ECOLOGICAL FEATURES OF THE STATE CHANGES OF THE AGROECOSYSTEM COMPONENTS DEPEND ON THE SPECIFIC EFFECTS OF ENVIRONMENTAL CLIMATIC FACTORS

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Abstract: The long-term dynamics of agro-climatic resources in Ukraine and forest steppe zones in the current climatic period was studied in this work (1997-2016 years.). The influence of the thermal regime and moistening regime on the state of agroecosystems of winter wheat and corn has been analyzed, namely the yield, the degree of weediness and damage by pests of the crops with the help of the correlation regression analysis. It was established that the amount of precipitation in May and June affect the productivity of winter wheat (the correlation coefficient is 0.8). Whereas for corn, the determining factor are the precipitation in July (correlation coefficient 0.6). In the course of analysis the degree of weediness was found to affect the yield of winter wheat and corn (correlation coefficient is -0,9 and -0,5). In addition, the productivity of certain crops depends on the degree of damage to pests and diseases (r = -0.87 and -0.7, respectively).

Keywords: agro-ecosystem, productivity, correlation coefficient, yielding capacity, the degree of weediness, the degree of damage to pests and diseases.

Introduction

At the present stage, global climate changes are one of the most acute environmental problems, the consequences which can affect the state of the entire biosphere. According to the forecasts of the leading international scientific centers for climate research the air temperature can rise 2-5 °C during the next century. This trend is capable of causing serious climate changes, as a result of which different types of ecosystems are threatened with extinction. In consideration of that the agro-ecosystems are particularly sensitive to changing environmental conditions and the problem is becoming increasingly important.

Heat providing of crops is characterized by a sum of average daily air temperatures exceeding 10 °C during the vegetation period. Both high and low temperatures disrupt the course of biochemical processes in cells and can cause their irreversible changes, leading to the cessation of growth and death of plants. Gradual warming in any area leads to earlier flowering and fruiting, causing changes in the life cycle of dependent organisms. Conversely, fall in temperature courses a delay of the biological cycles in plants. In turn, the productivity of crops depends on the provision of moisture in the most critical phases of the plant growth and development. At the same time, the highest activity of assimilation of nutrients from the soil solution is provided by an optimal water regime. While a moisture deficit leads to a decrease in the rate of biochemical processes in the cells, the intensity of photosynthesis and the decrease in a plant biomass (Didukh, 2011, Shcherban, 2011).

That is why, at this stage, there is a need to analyze the changes in environmental conditions that are crucial for the development of the agro-ecosystem, as well as the determination of the main state regularities state of the components of the agro-ecosystem complex, depending on changes in climatic parameters of the environment.

The analysis of recent research and publications

The study of the influence of climatic factors on the yield of crops was considered by V.L. Dmitrenko (Dmitrenko, 2010), L. M. Popitchenko (Popitchenko, 2009), Y.A. Tararico (Tarariko, 2008, pp. 64-67) and others. In particular, the scientists note that the work on assess the reaction of cereals to climate change and the conditions of growing crops has been underway in Ukraine in recent years (Popitchenko, 2009, Shvaika, 2010). The fact is that the determining factor is the ability to predict the productivity of individual crops in order to ensure a stable development of agricultural production. The optimum value of climatic parameters varies widely for similar soil-climatic conditions. The question of the dependence of the biological productivity of the agro-ecosystem on the complex effect of meteorological factors is very relevant nowadays and requires further studying.

The aim of the work is to identify to reveal the regularity of the development of agro-ecosystems of winter wheat and corn components depending on the specific effects of climatic factors in the conditions of the forest-steppe zone.

Method

The dependence of the productivity of agro-ecosystems of winter wheat and corn, the degree of weediness and damage by pests of their crops from the meteorological parameters of the environment (average monthly of air temperature, precipitation) were examined by correlation-regression analysis. The data on the crop yields were collected and based on the annual accounting reports of the district administration of the city Lubny. Observational sites were located on the basis of the research farming of the Lubny meteorological station of the "Roksolana" and "Kvitneve". The meteorological data were obtained from the archives of the Lubny Meteorological Station (the closest to the farming) for the period from 1997 to 2016 years.

Results

Over the past decades, there has been a significant increase in air temperature on our planet. Along with the 30-year period (1983-2012) the northern hemisphere was much warmer for the last 1400 (Climate Change 2013: The Physical Science Basis. IPCC Working Group Icontribution to AR5: Approved Summary for Policymakers). The rate of the change in the average annual global temperature between 1996 and 2012 was 0.14 degrees for the decade. The results of the studying of the thermal regime in Ukraine between 1997 and 2016 years showed significantly higher rates of the change of the average air temperature for a year (0.6 °C for the decade) and in the zone of the eastern forest-steppe 0.8 °C for the last 10 years. The average temperature of the air during the growing season of winter wheat and crops also increased greatly. Their rate of change in the eastern forest-steppe was 0.8 °C and 1.1 ° C for the decade (Fig. 1).

In turn, the amount of precipitation per year in all areas of land on a global scale has not changed greatly since 1901. However, there was a trend of increasing precipitation in the temperate latitudes in the Northern Hemisphere especially in the second half of the 20th century (Climate Change 2013: The Physical Science Basis. IPCC Working Group Icontribution to AR5: Approved Summary for Policymakers). During the analysis of moisture regime data on the territory of Ukraine from 1996 to 2016 a decrease in precipitation by 28 mm per decade was recorded while in the zone of the eastern forest-steppe by 48mm over the past 10 years. The amount of precipitation during the growing season of winter wheat and corn also decreased. The rate of their change in the eastern forest-steppe corresponded to 50mm and 28mm per decade (Fig. 1).

During the analysis of changes in the yield of winter wheat, it was noted that its indicators ranged from 0.8 t/ha to 4.9 t/ha. The value of the correlation coefficient for the yield of winter wheat and meteorological parameters for a 20-year period was calculated in order to determine the patterns of this change. It was established that the precipitations have a more significant effect on the productivity of cereals than the temperature. The amount of precipitation in May and June is very important for crops. The value of the correlation coefficient r = 0.8 indicates the presence of a direct correlation. The parameters of the equations of individual functions in the mathematical model for this factor are given in Table 1.

These needs for moisture are related primarily to its uneven absorption of winter wheat during the growing season (Tohachynska, 2010). The greatest need is related to the phase of the shoot stage, when the plant is in a state of intense growth (formation of flowers and ears of wheat) and the period from earing to full ripeness (May-June). The lack of moisture at this time is extremely unfavorable for culture and leads to a decrease in yield.

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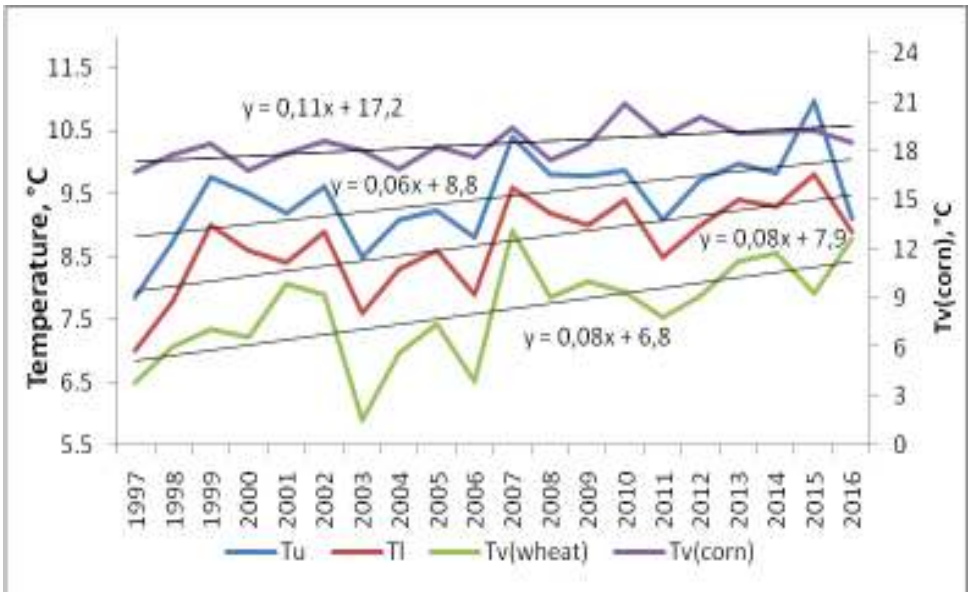
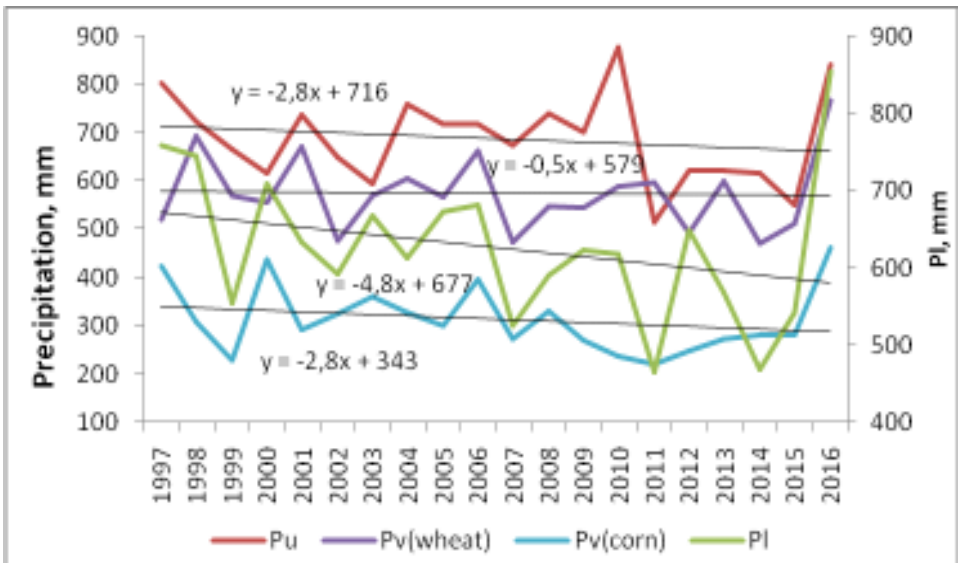


Tu - annual average of air temperature in Ukraine; Tl - annual average of air temperature according to the study; Tv (wheat) - average air temperature during the vegetation period of winter wheat; Tv (corn) - average air temperature during the vegetation period of corn.

A



Pu - annual average amount of precipitation in Ukraine; Pl - annual average amount of precipitation according to the study; Pv (wheat) - average amount of precipitation during the vegetation period of winter wheat; Pv (corn) - average amount of precipitation during the vegetation period of corn.

B

Figure 1. Change of air temperature (A) and amount of precipitation (B) in Ukraine and in the eastern forest steppe over 1997-2016 years.

Table 1

Title of the Table Mathematical and statistical model for productivity of winter wheat depending on the amount of precipitation

Factor	Equation of steam regression	Coefficient of steam correlation
Amount of precipitation in May	y=0,02x+1,89	0,8
Amount of precipitation in June	y=0,03x+0,88	0,8

In the analysis of the data, the presence of the correlation interdependence of the agro-ecosystem components of winter wheat has been determined. It has been established that the yield depends on the degree of contamination (r = -0.9) and damage of crops by pests and diseases (r = -0.87). At the same time, a decrease in the degree of weediness leads to an increase in yields and vice versa. The same patterns are applied to the degree of damage by pests and diseases. It has been established that an increase in the wheat yield by 2 tons per hectare contributes to a decrease in the contamination of crops by 1 point and damage to crops by pests and diseases by 5 percent.

Also, the main regularities of the influence of climatic factors on the contamination and damage to pests and diseases of winter wheat crops were analyzed and determined. It has been established that the average air temperature and the amount of precipitations during the growing season play a great role in the development of the agro-ecosystem.

In the area of the investigation, the air temperature during flowering and ripeness (June-July) and the amount of precipitation during the third-leaf and a tillering period (November, April) have the most significant effect on the degree of contamination and damage by pests and diseases.

In turn, during the study of the influence of climatic parameters on the productivity of corn, the dependence of the change in the yield on the amount of precipitation in July was determined. The paragraphs of the equations of the individual functions of the mathematical model for this factor are given in Table 2.

Table 2

Mathematical and statistical model for productivity of corn depending on the amount of precipitation

Factor	Equation of steam regression	Coefficient of steam correlation
Amount of precipitation in July	У=0,04x+2,02	0,6

According to Table 2, there is a direct correlation (r = 0.6) between the amount of precipitation in July and the productivity of the crop: an increase in the amount of precipitation in the given month affects the increase in yield. This is primarily due to the fact that in this period the corn passes the phase of grain filling, which mainly affects the final value of the yield indicator (Kalinichenko, 2008).

The analysis of the data on corn yields in the investigated region made us establish the dependence of this indicator on other components of the agro-ecosystem mainly, the degree of contamination (r = -0.5 and damage to the crop by pests and diseases (r = -0.7). Accordingly, the increase in the degree of contamination leads to a decrease in crop capacity and vice versa. This pattern is also characteristic of pest and disease damage. Analyzing these components separately, it was found that the degree of corn weediness is directly related to the amount of precipitation in May (r = 0.5). This is due to the fact that in agricultural crops with sufficient rainfall, favorable conditions are created for the germination of weed seeds. Weeds can germinate even at relatively low temperature conditions so their shoots develop before the corn, while the more thermophilic ones develop simultaneously with it (Ivashchenko, 2002). The optimal ratio of environmental conditions in a given period causes an intensive development of weeds which suppress the culture at the initial phases of its growth .and development. A direct dependence concerning the degree of damage by pests and diseases was determined by the precipitation in August (r = 0.6). Thus, cool and humid weather contributes to the intensive spread of crop diseases. During the blossoming period of the corn is most sensitive to damage (July, I-II decade of August). Thus, the alternation of dry periods with moderate moisture during August led to an intensive development of plant diseases.

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Conclusion

In the course of our full analysis of the dependence of the productive agro-ecosystem on the effects of climatic factors it was found that the amount of rainfall in May and June affects the yield of winter wheat (the correlation coefficient is 0.8) Accordingly, the July precipitations are the main factor for the corn (r = 0.6). The presence of a direct correlation indicates that the amount of precipitation in certain months is the most significant factor of the influence on crop yields. The average air temperature plays the main role in the development of agro-ecosystems. It has been established that in the area of the investigation the air temperature during flowering and ripeness (June-July) has the most significant effect on the degree of weediness and damage of winter wheat by pests and diseases.

During the analysis, the presence of the correlation interdependence of the agro-ecosystem components of winter wheat has been determined. It has been established that the yield of winter wheat depends on the degree of weediness (r = -0.9) and the crop damage by pests and diseases (r = -0.87). At the same time, a decrease in the degree of weediness leads to an increase in yields and vice versa. The same patterns are applied to the degree of damage by pests and diseases. In turn, the interdependence of corn yields on the degree of weediness (r = -0.5) and the crop damage by pests and diseases (r = -0.7) was determined. It was established that there is a direct relationship between the degree of weediness of crops and the amount of precipitation in May (r = 0.5) whereas the damage by pests and diseases directly depends on the precipitation in August (r = 0.6).

The study of the change in the state of the agro-ecosystem components depending on the dynamic change in environmental conditions is a very actual issue and has an ecological and practical importance. This is primarily due to the fact that the stability of agro-ecosystem complex is achieved by the optimal ratio of environmental factors. Taking into account the unstable and dynamic nature of climate change, it is necessary to define the main patterns and trends in the productivity of the agro-ecosystem (and its components in general) in detail as the main unit of the agro-industrial sector of production.

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