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Доля раннеспелых клеверов также осталась на прежнем уровне: 30,6 % (21122 га) в 2020 г. при 30,3 % (24149 га) в 2016 г., но при этом изменилось соотношение между сортами в сторону увеличения площадей под новыми сортами. Так, укосные площади кислотоустойчивого сорта Грин за последние пять лет возросли в 18,6 раза (со 109 до 2032 га), ультраранеспелого сорта Кретуновский - с 1360 до 2480 га или в 1,8 раза. При этом площади под раннеспелым сортом Трио снизились на 4972 га, но он, по-прежнему, занимает большие площади в сельхозпредприятиях Кировской области (14641 га в 2020 г.)

Таким образом, использование разнообразного исходного материала, провокационных фонов и различных методов селекции позволило создать раннеспелые зимостойкие адаптивные сорта клевера лугового с высоким адаптивным потенциалом, широко использующиеся в сельскохозяйственном производстве Кировской области.

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CLIMATE CHANGE AND ITS EFFECT ON THE FORMATION OF VEGETABLE PLANT YIELD IN THE CONDITIONS OF UKRAINE

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Abstract

The results of studies on the formation of vegetable plants under the effect of climate change in Ukraine are presented. At the global and regional levels of climate change, since the beginning of the 21st century the world countries, including Ukraine, have dealt with a number of extremely important and complex tasks related to the development of state security strategy and support of sustainable development in the conditions of climate change. Climate change experienced in recent years indicates a significant deviation of the system from the norm at the global biosphere level. These deviations are of great concern for the humanity, including the population of Ukraine. Changes in weather conditions in the territory of Ukraine have caused an increase in the air temperature, which in its turn results in the rainless period, in particular during the growing season of crops, including vegetable plants.

Keywords: vegetable plants, weather conditions, temperature, yield, climate, changes.

Introduction. Vegetable growing is one of the important branches of agriculture in Ukraine. Positive development in the country is facilitated by the warm climate, fertile soils and plant provision with light. In general, in Ukraine vegetable consumption has increased significantly in recent years and amounts to about 90-100 kg per capita. For human nutrition, the quantity of vegetables consumed is insufficient, so the main goal of agriculture is to increase the production of vegetables through expansion of the irrigated land, development and application of new farming technologies, which is related to weather conditions. In recent years, irrigation areas in Ukraine have increased. Previously, irrigation was used exclusively in the Steppe zone. However, in current economic conditions there is a need to grow vegetables using irrigation and in the conditions of the Forest-Steppe.

As a result of warming, during the XX century the average ocean level has increased both in Ukraine and around the world by 10-20 cm due to the thermal expansion of water and melting of ice. In the XX century, rainfall has increased over the decades on average by 0.5-1%, mainly in the high and mid latitudes of the Northern Hemisphere. The frequency and intensity of droughts increased substantially. In the Northern Hemisphere, the frequency of extremely low temperatures has decreased and the frequency of extremely high temperatures has increased slightly. But climate warming is uneven across the oceans and continents.

In the territory of Ukraine the yields of vegetable plants are very variable and their capacity is determined by the territory supply with light, heat, moisture, food, as well as soil fertility and biological characteristics [Bozhko L. Y., 2010].

The yields of vegetable crops can be increased due to many factors, e.g. introduction into production of new, more productive varieties or hybrids, implementation of varietal zoning, which involves the placement

of varieties differing by their maturity rate in accordance with the suitability of agro-climatic resources of the territory; biological features of these crops. The complexity and heterogeneity of relationships in the climate system, on-going evolution of its components with different inertia cause many climatic changes on the planet [Vrublevska O. O. 2013]. Climate change on the planet is one of the most serious current environmental problems, which more and more often causes negative impacts on the economy and society as a whole. Industrial development has a great environmental effect. An increase in the intensity of greenhouse gas emissions contributes to global warming, which in its turn leads to delays in human development due to reduced agricultural productivity, growing water demand, the risk of flooding of coastal territories and extreme meteorological phenomena, ecosystem collapse, treats to human health. But now it is becoming clear that the state of the environment also directly affects economic activity. It becomes more difficult and costly to get access to the resources used in economic activities, and the change of the models of economic development and growth of human well-being can lead to increased pressure on the infrastructure and natural ecosystems, tangible assets and supply chains. At present, both individual business structures and countries as well as entire regions are experiencing material losses caused by the negative effect of climate change [Udod N. M., 2015, Anup S. 2015].

Agricultural production depends on weather and climatic conditions. In recent years, changes in climate conditions affecting the cultivation of many agricultural crops have been observed in Ukraine [Stevenson, H. and Dryzek, J. S., 2014].

According to Bozhko L. Y., it has been established that in the irrigation conditions the main indicator of eggplant yield formation is availability of solar radiation and the sum of active air temperatures of the fruiting period. However, late eggplant varieties do not get enough heat during this period. Analytical relationships of eggplant yields with the sum of air temperatures during different interphase periods can be used to estimate expected yields [Bozhko L. Y., 2012].

The cause of climate change is the energy misbalance of the biosphere and its constituents, namely natural types of the ecosystems that arise under the influence of anthropogenic factor. The functioning of ecosystems is aimed at connecting energy, preserving the internal organization of its structure. Under availability of a large gradient between the energy reserves of individual blocks of the biosphere, there arises the imbalance: entropy indicators increase and orderliness decreases. Natural ecosystems are no longer capable of providing necessary stabilization, so external factors respond accordingly, moving energy in horizontal and vertical dimensions. This leads to the occurrence of rainfall, storms, tornadoes, an increase in average annual air temperatures and an increase in the amplitude of fluctuations in climatic indicators and other cataclysms [Shove, E., 2010; Shove, E., Pantzar, M. and Watson, M., 2012].

According to the current data, the temperature of our planet is rising due to anthropogenic influence. Such a negative effect has also been established in Ukraine. The average air temperature in Ukraine has increased by 0.3-0.6 °C over the past ten years and by 0.7 °C over the past 100 years [Global Carbon Project, 2014]. The year of 2016 appeared to be the hottest one in the history of observations. Nowadays, there are droughts, natural disasters, changes in temperature, fires, flooding, in addition, it also affects the health of the people and some species of plants and animals disappear [Jasanoff, S., 2010].

According to the estimations of international scientists, the temperature increase by 2 °C will lead to irreversible changes. To keep global warming within 2 °C, 80% of fossil resources must remain in the soil structure. At the same time, the air is undergoing significant changes. There are two main causes of pollution. The first one is direct contamination that is directly affected by humans. These include greenhouse gases from cars, heating, water utilization. The second cause of pollution is indirect costs for the activities of corporations, transportation, etc., which make up 80%. This is the pollution the origin of which cannot be directly seen [https://en.boell.org/en/2017/03/29/hto-naspravdi-vplivaie-na-zmini-klimatu].

Global climate change is the aggregate of climate change in different regions across time and space. In some countries, in recent years, natural disasters of destructive power have increased in number significantly, and they appear to be more intensive than those previously observed. Technological progress has not reduced losses from natural disasters in the last few decades, but, on the contrary, losses from climate extremes have increased. It is the regional changes accompanied by the extreme phenomena that have the most significant impact on the economic and social life of society. In the first decade of the XXI century the increase in weather and climatic anomalies, e.g. rainfall, tornadoes, squalls, floods, droughts, excessively hot weather, spring frosts, snowfall, has resulted in the concern on the rising global air temperatures. So far, society cannot develop measures that will stop this process. But in order to reduce losses, it is necessary to adapt to the climatic conditions quickly, understand the causes of climate fluctuations, and especially be able to anticipate future climate change. However, at present there is no clear answer on the possible mechanisms and processes that form this global phenomenon [nbuv.gov.ua ›j-pdf› ukjdzz_2015, Sivakumaran Sivaramanan, 2015].

While the attention was primarily focused on the temperature rise, nowadays other possible scenarios are being considered, which under all circumstances lead to significant changes in ecosystems, namely, an increase in temperature by 1 °C causes a shift of 160 km of natural zones. According to the estimates of scientists, the temperature can rise by 3 °C with subsequent destruction of a number of ecotopes, especially those located in extreme conditions: Arctic or Antarctic (areas of polar bear, walruses, penguins), alpine stations in the low mountains (for example, in the Carpathians) , many desert types, as well as Mediterranean habitats, tropical rainforests, etc. In total, 34 global hot spots

have been identified, rise of average winter temperatures (in Ukraine, the average January temperature has already increased by 1.5-2.5 °C and in February by 1-2 °C, prolongation of the growing season, increase/decrease in rainfall will change the hydrothermal temperature cycles that determine the development of biocenoses (mesophytization of ecosystems is observed in mid-latitudes) [Ukrainian Journal of Land Distance Zoning, 2015]. Low extreme winter temperatures, which have inhibited the spread of numerous weed species (including pathogens) are becoming less common, which has contributed to the spread of invasive species, cataclysms like snow in the desert, record highs and lows in temperature, late-spring frosts that reduce the yields of crops and wild species, floods (the Carpathian Mountains experienced two-month norm of rainfall within several days last year, rainfall in Arabia exceeded 4-5-year norm), droughts, desertification (330,000 tons of dust fell in Beijing in April 2008, and sand dunes moved closer to the city by 70 km), storms, tornadoes, etc. [Grin, J., Rotmans, J. and Schot, J., 2010], increase in the content of CO_2 and other gases provokes greenhouse effect development. Due to biomass burning, fossil fuel consumption forms brown clouds, which accelerates warming of the lower atmosphere. Ukraine has signed the United Nations Convention on Climate Change and ratified the Kyoto Protocol. Measures have been developed to reduce greenhouse gas emissions for energetics, industry, land use, agriculture, forestry and utilities, transport, household waste management, etc. The Climate Initiative Information Center has been established under the authority of the Ministry of Environment, and it main goal is to meet the requirements of the UN Convention and the Kyoto Protocol. Hence, some steps have been taken in Ukraine to solve this problem. These measures refer to the technical and technological aspects. It is quite logical that global warming is being discussed now and the degradation of ecosystems is going to be discussed in the future, since these problems are interrelated. Speaking at the 9th Meeting of the Parties of the Convention on Biological Diversity, A. Steiner noted that all international environmental governance measures were not effective in overcoming the biodiversity crisis. He called for search and suggestion of new directions and priorities for the conservation considering such issues as climate change and food security [Cook, J., Nuccitelli, D., Green, S. A., Richardson, M., Winkler, B., Painting, R., Way, R., Jacobs, P. and Skuce, A., 2013].

Methods. Climatic conditions of Ukraine were the object of research. The main research methods included geobotanical, hydrogeological, landscape-ecological, agro-ecological, retrospective analysis, as well as monitoring, statistical, cartographic and field methods of research in 2005-2018, and the yield of vegetable plants in 2010-2018.

Results and discussion. Formation of the total crop yield is significantly influenced by all well-known factors throughout the growing season. For this purpose, observations of the network of agrometeorological and hydrometeorological stations, the network of state variety testing and statistical offices as well as the materials of special experiments in the territory of Ukraine have been applied [Bozhko L. Y., 2012]. The analysis of observation materials in the years having high and low yields has showed that during the years characterized by unfavorable agrometeorological conditions for vegetable plants, including eggplant, the yield did not exceed 8.0-15.9 t/ha. Under favorable conditions, the total eggplant yield reduced if the crop damage by Colorado potato beetle exceeded 10 % [Bozhko L. Y., Barsukova O. A., 2012].

Table 1

Annual air temperature and amount of rainfall in the conditions of Ukraine (2005-2018)

Years of observation	Temperature, ^{0} C	Rainfall, mm
2005	8.7	492
2006	7.6	625
2007	9.4	548
2008	9.0	612
2009	8.7	443
2010	8.3	710
2011	8.3	438
2012	8.5	505
2013	7.7	623
2014	8.6	547
2015	9.8	370
2016	9.0	471
2017	9.1	524
2018	8.9	567

At the same time, it is proved that a decrease in the ambient temperature below the optimum value leads to the significant reduction of eggplant yield [Bozhko L. Y. 2012].

Based on the statistics data on the weather indicators, in particular, annual air temperature and rainfall in Ukraine in 2005-2018 the air temperature changed as follows: in 2005-2011 there was observed insufficient stabilization, and only in 207-2008 the average air temperature was at the level of 9.0^{0}C and higher. From 2012 to 2018, there was observed an increase in the average annual air temperature above 9.0 ^{0} C, especially in 2015, 2016 and 2017. The average annual air temperature in 2005-2011 was 8.6^{0}C, and it averaged 8.8^{0}C in 2012-2018, which was 0.3^{0}C higher than in the previous years of observation (Table 1). Changes were also observed in the amount of rainfall over the years. In 2005-2011, rainfall exceeded 600 mm, e.g. 625 mm in 2006, 612 mm in 2008, and 710 mm in 2010. In 2012-2018, rainfall exceeding 600 mm was recorded

only in 2013 (623 mm). The year of 2015 was dry, with an index of 370 mm.

In recent years, on the territory of Ukraine, there has been observed an increase in air temperature as well as the rainless season, which adversely affected crop growth and development. This factor causes the need to apply irrigation. While such a need was previously experienced in the Steppe zone of Ukraine, in recent years the Forest-Steppe zone of Ukraine has required it as well. This especially refers to plants that are demanding for soil moisture. Statistical processing of temperature figures over the period under research has showed that the maximum and minimum values of air temperatures are variable and differ insufficiently by years of observations (Table 2).

Table 2

Average annual maximum and minimum of air temperature values in conditions of Ukraine in 2005-2018, ^{0}C

Years of observation	Maximum value of air temperature	Minimum value of air temperature
2005	34.1	-23.6
2006	30.3	-28.8
2007	34.6	-18
2008	34.6	-19.7
2009	32.9	-21.0
2010	33.6	-27.2
2011	30.8	-18.5
2012	36.8	-28.2
2013	29.7	-19.0
2014	32.9	-23.5
2015	35.2	-18.5
2016	33.1	-22.2
2017	33.4	-21.6
2018	30.0	-22.3
Average value in 2005-2011	32.99	-22.40
Average value in 2012-2018	33.01	-22.19
Average value in 2005-2018	33.00	-22.30

According to the analysis conducted, during 2005-2010, the maximum value of air temperature was 34.6 ^{0}C (in 2007, 2008), while during 2011-2018, this value was 36.8 ^{0}C, which was 2.2^{0}C higher compared to the figures of the previous years. In 2005-2010, the air temperature was more even than during 2011-2018. From 2005 to 2010, the observed difference between the lowest and highest values of the maximum temperature was 4.3 ^{0}C, and from 2011 to 2018 this indicator was as high as 7.1 ^{0}C. The average index of the maximum value of air temperature for the period of 2005-2011 was 32.99 ^{0}C, for the period of 2012-2018 this index did not differ significantly, however it was characterized by a higher value, namely, 33.01 ^{0}C. The average value of the maximum temperature for the period of observation from 2005 to 2018 was 33.0 ^{0}C.

In 2005-2011 the minimum temperature value was 28.8 ^{0}C (in 2016), while in 2012-2018 this indicator was at the level of 28.2 ^{0}C (2012), which was 0.6 ^{0}C higher than in 2006. In 2005-2011 there was observed a more diverse air temperature compared to 2012-2018, and the difference between the lowest and the highest minimum of the temperature value was (−10.8) ^{0}C, while in 2012-2018 this indicator was (9.7) ^{0}C. The average index of the minimum temperature value for the period of 2005-2011 was (- 22.40) ^{0}C, for the period of 2012-2018 this index did not differ significantly, but it was slightly higher, at the level of (-22.19) ^{0}C. The average value of the minimum temperature during the observation period of 2005-2018 was (–22.30) ^{0}C.

Thus, according to Table 2, it can be found that over the years of observations the summer becomes hotter and the winter is quite cold.

According to the data on the total yield of vegetable plants, there were determined the values that depended on the weather conditions observed in the conditions of Ukraine (Table 3).

Table 3

The total yield of vegetable plants in the conditions of Ukraine, 2012-2016

Crop	Yield over the years of observation, t/ha							
	2010	2012	2013	2014	2015	2016	2017	2018
Cabbage	20.8	21.9	35.5	26.3	23.8	24.3	25.3	26.0
Cucumbers	13.5	19.2	19.4	14.5	14.2	14.3	13.1	15.3
Tomatoes	20.0	23.6	23.9	25.0	27.5	27.5	27.6	29.1
Onion	15.2	22.0	17.1	18.8	17.1	18.4	17.7	-
Carrot	16.2	22.8	20.6	20.3	19.2	20.3	19.5	19.7
Beet	18.1	25.5	22.7	21.9	21.1	21.4	21.6	21.4
Average yield	17.4	22,5	23.2	20.7	20.6	21.0	20.8	21.4

The data given in the Table 3 indicate that an increase in air temperature and a decrease in rainfall resulted in the lower yields of vegetable plants. Thus, in 2012–2013, the total yield was high enough under the optimal air temperature of 22.5-23.2 t/ha. At the same time, in 2015 the average yield of vegetable plants decreased and amounted to only 20.6 – 20.7 t/ha, where the average air temperature was higher compared to other years of observation and amounted to 9.8 ^{0}C, while the sum of rainfall was the lowest – 370 mm.

Only a decrease in air temperature by 6.2 ^{0}C and an increase in rainfall to the level of 567 mm has resulted in the yield increase up to 21.8 t/ha. Such changes adversely affect biological characteristics of vegetable plants, especially cold-resistant ones. The yield capacity reduces and thermophilic plants undergo biochemical changes, which is manifested in the reduction of their immunity to harmful organisms.

Conclusion. Thus, according to the analysis of Ukraine's climatic conditions and the yield of vegetable plants, it has been found that over the last 14 years the climate has been changing towards warming in the summer months and significant cooling in the winter months, and the yields have been decreasing, which negatively affects food security of the country.

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