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DYNAMICS OF CHANGE IN CLIMATE INDICATORS IN THE BEREZINSKO-PREDPOLESSKY GEOBOTANIC DISTRICT

Abstract. Meteorological data in the growth zone of geographical forest plantation of Scots pine and Norway spruce were analyzed in the period from 1968 to 2021. Average annual climate indicators were calculated and their dynamics were given for more than half a century of observations.

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ДИНАМИКА ИЗМЕНЕНИЯ КЛИМАТИЧЕСКИХ ПОКАЗАТЕЛЕЙ В БЕРЕЗИНСКО-ПРЕДПОЛЕССКОМ ГЕОБОТАНИЧЕСКОМ ОКРУГЕ

Аннотация. Проанализированы метеорологические данные в зоне произрастания географических культур сосны обыкновенной и ели европейской в период с 1968 по 2021 гг. Рассчитаны среднегодовые показатели климата и дана их динамика за более чем полувековой период наблюдений.

The strategy for the development of forestry in Belarus in the near and

distant future is impossible without taking into account the directional variability of the condition and stem productivity of the main forest-forming species (Scots pine and European spruce), the nature of which remains incompletely studied. It is not always possible to explain the simultaneous onset of periods of maximum stem productivity and suppression of the stand, regardless of its age, by weather and climate conditions. By now, an unfavorable environmental situation has developed for the forests of Belarus, which has led to a decrease in their sustainability and productivity, while their socio-economic and environmental significance is increasing. In the near and distant future, the impact of rapidly changing environmental natural and anthropogenic factors on forest ecosystems will not decrease. This circumstance must be taken into account when making decisions in the field of use, reproduction and protection of forest resources [1, 2].

The features of modern climate changes in the territory of Belarus, which consist mainly in an increase in heat supply, are presented in sufficient detail and thoroughly in the works of V.F. Loginov, S.A. Lysenko, Yu.A. Brovka, V.S. Mikutsky, M.A. Khitrikov [3, 4].

Changes in climate indicators across the territory of Belarus are uneven; areas with a more arid climate and areas with indicators of sufficient moisture have been identified [3].

The influence of climatic parameters on the dynamics of woody plant growth is most clearly seen in geographical forest plantation represented by ecotypes of the main climatic zones of Eurasia. Geographical crops of Scots pine and European spruce, created in 1959 and 1961, respectively, on the territory of the Negorelsky educational and experimental forestry enterprise, grow in the Berezinsko-Predpolessky geobotanical district, which belongs to the territory with a hydrothermal coefficient of 1.3–1.4, which corresponds to the average indicators for the republic. For a more detailed analysis of changes in climatic parameters in the area of growth of geographical forest plantation, changes in climate parameters were analyzed according to the data of the Gorodishche meteorological station in the period from 1968 to 1984 and the Stolbtsy meteorological station in the period from 1985 to 2021.

Analyzing the change in average temperature by decades, it was found that for the first two decades the average temperature was 5.53°C. Beginning in 1988, the average air temperature began to rise and by the end of the decade it was 6.84°C, which is 1.31°C higher than the first two decades. In the period from 1998 to 2007, the temperature increase was not so intense and the increase was 0.43°C, reaching an average of 7.47°C per decade. In recent years, in the period from 2008 to 2021, the average annual air temperature continued to increase, reaching an average of 7.68°C per twelve years. In general, over the observation period from 1968 to 2021, the increase in the average temperature in the area of geographical crop growth was 2.15°C (Table 1).

Indicator	For the entire observation period (1968–2021)	Period				
		1968–1978	1979–1987	1988–1997	1998–2007	2008–2021
Average air temperature, °C	6.69	5.62	5.44	6.84	7.47	7.68
Average sum of temperatures above 5°C	2826.9	2603.0	2551.5	2798.1	3043.2	3049.7
Average sum of temperatures above 10°C	2446.4	2172.5	2139.8	2402.5	2655.6	2742.8
Average precipitation, mm	640.4	696.0	632.9	582.1	606.2	672.1
Hydrothermal coefficient	1.43	1.55	1.69	1.31	1.26	1.38
Average air humidity, %	79	81	80	79	78	77

 Table 1 – Changes in climatic indicators in the growing area of the geographical forest plantation of Scots pine and European spruce by decades

For the successful growth of woody plants, the sum of active temperatures above 5°C and 10°C is more important than the average annual temperature. The change in the sum of active temperatures over the study period by decades is presented in Table 1. The average annual sum of active temperatures above 5°C for the observation period from 1968 to 2021 is 2826.9°C, and above 10° C – 2446.4°C. There is a gradual increase in the average annual sum of active temperatures both above 5°C and above 10° C in the period from 1988 to 2021. Compared with the previous decade (1979–1987), the average annual sum of temperatures above 5°C increased by 497.7°C or 19.5%, and the average annual sum of temperatures above 10° C – by 603.0°C or 28.1%.

In the last decade, the frequency of years with the sum of active temperatures in July and August above 600°C and the average temperature close to or above 20°C has increased. The average amount of precipitation for the observation period (1968–2021) is 640.4 mm. The distribution of precipitation by year fluctuates widely – from 885.9 mm in 1970 to 441.3 mm in 1999. Analyzing the distribution of precipitation by decades, it was found that the driest period was observed from 1988 to 1997. The average amount of precipitation for this period was 582 mm. The next decade (1998–2007) is also characterized as a drier period compared to both the subsequent one (2008–2021) and the first decades of the beginning of the studies (1968–1987).

One of the most important indicators characterizing climate change is

the hydrothermal coefficient according to G.T. Selyaninov, which is calculated as the ratio of the sum of precipitation, increased by 10 times during the period with average temperatures above 10°C to the sum of temperatures above 10°C. The data obtained indicate an increase in the aridity of the climate during the period of reduced precipitation, with a simultaneous increase in air temperature since 1988.

The hydrothermal coefficient decreased by 0.38 in the period from 1988 to 1997, with a simultaneous decrease in precipitation to 582 mm in the next ten-year period. Despite some increase in precipitation (to 606 mm), the hydrothermal coefficient continues to decrease, and in the period from 1998 to 2008 it was 1.26, which is more typical of an arid climate zone. Over the past 15 years, the average annual precipitation has increased by 64 mm, which has reduced the aridity of the climate. The hydrothermal coefficient value was 1.38, which is close to the average annual value for the entire observation period, but significantly lower than the period before the onset of modern warming (1968–1987).

The increase in climate aridity in the last two decades is also evidenced by the decrease in air humidity. Compared with the initial period of the study, the relative air humidity has decreased by 4%, which is quite noticeable for the successful growth of woody plants, primarily the European spruce. The greatest decrease in humidity is observed in the summer: starting in 2014, the relative humidity during the growing season in some years dropped below 60%. The most unfavorable months were April, May and June, when the average air humidity over the last 15 years in these months was 68% (Figures 1–3).



Year (April)

Fig. 1 – Dynamics of relative air humidity in April



Year (June)

Fig. 3 – Dynamics of relative air humidity in June

During the growing season, in some years there is an increase in the number of days with humidity of 30%, which is the limit for successful plant growth. In general, summing up the analysis of climatic indicators in the area of growth of geographical forest plantation of Scots pine and European spruce, a significant increase in heat supply was established (the increase in average temperature was 39.5%, the sum of active temperatures above $5^{\circ}C - 19.5\%$ and the sum of active temperatures above $10^{\circ}C - 28.1\%$) and an increase in aridity (a decrease in the hydrothermal coefficient by 0.31 and a decrease in air humidity by 4%).

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ПРИМЕНЕНИЕ ИОННО-ПЛАЗМЕННЫХ ТЕХНОЛОГИЙ ДЛЯ ФОРМИРОВАНИЯ ОСНОВНЫХ КОМПОНЕНТОВ НИЗКОТЕМПЕРАТУРНЫХ ТОПЛИВНЫХ ЭЛЕМЕНТОВ

Аннотация. Показана возможность применения ионно-плазменных технологий для формирования электрокатализаторов мембранно-электродных блоков топливных элементов прямого окисления этанола и метанола с полимерным мембранным электролитом и защитных слоев на поверхности их токовых коллекторов.

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APPLICATION OF ION-PLASMA TECHNOLOGIES FOR THE