of the Republic of Kazakhstan and Central Asia for the period from the beginning of the XXI century to 2021. The spatial distribution of the sums of precipitation during the active vegetation period, the sums of active temperatures and HTC in eastern Uzbekistan, Tajikistan, Kyrgyzstan and southeastern Kazakhstan was studied. Calculated indicators for the allocation of agro-climatic zones of the flat part of Kazakhstan and Central Asia. The zoning of the heat supply during the active vegetation period according to the sums of active temperatures (above 10 °C), moisture content according to the sums of precipitation during the active vegetation period, the Selyaninov State Customs Committee, the humidification coefficient (HC), which also takes into account the precipitation of the cold period of the year, was carried out. (Nazarenko et al., 2023).

This at work considers the problem of updating the maps of the agroclimatic zones of Russia and Kazakhstan, taking current climate warming into account. Agroclimatic zoning of a territory is one of the most important parameters of agroclimatic support of the economy; however, the problem of creating modern specialized maps on this topic and updating climate standards in Russia and Kazakhstan remains. In the course of this study, the sum of active temperatures (ΣT10) was calculated for 270 meteorological stations in Russia, Kazakhstan, and adjacent territories for the 2001…2018 period. The results recorded a noticeable shift in the boundaries of agroclimatic zones and an increase in ΣT10 by 200…600°C depending on the specific territory compared with data from the 1950s…1960s. The agroclimatic zones shifted to the greatest extent to 1600…2200 and 2200…2800 °C, but Kamchatka, the Aral Sea region, and the Syrdarya basin are dominant in absolute value. The subtropical zone also expanded significantly beyond the Black Sea coast of Krasnodar krai, the southern coast of the Crimea and the extreme south of the Turkistan Region. (Mingalev, 2021).

Agriculture in Kazakhstan is sensitive to climate, and wheat yields could be reduced up to 70 % under climate change. With the transition from a socialist economy to a free market economy, decisions are being made now that will affect Kazakhstan's ability to cope with climate change. A team of Kazakh and American researchers examined the cost-effectiveness and barriers to implementations of adaptation options for climate change (Mizina et al., 1999).

Currently, this agro-climatic reference book is information and technologically outdated, since it used data from the 1940…1970 years. Accordingly, it became necessary to re-evaluate agro-climatic conditions based on modern data and develop agro-climatic maps using GIS technology. It should be noted that rain-fed and irrigated agriculture, as well as pasture livestock farming are developed in the Almaty region (Agro-climatic resources of the Alma-Ata region, 1978).

MATERIALS AND METHODS

Long-term data from meteorological stations (MS) of the Almaty region of RSE «Kazhydromet» of the Ministry of ecology and natural resources of the Republic of Kazakhstan for the period from 1991 to 2021 (Auyl-4, Aidarly, Aksengir, Bakanas, Esik, Zhalanash, Konaev, Kyrgyzsai, Kegen, Narynkol, Uzynagash, Shelek) were used as initial data to characterize agro-climatic conditions. Long-term data were processed using generally accepted statistical and climatological data processing methods.

The growth and development of plants begins from the date of the steady transition of the average daily air temperature above the level of its biological minimum temperature. For most crops, this limit is 5 °C (early spring crops), 10 °C for late spring crops and 15 °C for heat-loving crops. For example, for wheat, the biological minimum air temperature required for the formation of vegetative organs is 5 °C, and for the formation of generative organs – 12 °C. The biological minimum of millet is 12 °C, cotton and rice in the initial phases of development is 15 °C, and in the ripening period – 20 °C (Losev, 1994).

Accordingly, to characterize there are used the heat supply of the growing season, the dates of the transition of air temperature through 5 °C, 10 °C and 15 °C, as well as the duration of

the period with such temperatures and the sum of daily temperatures for this period.

In climatic studies, the time between the transition of the average daily air temperature in spring and autumn through 5 °C is designated as the index of the duration of the growing season - GSL, i.e. the growing season of cold-resistant plants. Also, the GDDgrow10 index is used as an indicator of heat accumulation - the sum of temperatures above 10 °C during the growing season (Gringof, 2011).

In agrometeorology, when establishing heat supply and climatic boundaries of crop cultivation, the sums of climatic and biological temperatures are distinguished. The sum of climatic temperatures characterizes the total heat resources of a given area. The sums of biological temperatures characterize the need of plants for heat, which is understood as the sum of the average daily air temperatures during the growing season of a given crop, from the beginning of growth to maturation (sowing–maturation). For example, for wheat from sowing to maturation, the sum of daily air temperatures of 1400…1700 ° C is required, and for millet – 1600…1900 °C, for corn – 2200…2900 °C (Mishchenko, 2009)

Accordingly, to determine the supply of plants with heat, it is sufficient to compare the biological sum of plant temperatures with the climatic sum of temperatures of 90 % of the supply. For spring crops of moderate heat - with the sum of active air temperatures above 10 °C, for heat-loving crops – above 15 °C (Baisholanov et al., 2017 y.).

In the temperate zone, the duration of the period with an average daily air temperature above 10 °C corresponds to the growing season of most crops. Therefore, the thermal resources of the growing season are most often estimated by the sum of active air temperatures above 10 °C.

To analyze the spatial distribution of the main heat supply indicators, maps based on GIS technology were built – ArcGIS-10.

RESULTS AND DISCUSSION

Heat supply of the growing season

To characterize the heat supply of the growing season, the dates of the transition of air temperature (D) through 5 °C (early spring crops), 10 °C (late spring crops), 15 °C (thermophilic crops), the duration of the period with such temperatures (N) and the sum of daily temperatures for these periods (∑T) were used (Polevoy, 1992).

The characteristics of heat supply indicators for the meteorological stations in the Almaty region are presented in Table 1.

Table 1

Indicators of thermal resources in the Almaty region (transition dates (D), duration of the period (N, day), sum of temperatures (∑T, °C) of air 5, 10 and 15°C above) (s-spring, a-autumn)

Ms	$D_{5(s)}$	$D_{10(s)}$	$D_{15(s)}$	$D_{15(a)}$	$D_{10(a)}$	$D_{5(a)}$	N_5	N_{10}	N_{15}	$\sum T_5$	$\sum T_{10}$	$\sum T_{15}$
Aul-4	21.03	08.04	25.04	24.09	13.10	04.11	228	188	152	4099	3776	3505
Aidarly	20.03	08.04	25.04	27.09	15.10	07.11	232	190	155	4264	3917	3481
The Accelerator	22.03	12.04	09.05	21.09	11.10	02.11	225	182	135	3774	3452	2835
Bakanas	21.03	08.04	25.04	24.09	13.10	04.11	228	188	152	4100	3776	3505
Esik	22.03	12.04	10.05	23.09	13.10	07.11	230	184	136	3751	3380	2790
Zhalanash	07.04	02.05	07.06	03.09	20.09	21.10	197	149	88	2620	2250	1480
Konaev	20.03	08.04	29.04	28.09	15.10	07.11	232	190	152	4112	3762	3280
Kyrgyzsay	23.03	14.04	13.05	21.09	10.10	04.11	226	179	131	3497	3182	2500
Kegen	12.04	14.05	24.06	13.08	17.09	10.10	181	126	50	2250	1753	785
Narynkol	07.04	03.05	20.06	22.08	25.09	15.10	191	145	63	2415	2050	1010
Uzynagash	22.03	12.04	09.05	19.09	09.10	02.11	225	180	133	3613	3302	2689
Shelek	17.03	03.04	22.04	30.09	18.10	08.11	236	198	161	4224	3964	3499

Note: (s)-spring,(a)-autumn

As can be seen from Table 1 in the Almaty region on the flat territory (MS Shelek, Konaev, Bakanas, Aidarly, Aul-4), the air temperature steadily passes through 5 °C in the spring on March 17…21, in the autumn it goes back to November 4…8 and the duration of such a period is 228…236 days. The duration of the period with an air temperature above 10 °C is 188…198 days, and with an air temperature above 15°C – 152…161 days. During the period with an air temperature above 5 °C, heat accumulates in the amount of 4100…4264 °C, with an air temperature above 10 °C, it is 3762…3964 °C, and with an air temperature above 15 °C, it is 3280…3505 °C.

At meteorological stations located in the foothill territories of the region (MS Aksengir, Uzynagash, Esik, Kyrgyzsai), the air temperature steadily passes through 5 °C from spring on March 22…23, in autumn it goes back to November 2…7 and the duration of such a period is 225…230 days. The duration of the period with an air temperature above 10°C is 179…184 days, and with an air temperature above 15 °C – 131…136 days. During the period with an air temperature above 5 °C, heat accumulates in the amount of 3497…3774 °C, with an air temperature above 10°C – 3182…3452 °C, and with an air temperature above 15 °C – 2500…2835 °C.

In the mountainous agricultural territories of the region (villages of Zhalanash, Kegen, Narynkol), the air temperature steadily passes 5 °C on April 7…12 in spring, returns to October 10…21 in autumn and the duration of such a period is 181…197 days.

The duration of the period with an air temperature above 10 °C is 126…149 days, and with an air temperature above 15 °C – 50…63 days. During the period with an air temperature above 5 °C, heat accumulates in the amount of 2250…2620 °C, with an air temperature above 10 °C – 1750…2250 °C, and with an air temperature above 15 °C – 785…1480 °C.

The thermal resources of the growing season are most often estimated by the sum of active air temperatures above 10 °C. Accordingly, on the basis of such data there were built maps of the duration and heat supply of the growing season.

The longest growing season (190…200 days) is observed in the central part of the region, specifically in the foothill semi-desert zone (MS Aidarly, Konaev, Shelek). To the north and south of this zone, the duration of the growing season is shortened. In the northern part of the region, the growing season lasts 170…190 days up to Lake Balkhash, as well as in the foothill zone of the southern part of the region. In the mountainous agricultural territories of the region, the duration of the growing season is 120…170 days (figure 2).

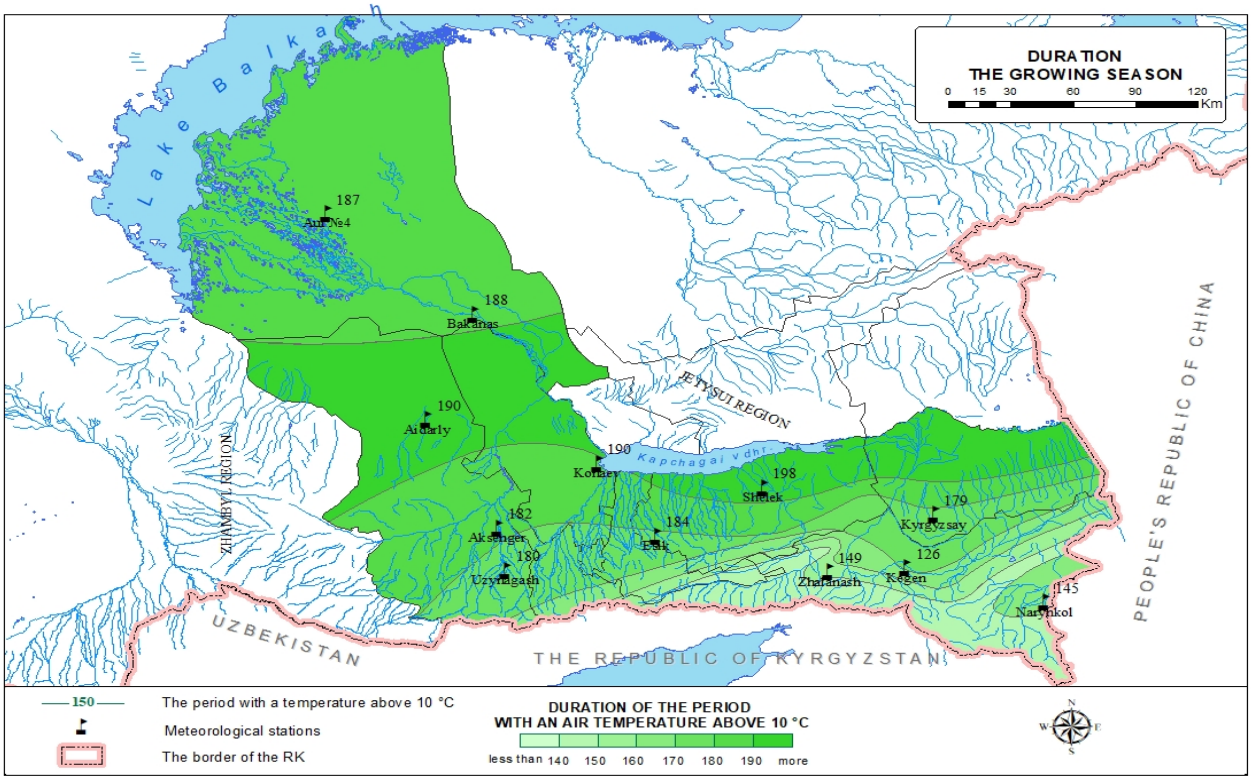

Fig. 2. *Spatial distribution of the duration of the growing season in the Almaty region at an air temperature above 10 °C*

The greatest heat supply of the growing season (3800…4000 ° C) is observed in the central part of the region in the foothill semi-desert zone. To the north and south of this zone, the heat supply of the growing season decreases. In the northern part of the region, up to Lake Balkhash, the heat supply temperature is 3600…3800 °C. In the foothill zone of the southern part of the region, the heat supply is 3000…3800 °C. In the mountainous agricultural territories of the region, the heat supply during the growing season is 1700…3000 °C (figure 3).

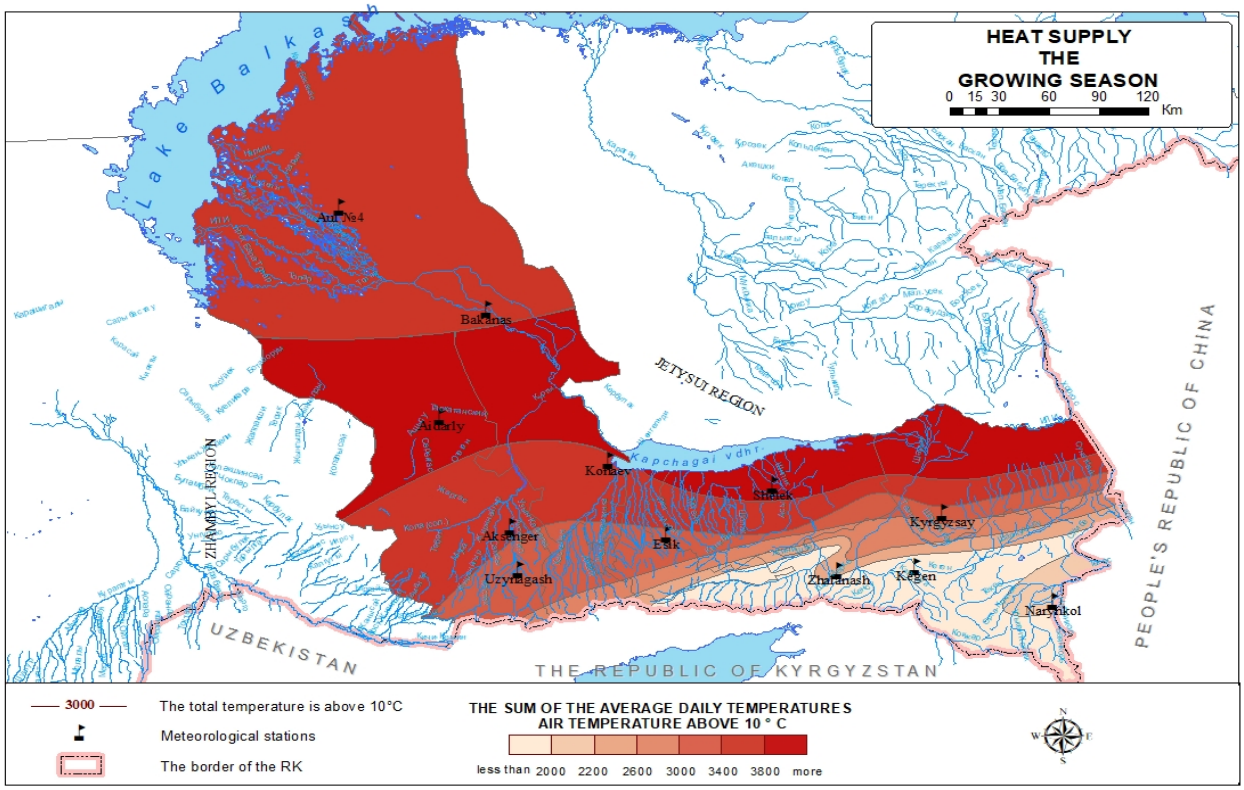

Fig. 3. *Spatial distribution of heat supply in the growing season of the Almaty region at a total air temperature above 10 °C*

Provision of agricultural crops with heat

Based on the assessment of agro-climatic indicators, heat and moisture availability, taking into account soil types, it is possible to determine the crops that are grown in this area. In this case, the main factor may be the heat supply. Thus, in this work, the heat supply of 26 types of agricultural crops was determined, according to which their heat needs are known. Such needs are expressed by the sum of the average daily air temperatures required during the entire growing season from the beginning of growth to full ripeness (Baisholanov, 2020).

The need of agricultural crops for heat, expressed in the biological sum of air temperatures for northern latitude 55 °C, currently accepted for practical use, is highlighted in the works (Gordeev A.V. et al., 2006).

As they move south from 55 °C north latitude, due to the photoperiodic reaction, the required sum of temperatures increases for plants with a long day and decreases for plants with a short day. For plants that are neutral to daylight, the required temperature remains the same. In the works (Baisholanov, 2020; Baisholanov et al., 2017), the heat demand of the main agricultural crops was determined, expressed in the biological sum of air temperatures for the south of Kazakhstan, i.e. for latitudes 42…46 °C north latitude. To facilitate calculations and analysis, crops were grouped according to the need for heat, expressed by the required sum of average daily air temperatures above 10 °C for moderately thermophilic crops and above 15 °C for thermophilic crops. Table 2 shows agricultural crops grouped by heat demand, taking into account the precocity of varieties (hp – the earliest ripe, p – early ripe, c – medium ripe, sp – medium late, p – late ripe), as applied to the south of Kazakhstan (42…46 °C). At the moment, for spring moderately warm crops (A1…A9), the average daily air temperature above 10 °C was taken into account, and for thermophilic crops (B1…B5) – above 15 °C.

Table 2

Distribution of spring cereals, legumes, oilseeds, industrial and vegetable crops into groups according to heat demand (Baisholanov, 2020)

Gr.	$\sum t_6$, °C	Culture (r–early maturing, c–middle maturing, p–late maturing)
A1	1200...1400	Buckwheat–r, Buckwheat–s, Peas–r, Potatoes–r, Cucumbers–r, Cucumbers–C.
A2	1400...1600	Buckwheat–p, Peas–s, Peas–p, Potatoes–s, Cucumbers–p, Barley–r, Barley–s, Oats–r, Wheat (m)–r, Wheat (t)–r, Millet–r, Millet–s, Beans–r, Rank–r, Lentils–r, Lentils–s, Chickpeas–r, Chickpeas–s, Lupin–r, Beans–r, Oilseed flax–r, Flax long–r, Flax long–s, Cabbage–r, Cabbage–s, Tomatoes–R.
A3	1600...1800	Potatoes–p, Barley–p, Oats–s, Oats–p, Wheat (m)–s, Wheat (t)–s, Millet–p, Beans–s, Rank–s, Chickpeas-p, Oilseed flax–s, Cabbage–p, Tomatoes–s, Tomatoes– P.
A4	1800...2000	Wheat (m)–p, Wheat (t)–p, Beans–p, Lupin–s, Sunflower–r, Rapeseed–R.
A5	2000...2200	Lupin–p, Sunflower–c, Rapeseed–p, Soy–hp, Sugar beet–r
A6	2200...2400	Sunflower–p, Soy–r, Sugar beet–c, Corn–r, Sorghum–R.
A7	2400...2600	Soy–c, Sugar beet–p, Corn–c, Sorghum–c
A8	2600...2800	Soy–sp, Corn–sp, Sorghum–P.
A9	2800...3000	Soy–p, Corn–P.
B1	2500...2700	Rice–p.
B2	2700...2900	Rice–c.
B3	2900...3300	Rice–p, Cotton–R.
B4	3300...3600	Cotton–C.
B5	3600...4000	Cotton–P.

Crops are sown when the soil has warmed up sufficiently and has reached its soft-plastic state, when the average daily air temperature already exceeds 10 °C. Therefore, to determine the supply of plants with heat, it is sufficient to compare the biological sum of temperatures with the climatic sum of temperatures, i.e. with the sum of active air temperatures above 10 °C. At the same time, for accuracy, it must be counted from the date of completion of sowing the crop (Zhunisova M.A., 2023 y.).

To assess the compliance of climatic resources with the requirements of agricultural crops, the values of climatic indicators of various security are determined. For example, 80…90 % is sufficient to provide plants with climatic resources (Losev, 1994 y.; Baisholanov et al., 2017 y.).

Table 3 shows the sum of air temperatures above 10 and 15 °C. 90 % of the norm for the studied meteorological stations.

Table 3

The sum of temperatures above 10 and 15 °C is 90 % safe, the climatic terms of sowing early spring (Dc1) and thermophilic (Dc2) crops in the Almaty region

MS	$\sum T_{10}$ (90 %)	$\sum T_{15}$(90 %)
Aul-4	3625	3365
Aidarly	3760	3342
Aksenger	3314	2721
Bakanas	3625	3365
Esik	3245	2678
Zhalanash	2124	1436
Konaev	3611	3148
Kyrgyzsay	3024	2409
Kegen	1667	743
Narynkol	1942	971
Uzunagash	3170	2582
Shelek	3805	3359

To determine the heat supply of crops, we compare the sum of daily air temperatures above 10 °C (for moderately thermophilic spring crops) and above 15 °C (for thermophilic crops), which account for 90 % of the supply, with the heat demand of crops shown in Table 2. For example, for an early-ripening variety of spring wheat the biological sum of temperatures from sowing to maturation at the level of 1400…1600 °C is required. Accordingly, spring wheat can be grown in areas where the temperature of 1600 °C is provided by 80…90 % with the sum of active temperatures above 10 °C. (Zhunisova M.A., 2023 y.). To fully determine the possibility of cultivating an agricultural crop without irrigation, it is necessary to further analyze soil fertility and moisture availability by the moisture coefficient K.

Comparing the sum of the daily air temperatures above 10 °C and 15 °C of 90 % availability with the heat demanding of crops, there were determined the types of crops that are fully provided with heat by meteorological stations. In the area of MS Aul-4, Aidarly, Bakanas and Shelek, groups of crops from A1 to B3 are provided with heat, in the area of MS Konaev – from A1 to B2, in the area of MS Aksengir, Esik, Kyrgyzsai and Uzynagash – from A1 to A9, in the area of MS Zhalanash and Narynkol – from A1 to A4, in the area of MS Kegen is A1 and A2 (Table 4).

Table 4

Groups of crops provided with heat

MS	Group A	Group B
Aul-4	A1…A9	B1…B3
Aidarly	A1…A9	B1…B3
Aksenger	A1…A9	-
Bakanas	A1…A9	B1…B3
Esik	A1…A9	-
Zhalanash	A1…A4	-
Konaev	A1…A9	B1…B2
Kyrgyzsay	A1…A9	-
Keygen	A1…A2	-
Narynkol	A1…A4	-
Uzynagash	A1…A9	-
Shelek	A1…A9	B1…B3

Thus, in the northern and central part of the Almaty region, crops of moderate heat demanding and heat-loving crops are provided with heat (table 4) In the foothill zone, thermophilic crops are not provided with heat, and in mountainous agricultural territories, late spring crops are also not provided with heat. It should be noted that in particularly cold years, late spring and early autumn frosts can be a limiting factor. To make a final decision on the cultivation of crops, in addition to heat, it is necessary to consider the properties of the soil, the availability of precipitation or irrigation water.

CONCLUSION

As a result of the conducted research, there were established modern climatic norms of the main indicators of heat supply of the growing season in the Almaty region. To characterize the heat supply of the growing season, the dates of the transition of air temperature through 5 °C, 10 °C and 15 °C, the duration of the period with such temperatures and the sum of daily temperatures for these periods were used.

In the Almaty region, on a flat territory, the air temperature steadily passes through 5 °C in the spring on March 17…21, in the autumn it goes back on November 4…8 and the duration of such a period is 228…236 days. In the foothill areas of the region, the air temperature steadily passes through 5 °C from March 22…23 in spring, back in autumn – November 2…7 and the duration of such a period is 225…230 days. In mountainous agricultural areas, the air temperature passes through 5 °C from April 7…12 in spring, back in autumn – October 10…21 and the duration of the period is 181…197 days.

Based on air temperature data above 10 °C,

maps of the duration and heat supply of the growing season were constructed.

The longest growing season (190…200 days) is observed in the central part of the region, particularly in the foothill semi-desert zone. To the north and south of this zone, the duration of the growing season is shortened. In the northern part of the region, the distance to Lake Balkash, as well as in the foothill zone of the southern part of the region is 170…190 days, in the mountainous agricultural territories of the region – 120…170 days.

The greatest heat supply of the growing season (3800…4000 °C) is observed in the central part of the region in the foothill semi-desert zone. To the north and south of this zone, the heat supply of the growing season decreases. In the northern part of the region to Lake Balkash, the heat supply is 3600…3800 °C, in the foothill zone of the southern part of the region – 3000…3800 °C, and in the mountainous agricultural territories of the region – 1700…3000 °C.

Comparing the sum of the daily air temperatures above 10 °C and 15 °C of 90 % availability with the heat demand of crops, the types of crops that are fully provided with heat were determined by meteorological stations. In the northern and central part of the Almaty region, moderate heat demand and heat-loving crops are provided with heat. In the foothill zone, thermophilic crops are not provided with heat, and in mountainous agricultural territories, late spring crops are also not provided with heat.

The results obtained will be useful in solving practical and scientific problems in agriculture. The results of the work are recommended to be used in planning the development of the region to ensure food security. For example, when dealing with issues such as the rational placement of crops, management decisions, the development of scientific recommendations, etc.

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АЛМАТЫ ОБЛЫСЫНДА ВЕГЕТАЦИЯЛЫҚ КЕЗЕҢНІҢ ЖЫЛУМЕН ҚАМТАМАСЫЗ ЕТІЛУІН БАҒАЛАУ

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1991 жылдан 2021 жылға дейінгі кезеңде Алматы облысында вегетациялық кезеңнің жылумен қамтамасыз етілуінің негізгі көрсеткіштерінің қазіргі заманғы климаттық нормалары белгіленді. 10 °С және 15 °С жоғары тәуліктік ауа температурасының 90 % қамтамасыз етілуін ауыл шаруашылығы дақылдарының жылу қажеттілігімен салыстыра отырып, метеорологиялық станциялар бойынша жылумен толық қамтамасыз етілген ауыл шаруашылығы дақылдарының түрлері анықталды. Вегетациялық кезеңнің ең ұзақ ұзақтығы (190…200 тәулік) облыстың орталық бөлігінде тау бөктеріндегі шөлейт аймақта байқалады. Вегетациялық кезеңнің ең жоғары жылумен қамтамасыз етілуі (3800…4000 °С) облыстың орталық бөлігінде тау бөктеріндегі шөлейт аймақта байқалады. Алматы облысының солтүстік және орталық бөлігінде жылу қажеттілігі орташа дақылдар мен жылу сүйгіш дақылдар жылумен қамтамасыз етілген. Тау бөктеріндегі аймақта жылу сүйгіш дақылдар жылумен қамтамасыз етілмейді, ал таулы егіншілік аумақтарында жаздық кеш дақылдар да жылумен қамтамасыз етілмейді. Вегетациялық кезеңнің ұзақтығы мен жылумен қамтамасыз етілу карталары салынды. Алынған нәтижелер ауыл шаруашылығындағы практикалық және ғылыми мәселелерді шешуде пайдалы болады. Мысалы, дақылдарды ұтымды орналастыру, аймақтың дамуын жоспарлау, азық-түлік қауіпсіздігін қамтамасыз ету.

Түйін сөздер: кезең ұзақтығы, ауаның орташа тәуліктік температурасы, жауын-шашын, вегетациялық кезең, жылумен қамтамасыз ету.

ОЦЕНКА ТЕПЛООБЕСПЕЧЕННОСТИ ВЕГЕТАЦИОННОГО ПЕРИОДА В АЛМАТИНСКОЙ ОБЛАСТИ

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Были установлены современные климатические нормы основных показателей теплообеспеченности вегетационного периода в Алматинской области за период с 1991 по 2021 год. Сопоставляя сумму суточных температур воздуха выше 10 °С и 15 °С 90 %-ой обеспеченности с теплопотребностью сельскохозяйственных культур, по метеорологическим станциям были определены виды сельскохозяйственных культур, которые полностью обеспечены теплом. Наибольшая продолжительность вегетационного периода (190…200 суток) наблюдается в центральной части области в предгорной полупустынной зоне. Наибольшая теплообеспеченность вегетационного периода (3800…4000 °С) отмечается в центральной части области в предгорной полупустынной зоне. В северной и центральной части Алматинской области обеспечены теплом культуры умеренней теплопотребности и теплолюбивые культуры. В предгорной зоне теплолюбивые культуры не обеспечены теплом, а в горных земледельческих территориях – также не обеспечены теплом и поздние яровые культуры. Были построены карты продолжительности и теплообеспеченности вегетационного периода. Полученные результаты будут

полезны при решении практических и научных задач в сельском хозяйстве. Например, рациональное размещение сельскохозяйственных культур, планирование развития региона, обеспечение продовольственной безопасности.

Ключевые слова: продолжительность периода, среднесуточная температура воздуха, осадки, вегетационный период, теплообеспеченность.

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