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Influence of climate fluctuations on development of plant growing in conditions of Western region

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The purpose. To determine parameters of climate fluctuations in region for 1945 – 2018 and their influence on development and efficiency of branch of plant growing. **Methods.** Field, laboratory-analytical and mathematical-statistical (applied according to available techniques). **Results.** Results of weather observations of Rivne center of hydrometeorology for 1945 – 2018 were analyzed. It is noted that the threshold of the average annual air temperature (7°C) was exceeded in 1988 – 1992. On the average for 1988 – 2017 it exceeded the norm on 1,2°C, in 2018 — on 1,8°C. The sums of effective temperatures were above 5 and 10°C during 1971 – 2018 and had grown accordingly on 30,8 and 52,8%. Mid-annual rainfall amount in 2013 – 2017 matched to norm (569 mm), and in 2018 was less than the norm on 29%. It was established that practically at equal rainfall amount stores of productive moisture under winter wheat in 0 – 100 cm soil layer in June-July 2013 – 2018 were twice less than in 1985 – 1990. It was established that at the similar depth of precipitation, productive moisture reserves at winter wheat cultivation in 0 – 100 cm soil layer of in June-July 2013 – 2018 were twice as low as in 1985 – 1990. Improvement of heat supply of the territory contributed to increase in the share of corn, soybeans and sunflower in the structure of crops from 4% in 2000 to 52,3% in 2018. As a result of implementation of modern technologies and improvement of temperature regimen in 2010 – 2018, the yield of winter wheat increased from 2,9 to 4,5 t/hectare, grain corn — from 4,9 to 8,2, soybeans — from 1,4 to 2,7, winter rape — from 2,3 to 3,2, and sunflower — from 1,9 to 2,4 t/hectare. **Conclusions.** Due to the progressive global climate changes, the heat supply of Western Forest-Steppe and Western Polissia improved significantly. That led to domination in the structure of crops sowing area of the region of warm-weather crops (grain corn, soybean and sunflower). And also in combination with the use of modern cultivation technologies, that ensured rapid increase in the yield of all agricultural crops.

Key words: *temperature of air, rainfall, moisture insurance, thermophilic crops, disposition of sown area, productivity.*

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The rapid progressive climate changes caused by the global warming is probably one of the biggest threats of the development of natural ecosystems, the agro-industrial complex, the economy and humanity as a whole. The seriousness of the challenges can be estimated from the fact that the developed numerical prediction models of climate changes even for the next 50-100 years are not optimistic [1-4].

Agriculture is the industry the most dependent on agro-climatic conditions. To substantiate the strategies of sustainable development of agricultural production of the state, systematic study of the properties and tendencies of changes of all components of agro-climatic resources is essential [5-7].

A number of researchers [8-10] note that the global warming is the proven fact and therefore the possibility of rational use of heat resources in agriculture depends on the speed of adaptation to changing climatic conditions.

However, the development of the adaptation strategy of practical measures for its implementation in the regions is constrained by insufficiently formed scientific bases on this problem and limited results of monitoring researches of processes occurring in agro and natural ecosystems under the influence of global warming.

According to the reasons that caused it, global warming is considered the key factor that caused the whole complex of climate changes in a certain sequence. The western region is one of the areas with the most active growth of heat supply. The average annual temperature of 7 °C was exceeded in 1988–1992. (Fig. 1).

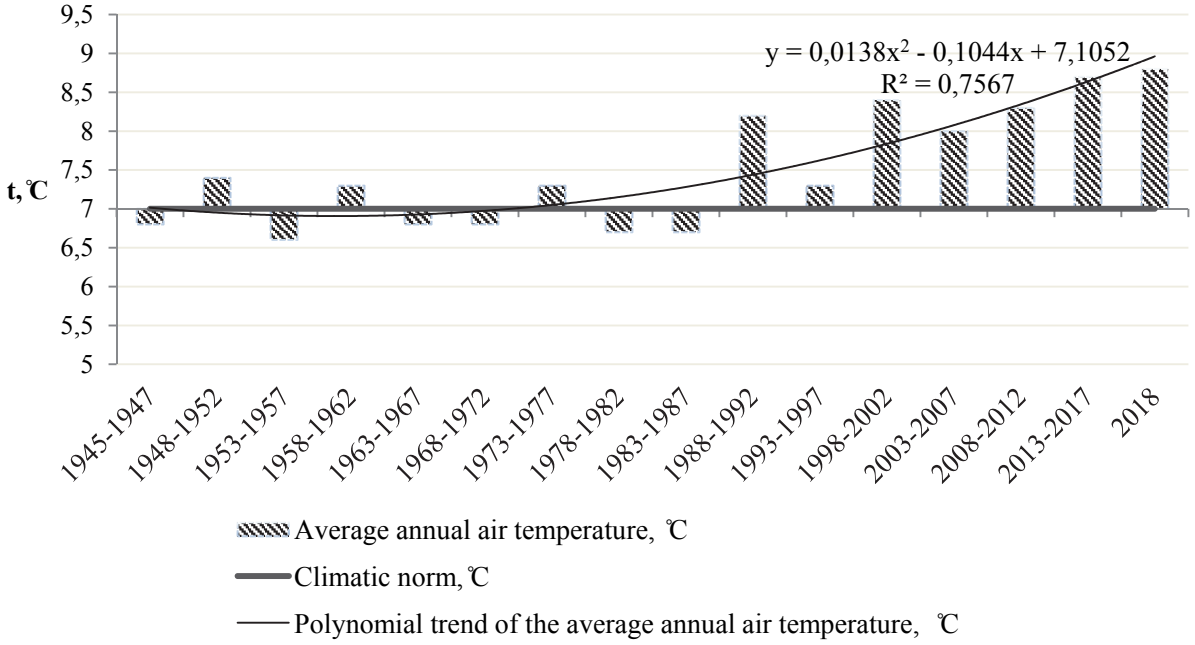

Fig. 1. Average annual air temperature according to the weather station in Rivne

In the next decade, the average temperature was higher than norm, but the process of its growth was not characterized by linear dependence. In particular, in 1988–1992 it was 8.2, and in 1991–1997 it decreased to 7.3 °C, which gave reason to hope for the return of temperature to norm. However, during the period of 2003–2018, the average annual air temperature increased steadily, reaching 8.8 °C at the end of the period. That is, in 2018 it exceeded the norm by 1.8 °C. It is important to note that the increase in the average annual temperature is primarily caused by the warming of the summer months, although winters also become warmer.

One of the main criteria of assessing of the possibility of crops growing and their varieties and hybrids of different ripeness is the sum of effective air temperatures during their growing season. It increased with increasing the average air temperature (Fig. 2).

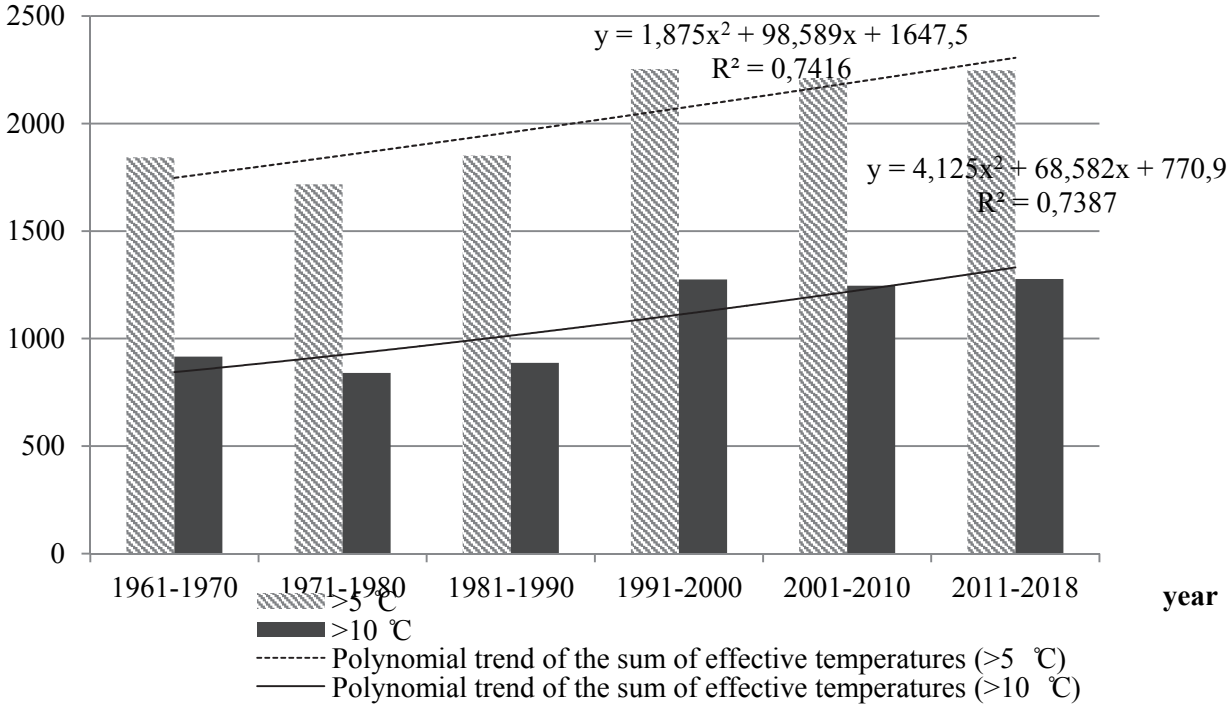

Fig. 2. The sum of effective temperatures

The analysis of the average values of the sum of effective temperatures above 5 and 10 °C since 1961 for five-year periods indicates their stable growth. The sum of effective temperatures > 5 °C in 1971–1980 was 1718 °C, in 2011–2018 it increased by 30.8 % to 2248 °C. The sum of effective temperatures > 10°C during this period increased from 840 °C to 1277 °C, or by 52.0 %. Before the beginning of the period of global warming such sum of effective temperatures > 10 °C was typical for Vinnitsa region.

The influence of climatic conditions on the growth and development of crops is primarily determined by their water availability [11].

There is the close relationship between soil moisture reserves, annual precipitation and their monthly dynamics. There is an increase in annual precipitation over the last 20 years. During the period of 1998–2007, precipitation was at the level of 634 mm, which is 65 mm or 11.4 % more than the climatic norm. During the period of 2008–2017, precipitation was 602 mm, which is 33 mm (5.8%) higher than the norm. However, in 2018 precipitation was less than the norm by 29 % (Fig. 3).

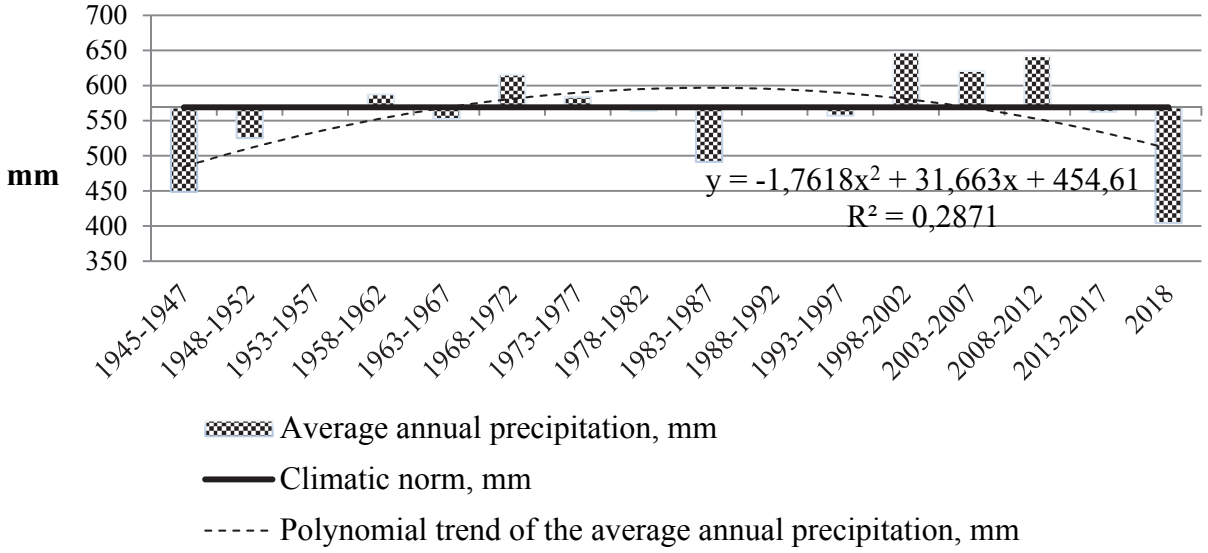

Fig. 3. Average annual precipitation

However, the total precipitation during the year and during the growing season is not a reliable starting criterion for assessing the actual moisture supply of crops during the growing season.

We compared the dynamics of soil moisture reserves under winter wheat in 1986–1990 and in 2014–2018 to assess the impact of climate changes on their consumption (Fig. 4).

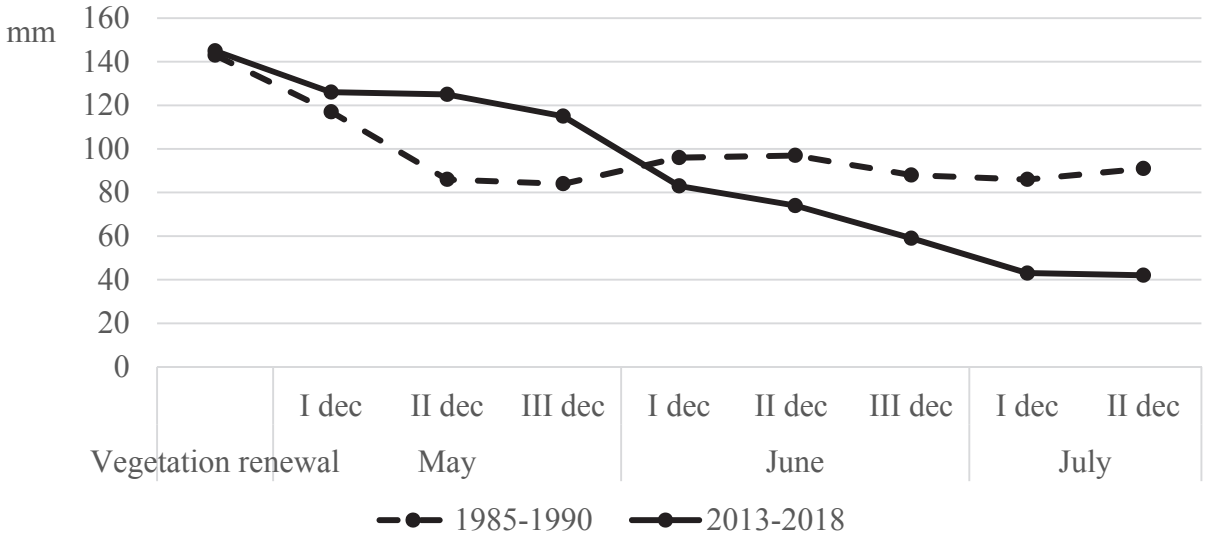

Fig. 4. Dynamics of productive moisture reserves under winter wheat

These data indicate that the processes caused by global warming have significantly impaired the supply of plants with moisture. It was established that at the same amount of precipitation, the reserves of productive moisture at the winter wheat growing in the 0–100 cm soil layer in June–July of 2013–2018 were twice smaller than in 1985–1990.

The above data indicate the gradual aridization of the territory. Although due to the increase in winter precipitation and their better soil absorption due to slight freezing, early spring moisture reserves have increased slightly, but there are clearly declining trends in the summer. As a result, the rapid decline of soil moisture reserves starts in June, which begin to restore only in the second half of autumn. Increasing the temperature of the air and soil during the growing season of crops, combined with increase in winds and decrease in relative humidity significantly increases the evaporation of moisture, which causes worse water availability of plants, even if consumption does not decrease.

The prospective variants of the sown areas structure can be justified objectively if the potential of hydrothermal resources of individual natural and climatic zones is objectively evaluated [12].

The rapid increase in the sums of effective temperatures has created favorable conditions for the cultivation of warm-weather crops such as corn for grain, soybeans, sunflowers and others in the Western Forest-Steppe zone. The planting of these crops are increasing rapidly, making the structure of the sowing areas and the general types of agro-landscapes in the region very similar to the right-bank Forest Steppe.

In 2000, in the agricultural enterprises of the Rivne region corn was grown only on the area of 3.9 thousand hectares, which was 0.9 % of the structure of sowing areas, and soybean and sunflower were practically not grown. In 2018, the sowing areas of these crops was 50.5; 72,8 and 24,2 thousand hectares respectively, or 17,9; 25,8 and 8,6 % in the structure of sowing areas. In total, 52.3% of the sowing areas was occupied by these crops.

The climate changes, new structure of the sowing areas, combined with the widespread introduction of new technical means, fertilizers, plant protection products and breeding grounds, dictate the urgent need to create the new scientific bases of zonal farming.

Crop yields are forming at the influence of many factors and their interaction. The analysis of its achieved indicators at the period of 2010–2018 indicates their stable growth (рис. 5).

During this period, the yield of winter wheat increased from 2.9 to 4.6 t/ha, corn for grain – from 4.9 to 8.2 t/ha, soybeans – from 1.4 to 2.7 t/ha, winter rape – from 2.3 to 3.8 t/ha, sunflower – from 1.1 to 2.4 t/ha, or by 59.67, 93.65 and 118 % respectively. It is difficult to determine the size of the particles of all components that caused such a rapid increase in yield. This is primarily due to the transition of most agribusinesses to the innovative way of development. Due to the globalization of the economy, they widely use the best domestic and foreign scientific achievements, which include the latest technologies, varieties and hybrids, machinery, fertilizers, plant protection products and other. It is also undisputed that the significant contribution to improving the crop productivity is the improvement of the area's heat supply and increase in CO_2 content in the air.

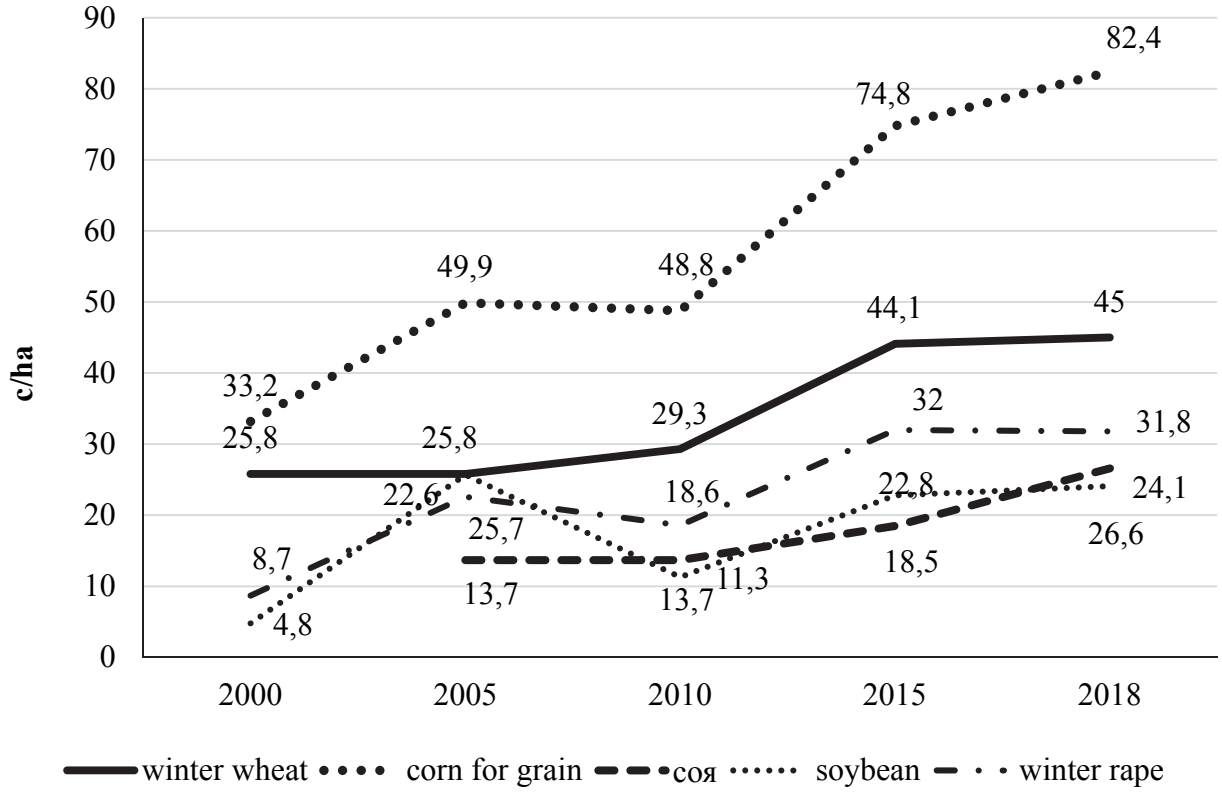

Fig. 5. Dynamics of yield of basic crops in Rivne region wheat winter corn for grain soybean sunflower winter rape

However, despite significant achievements, the prospects of further development of crop production in the region are less optimistic due to the persistent deterioration of the water availability of crops, which may impede further growth of their productivity.

Conclusions

Due to the progressive global climate changes, the heat supply of the Western Forest Steppe and Western Polissia has improved significantly, which has led to the dominance of warm-weather crops in the sowing area such as corn, soybeans and sunflowers. In combination with the introduction of modern growing technologies, this has ensured the rapid increase in the yield of all crops.

References

1. Adamenko, T.I., Kulbida, M.I., & Prokopenko, A.L. (2016) *Atlas ahroklimatychni resursy Ukrainy* [Atlas of Agroclimatic Resources of Ukraine]. Kyiv. [In Ukrainian].

2. Zaiavlenie VMO o sostoianii hlobalnoho klimata v 2016 hodu [Statement by the WMO on the state of the global climate in 2016]. *WMO,* 1189, 24. [In Russian].

3. Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley (Eds.). IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

4. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, & L.L. White (Eds.). IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the

Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

5. Romashchenko, M.I., & Tatariko, Yu.O. (2017). *Memorovani ahroekosystemy. Otsinka ta ratsionalne vykorystannia ahroresursnoho potentsialu Ukrainy (zony zroshennia i osushennia)* [Memorized agroecosystems. Estimation and rational use of agroresource potential of Ukraine (irrigation and drainage zones)]. Kyiv; Nizhyn: PE Lysenko M. M. [In Ukrainian].

6. *Natsionalna dopovid «Pro stan navkolyshnoho seredovyshcha v Ukraini u 2009 rotsi»* (2011). [National Report on the State of the Environment in Ukraine in 2009]. Kyiv: Center of Environmental Education and Information. [In Ukrainian].

7. Veremeienko, S.I., Polovyi, V.M., & Furmanets, O.A. (2016*). Evoliutsiia temno-sirykh gruntiv za tryvaloho silskohospodarskoho vykorystannia* [The evolution of dark gray soils during prolonged agricultural use]. Monograph. Rivne, Kamianets-Podilskyi: TOV «Drukarnia «Ruta». [In Ukrainian].

8. Saiko, V.F. (2008). Zemlerobstvo v konteksti zmin klimatu [Agriculture in the context of climate changes]. *Scientific Magazine of NSC "Institute of Agriculture"*. Special issue. pp. 3–14. [In Ukrainian].

9. Petrychenko, V.F., Baliuk, S.A., & Nosko, B.S. (2013). Pidvyshchennia stiikosti zemlerobstva v umovakh hlobalnoho poteplinnia [Increasing the sustainability of agriculture in the context of global warming]. *Bulletin of Agricultural Science, 5,* 5–12. [In Ukrainian].

10. Babichenko, V. M., Nikolaieva, N. V., & Tushchyna, L. M. (2007). Zminy temperatury povitria na terytorii Ukrainy naprykintsi XX ta na pochatku XXI stolittia [Changes of air temperature on the territory of Ukraine at the end of the XX and the beginning of the XXI century]. *Ukrainian Geographical Journal, 4,* 3–12. [In Ukrainian].

11. Rode, A.A. (1978). *Voprosy vodnoho rezhyma pochv* [Questions of the water regime of soils]. Lenynhrad: Gidrometeoizdat. [In Russian].

12. Tatariko, Yu. O., Saidak, R. V., & Soroka, Yu. V. (2016). Perspektyvy vykorystannia meliorovanykh zemel huminovoi zony Ukrainy v umovakh zmin klimatu [Prospects of the use of the reclaimed lands of the humic zone of Ukraine in the conditions of climate change]. *Bulletin of Agricultural Science, 7,* 55–59. [In Ukrainian].