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POPULATION DYNAMICS OF CORN INSECT PESTS IN UKRAINE UNDER CLIMATE CHANGE

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Aim. To determine the specificities of perennial dynamics in the number of the main corn insect pests in different natural and climatic zones of Ukraine under climate change. **Methods**. The field, laboratory, mathematical methods were used. The materials of the phytosanitary entomological monitoring of the State Service of Ukraine on Food Safety and Consumer Protection (2005–2021) in the basic 161 enterprises in Ukraine's regions using methodologically standardized annual registrations of the main harmful organisms of agrocenoses (Borzykh et al, 2018). Six groups of the main corn insect pests were investigated: corn borers (*Ostrinia nubilalis* Hübner), wireworms (Elateridae) and false wireworms (Tenebrionidae), cutworms (Noctuida), southern dusty surface beetle (*Tanymecus dilaticollis* Gyllenhal), cotton bollworm (*Helicoverpa armigera* Hübner), and cereal aphids (*Schizaphis graminum*) Rondani. The database of the Hydrometeorological Center of Ukraine was used to analyze climate parameters (2005–2021). The statistical analysis of the data was conducted using MS Excel and the linear correlation-regression analysis according to Pearson, Student's criterion was used to evaluate the reliability (probability) of the correlation coefficients. **Results.** The results of correlational analysis of the state of populations of the main corn insect pests demonstrated that climate change has not considerably affected the number of corn borers as well as wireworms and false wireworms in all the natural and climatic zones of Ukraine yet. A reliable moderate reverse correlation (r = –0.309) was found between the number of cutworms and the sum of effective temperatures (SET) only for the Forest-Steppe conditions – under the increase in the SET, the number of these insects was smaller. The number of the southern dusty surface beetle was in direct, reliable, moderate correlation (r = 0.335) with the SET in the Steppe, for instance, the pest responded to the increase in the SET with the rise in its number. The number of cotton bollworms in Polissia was in reliable moderate correlation (r = –0.489) with the SET. The number of cereal aphids was in a reliable moderate direct correlation (r = 0.529) with the SET in Polissia: at the increase in the SET, the number of these pests was increasing. **Conclusions.** Conclusions: Climate changes do not considerably affect the state of the populations of the main corn insect pests in all the natural and climatic zones of Ukraine yet: we found the correlations between the number of insect pests and the SET which did not exceed such values as weak, moderate, and conspicuous. Significant changes in the state of insect pest populations should be expected if the sum of effective temperatures during the vegetation period will considerably affect the performance and feeding qualities of the cultivated plants.

Key words: corn, insect pests, the dynamics in the number of populations, climate change, the sum of effective temperatures, correlations.

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INTRODUCTION

In Ukraine, the area of corn fields is ranked second after that under winter wheat. Since 1990, the area of corn fields has been enlarged almost 4.5 times, and in 2021, it was 5,522.4 thousand ha. The average productivity of corn in 2005 was 43.2 centner/ha, but in

2021, it increased to 76.8 centner/ha (Plantation of Ukraine, 2022).

Climate change and global warming are of serious concern as they pose a threat to global agriculture and are among the most frequently discussed issues in scientific literature. Such climate parameters as a rise in temperature, the increased level of CO_2 in the atmosphere, and a change in the precipitation pattern have a significant impact on the development and state of plants, their pests, and disease agents, and on the agricultural production in general (Sanchez-Bayoa, Wyckhuy et al, 2019; Shrestha, 2019; Lehmann et al, 2020; Hallmann et al, 2021; Skendzic et al, 2021).

Climate change may affect pests in several ways. It may lead to the enlargement of their living area, enhance their survival in winter, an increase in the number of generations, a change in synchronicity between plants and pests, a change in interbreed interaction, risk of pest invasion, the incidence of plant diseases, transmitted by insects, and a decrease in the efficiency of regulating the populations using natural enemies (Sanchez-Bayoa, Wyckhuy, 2019; Skendzic et al, 2021). Due to this, there is a severe risk of economic loss of the yield and a threat to food safety. Since temperature changes are among the main factors, affecting the population dynamics in harmful organisms, there is a need to study the tendencies in the phytosanitary state of agrocenoses to have a possibility to control the pests (Shrestha, 2019; Skendzic et al, 2021; Wang et al, 2022). Although it is well known that insects are sensitive to temperature (Skendzic et al, 2021), it is still unknown how they will be affected by lasting global warming since these reactions are multifaceted and ecologically complicated (Lehmann et al, 2020). The results of long-term observations of the population density of insect species are of particular relevance in determining the tendencies in their population dynamics under climate change.

The impact of climate change on the population dynamics of insects-phytophages of agro landscapes in Ukraine has not been investigated sufficiently. For instance, the analysis of long-term dynamics in the populations of winter wheat pests demonstrated that the reaction of insects to the warming depends on the species biology, and the population density of some groups of species decreased under a change in the temperature regime (Chaika et al, 2021). The impact of the warming on the population density of the main corn pests was not analyzed. Publications predict the increase under warming condition in the populations of wheat pests, which are usually cultivated in moderate climates. At the same time, the reaction of the populations of pests of corn, which is cultivated both in moderate and tropic regions, may be ambiguous (Deutsch et al, 2018; Skendzic et al, 2021). It may be related to a different type of photosynthesis in plants of moderate latitudes (for instance, wheat) and plants of tropical origin (for instance, corn).

The aim of the work is to determine the specificities of long-term population dynamics of the main corn pests in different natural and climatic zones of Ukraine under climate change.

MATERIALS AND METHODS

The study was based on the results of phytosanitary entomological monitoring conducted by specialists of the regional departments of the State Service of Ukraine on Food Safety and Consumer Protection. The monitoring is done at the basic farms located in different regions of Ukraine (a total of 161 farms) using the methodologically standardized annual inventories of the main pests in agrocenoses (Borzykh et al, 2018).

Three natural and climatic zones are known in the flat-bottom part of Ukraine by the differences in the landscape and soil and climatic conditions: Polissya, Forest-Steppe, and Steppe (Vasyljev et al, 1973). Polissya covers the northern regions of Ukraine. In the scheme of Ukraine's agroclimatic zoning, Polissya belongs to a humid, moderately warm zone. The average annual precipitation is 550–700 mm. The total area of Polissya is 111,500 sq. km which is 19 % of Ukraine's territory. Soddy-weakly podzolic and soddy-moderately podzolic soils prevail in the soil complex. Over 65.7 % of the land isarable fields.

The Forest-Steppe zone extends from the northerneast of the Carpathian foothill to the eastern borders of Ukraine. The total area of this zone is about 202,000 sq. km (34 % of Ukraine's territory). The soil complex is very diverse, represented by podzolic and typical chernozem, low- and moderately humus, dark gray, gray, and light gray podzolized soils of different levels of bleaching, carbonate content, salinity, and complex of alluvial soils. The precipitation is from 550 to 700 mm a year in the west and up to 450 mm in the southern east. The rate of land tilling is about 80.8 %.

The Steppe is situated to the south of the Forest-Steppe zone. The total area of this zone is about 240,200 sq. km (40 % of the territory). The soils of chernozem and chestnut types are formed on loess solids in the Steppe. The northern stripe of the zone is comprised of plain moderately- and low-humus chernozem, and the middle stripe – of the southern low-humus chernozem. The latter goes into a thin strip of the southern solonetzic chernozem, which passes into dark chestnut soils farther south. The annual precipitation on the southern border of the Steppe zone is 475 mm. The annual precipitation farther south decreases down to 450–350 mm. The rate of land tilling is about 81.2 %.

The natural and climatic zones of Ukraine are characterized by specific SET indices. The temperature standards of the regions were evaluated by the specialists of the Ukrainian Hydrometeorological Center. As of the period under analysis, the standards for different natural and climatic zones were as follows: Polissya – 969 °C, Forest-Steppe – 1,124 °C, Steppe – 1,400 °C (Adamenko et al, 2011).

The data, supplementing the annual reports of the regional departments of the State Service of Ukraine on Food Safety and Consumer Protection in 2005–2021, were used to analyze the course of climate change. The calculations included SET above 10 °C during the vegetation period for each natural and climatic zone. The lower temperature threshold of the development of insect pests was accepted as +10 °C (Kulieshov et al, 2011).

About 85 species of pests live in Ukraine's corn fields (Vasyljev et al, 1975**)**. The specialists of the State monitoring service monitor the population density of six groups of the main corn pests: the European corn borer (*Ostrinia nubilalis* Hübner, 1796), click beetles (Insecta: Coleoptera: Elateridae) and darkling beetles (Insecta: Coleoptera: Tenebrionidae), cutworms (Insecta: Lepidoptera: Noctuidae), maize leaf weevil (*Tanymecus dilaticollis* Gyllenhal, 1834), cotton bollworm (*Helicoverpa armigera* Hübner, 1808), and spring grain aphid (*Schizaphis graminum* Rondani, 1852). During the inventory, some species with similar biology were considered cumulatively (for instance, click beetles and darkling beetles, cutworms, and aphids). The population density of insect pests was averaged by the natural and climatic zones.

The European corn borer is one of the most dangerous corn pests, which can decrease crop productivity down to 50 % in the years of their outbreaks. This pest is especially widespread in the north of the Steppe zone and the Forest-Steppe of Ukraine. Under climate warming and extension of the corn fields, the distribution and plant damage by the European corn borer was found in 4–10 % of plants in 28–100 % of the investigated fields of grain corn (Gavrilyuk, 2022).

Among soil-inhabiting corn pests, the threat comes from the larvae of the darkling beetles (Tenebrionidae), and click beetles (Elateridae), common for the entire territory of Ukraine. During corn vegetation under normal humidification, click beetles and darkling beetles damage up to 20 % of corn plants everywhere.

Cutworms cause much damage to corn crops in Ukraine. These are turnip moth (*Agrotis segetum* Denis & Schiffermüller, 1775), heart-and-dart moth (*Agrotis exclamationis* Linnaeus, 1758), *Euxoa conspicua* Hübner, white-line dart moth (*Euxoa tritici* Linnaeus, 1761) and black cutworm *Agrotis ipsilon* Hufnagel, 1766). Their biological specificities, lifestyle, and harmfulness are similar in many aspects. The most common among them is turnip moth.

Maize leaf weevil (*T. dilaticollis*) is widespread in the south-west of Ukraine. Beetles feed on the sprouts of winter wheat, then those of spring wheat, beet, sunflower, corn, tobacco, and different weeds; the larvae prefer corn.

Cotton bollworm (*H. armigera*) is the most dangerous pest for the Steppe of Ukraine, mostly damaging corn, and sunflowers.

In Ukraine, the following species of aphids damage corn: monoecious – spring grain aphid (Schizaphis *graminum*), *Rungsia maydis* Passerini, 1860, corn leaf aphid (*Rhopalosiphum maidis* Fitch, 1856); dioecious – bird-cherry aphid (*Rhopalosiphum padi* Linnaeus, 1758), *Aphis solanella* Theobald, 1914, which are among the first pests (late May – early June) to attack corn. A widely common spring grain aphid is the dominant species. It mainly feeds on the fields of winter and spring wheat, barley, rye, oat, and corn, eating leaves, leaf sheaths, stems, and spikelets.

Insects of different species differ in their lifestyle, biology, ecology, and size. Depending on species specificities, the following methods of monitoring are used: soil samples, registration of pests, sweep netting on the soil surface, registration of pests, living on plants or inside them, etc. (Borzykh et al, 2018). Species are identified by the specialists of the State service using reference literature (Benada, 1967).

The results of the analysis were processed using the software package based on MS Excel along with the correlation analysis between the population density of insects and SET according to Pearson (Chaddock, 1925). The correlation was evaluated by Chaddock's scale: if the absolute value of the correlation coefficient $r_{xy} < 0.3$, the correlation is weak, at r_{xy} from 0.3 to 0.5 – moderate, at r_{xy} from 0.5 to 0.7 – conspicuous¸ at r_{xy} from 0.7 to 0.9 – high, at the absolute value of

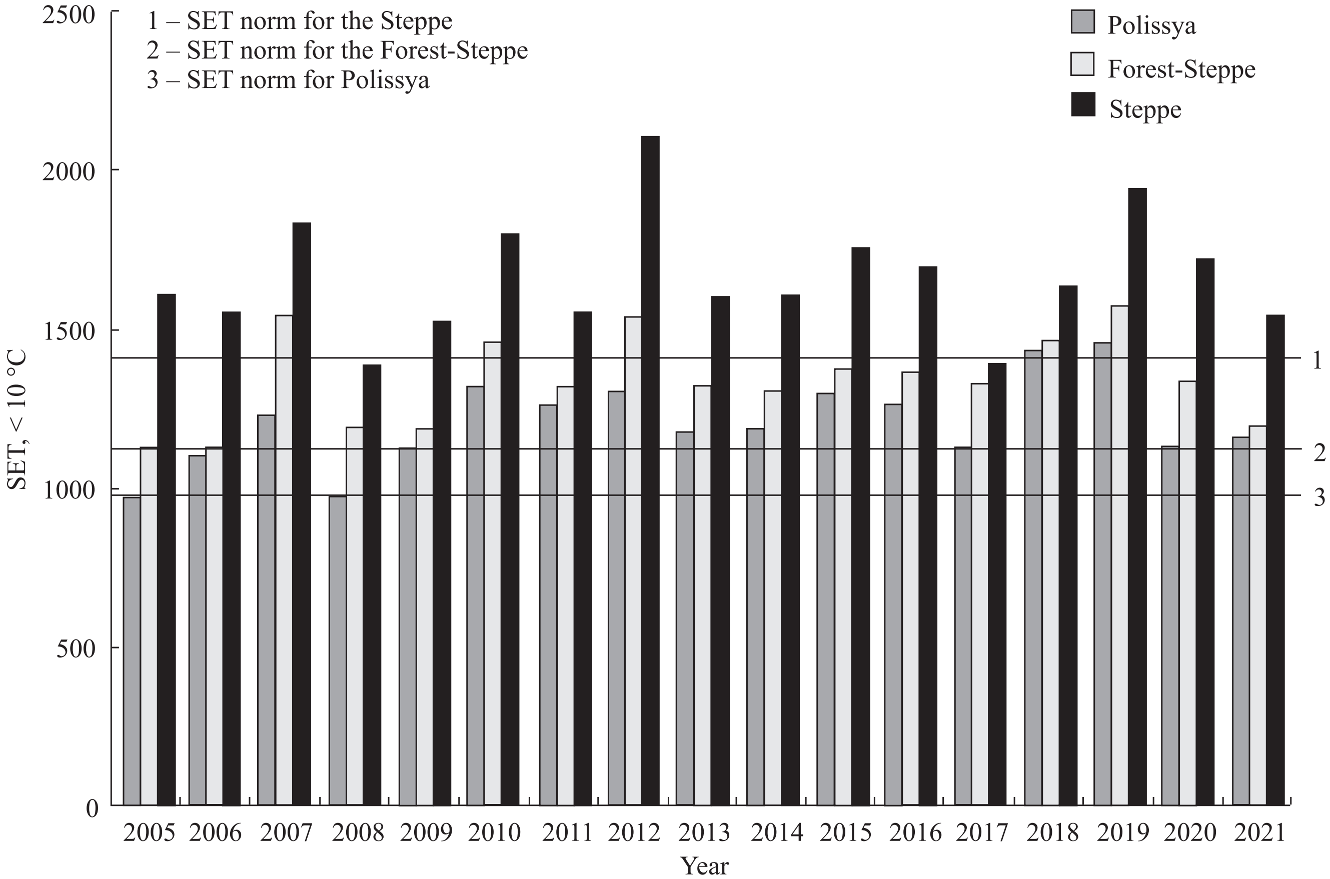

Fig. 1. The SET dynamics (>10 °C) in different natural and climatic zones of Ukraine

$r_{xy} > 0.9$ – the correlation is very high. Student's t-test was used to evaluate the reliability (probability) of the correlation coefficients.

RESULTS

The analysis demonstrated that, in 2005–2021, the sum of effective temperatures exceeded the climatic standards of the corresponding natural and climatic zones almost every year, but the magnitude of warming was different (**Fig. 1**). For instance, in Polissya, the standard was exceeded minimally by +1 °C in 2005 and 2008, maximally – by +331 °C in 2012. On average, in the years under analysis, the sum of effective temperatures increased by 234 °C.

In the Forest-Steppe, the minimal excess in the sum of effective temperatures was registered in 2009 (16 °C), and the maximal one – in 2012 (726 °C). In terms of the climate standard, the average zonal sum of temperatures in 2005–2021 increased by 210 °C.

In the Steppe, from 2008 to 2017, SET had a slight decrease as compared to the climate standard (by 15 and 20 °C, respectively). The maximal rise in heat (+700 °C) was registered in 2012, which was considered the warmest year in all the zones during the investigated period. In 2005–2021, SET in the Steppe increased by 256 °C on average. On average, for the year, the sum of heat increased by 233 °C in all the zones.

It is known (Adamenko, 2014) that Ukraine's climate changes along with the global climate, but the warming in our territory occurs even faster than in other regions of the southern hemisphere. The results of our studies are a good illustration of the warming process in Ukraine.

During the observation period, the population density of the European corn borer was maximal in 2005-2007 in the Forest-Steppe and Steppe, where it was 1.5–2.0 specimens/plant (**Fig. 2**). Leter on, it decreased a little and fluctuated within the range of 1.0–1.4 specimens/plant in all natural and climatic zones. The highest decrease in the population density was confirmed in the Steppe. In Polissya, the population density of pests was moderately stable: in 17 years of observations, it fluctuated at the level of 1.25–1.4 specimens/plant.

As seen in the presented data, the highest number of click beetles and darkling beetles (**Fig. 3**) was observed in Polissya, where it reached almost 1.6 specimens/sq. m during the observation period (2006). In 2009, it was

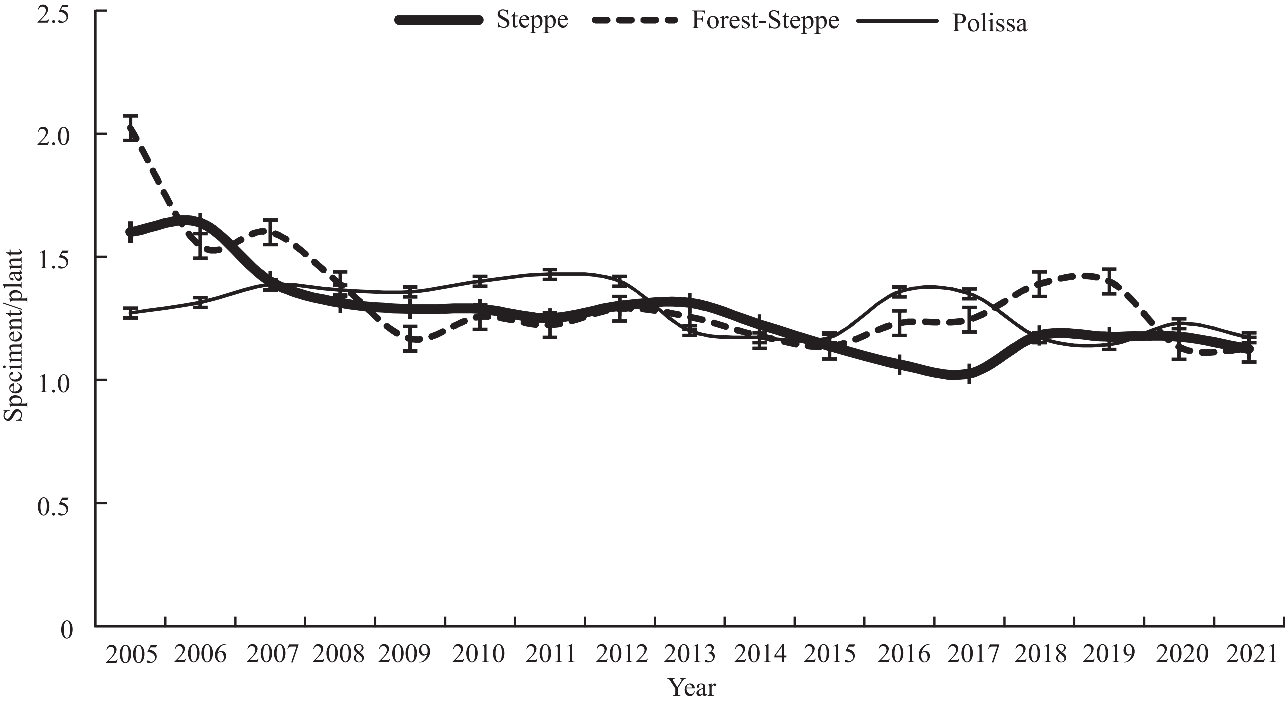

Fig. 2. The longterm dynamics in the population density of the European corn borer *Ostrinia nubilalis* in different natural and climatic zones of Ukraine

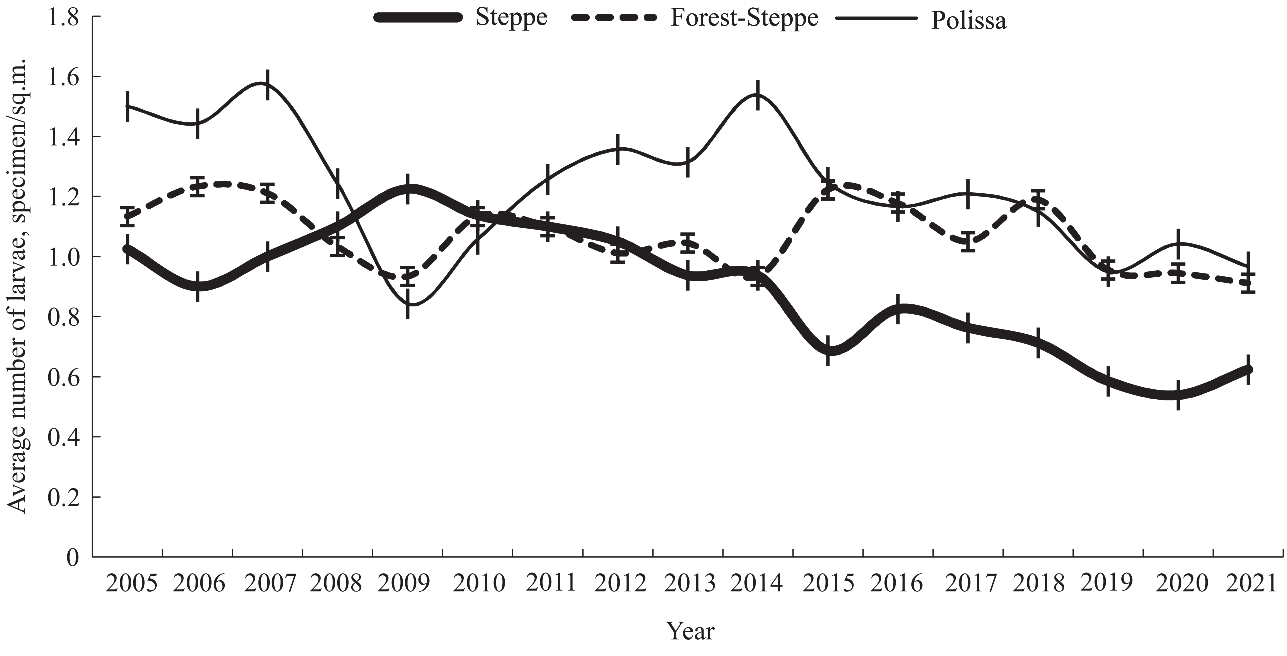

Fig. 3. The longterm dynamics in the population density of the click beetles (Insecta: Coleoptera: Elateridae) and the darkling beetles (Insecta: Coleoptera: Tenebrionidae) in different natural and climatic zones of Ukraine

minimal during the observation period (0.8 specimens/sq. m). In 2014, it restored its number; in the following years, it fluctuated and gradually decreased.

In the Forest-Steppe zone, the population density of pests fluctuated within the range of 0.9–1.25 specimens/sq. m but was relatively stable. In the Steppe, after the maximal density of 1.2 specimens/sq. m (2009), a gradual decrease down to 0.6 specimens/sq. m was registered (2021).

As seen in the presented data, during the years of monitoring, cutworms were presented in all zones of Ukraine, but the maximal average density of approximately 1 spec-

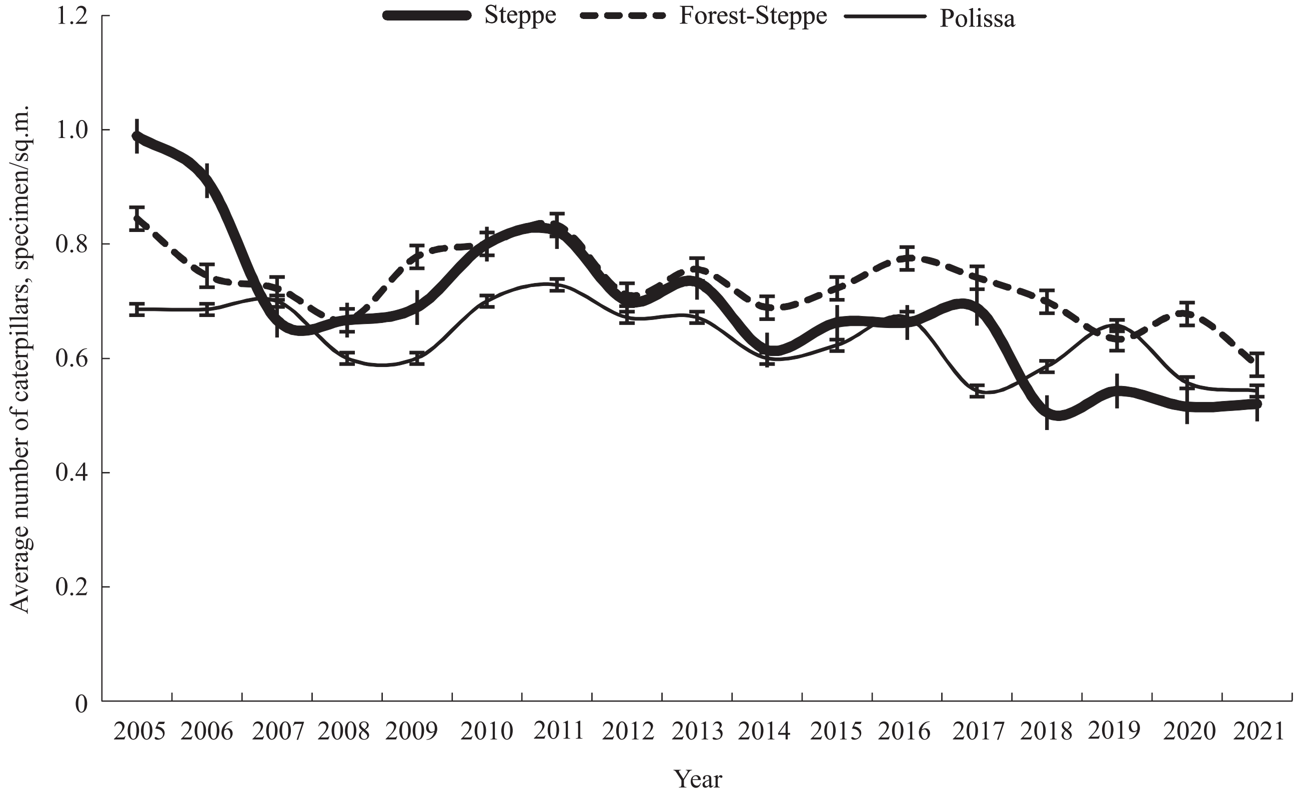

Fig. 4. The longterm dynamics in population density of cutworms (Insecta: Lepidoptera: Noctuidae) in different natural and climatic zones of Ukraine

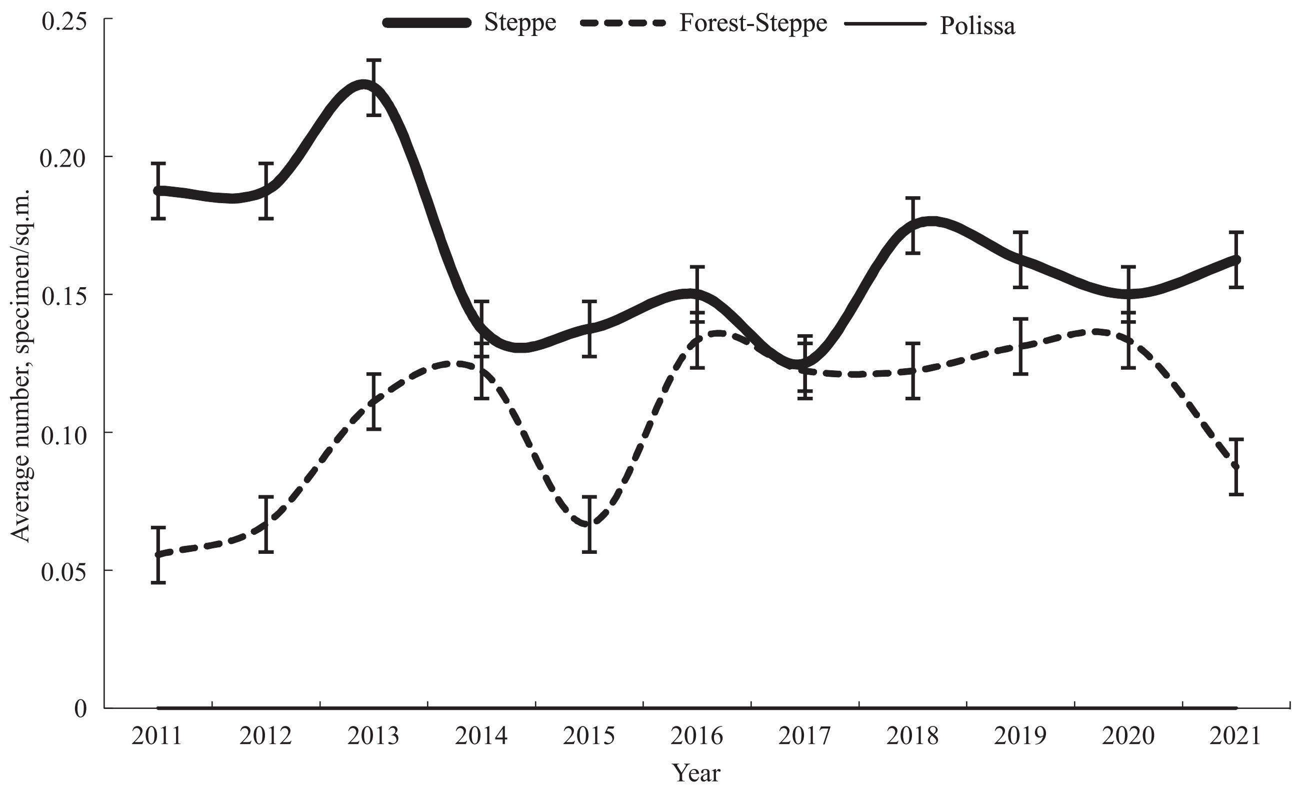

Fig. 5. The longterm population dynamics of the maize leaf weevils *Tanymecus dilaticollis* during the vegetation period in different natural and climatic zones of Ukraine

imen/sq. m was registered in the Steppe in 2005 (**Fig. 4**). Later on, the fluctuation of the pest density in this zone decreased and amounted to 0.5 specimens/sq. m in 2021.

In the Forest-Steppe, the number of cutworms fluctuated between 0.6–0.85 specimens/sq. m during the years under analysis. Yet there was a tendency towards a decrease in the number of pests after 2016. In Polissya, the number of cutworms was less stable and fluctuated between 0.55 and 0.7 specimens/sq. m during the monitoring period.

The analysis of the monitoring results demonstrated that the population of the maize leaf weevil in Ukraine (**Fig. 5**) was the most abundant in the Steppe. The maximal number was registered in 2013, amounting to 0.22 specimens/sq. m Further on, till 2017, there was a depression in the population at the level of 0.12 specimens/sq. m, in the following years, there was some increase in the number against the background of fluctuations within 0.16–0.17 specimens/sq. m.

In the Forest-Steppe, in 2012–2020, the number of pests fluctuated constantly (the maximum occurred in 2016 – 0.13 specimen/sq.m.), but it tended to increase. In 2021, there was a drop in the population density. In Polissya, the maize leaf weevil did not cause much damage, it was found in the outbreak spots with a minimal density.

Climate warming promotes the distribution of cotton bollworms in all natural and climatic zones (**Fig. 6**). Here, the maximal number of 1.5 specimens/sq. m was registered in the Steppe (2013); later, by 2019, there was some depression in the population density. The minimum number was registered in 2019, amounting to 0.4 specimens/sq. m. In 2020–2021, the population density of these pests in the Steppe increased to 1.0 specimens/sq. m.

In the Forest-Steppe, the abundance of pests was moderate and fluctuated between 0.3–0.5 insects/sq. m during the years under analysis. In 2021, there was a decrease in the number of cotton bollworms up to 0.6 specimens /sq.m. In Polissya, the pests were found in separate places, the population density being 0.1 specimens/sq. m, the increase up to 0.3–0.4 specimens/sq. m was observed in 2017–2020.

The average number of spring grain aphid in the vegetation period (complete germination phase) under climate change is presented in **Fig. 7.** As seen in the presented data, the pests were constantly found in all natural and climatic zones of Ukraine. Yet, the indices of maximal population density were registered in the Steppe (2013 – 10 specimens/plant). In 2014–2017, the abundance of aphids in the Steppe decreased down to 3 specimens/plant, and in 2018–

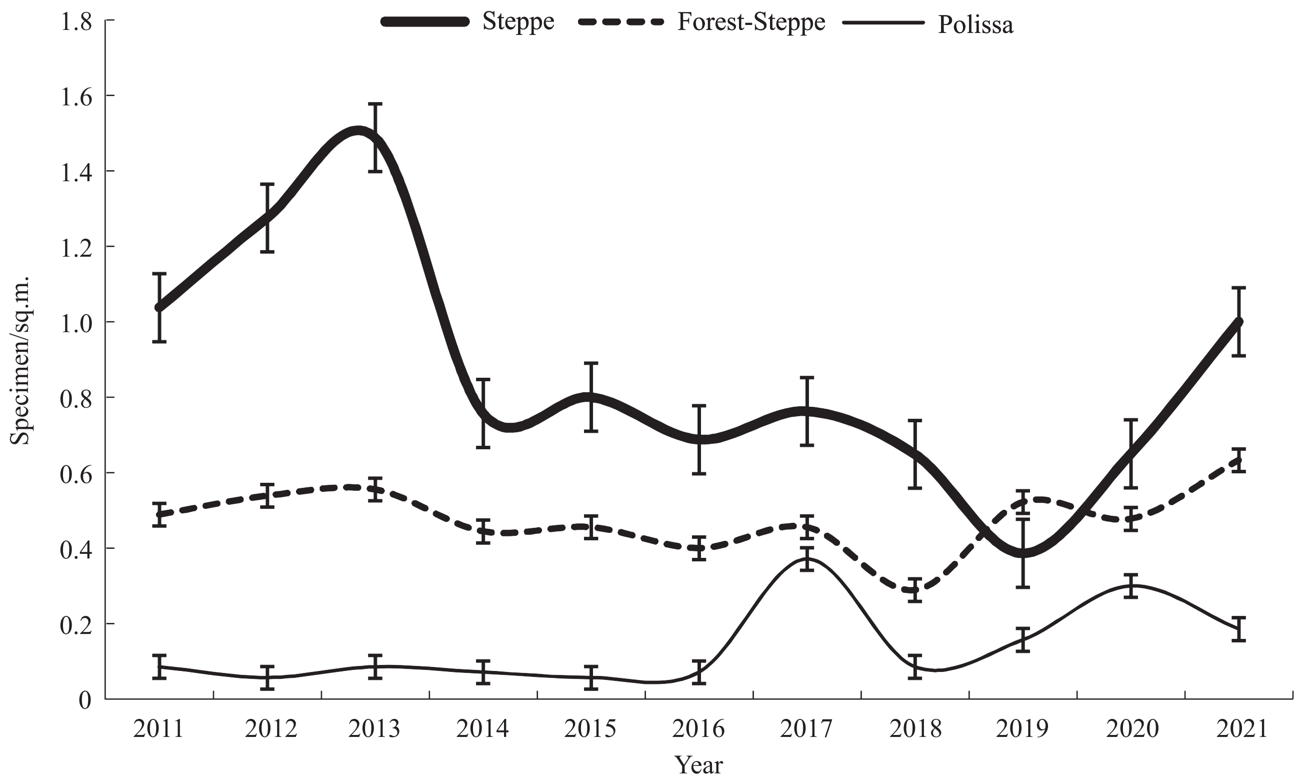

Fig. 6. The longterm population dynamics of cotton bollworm *Helicoverpa armigera* in different natural and climatic zones of Ukraine

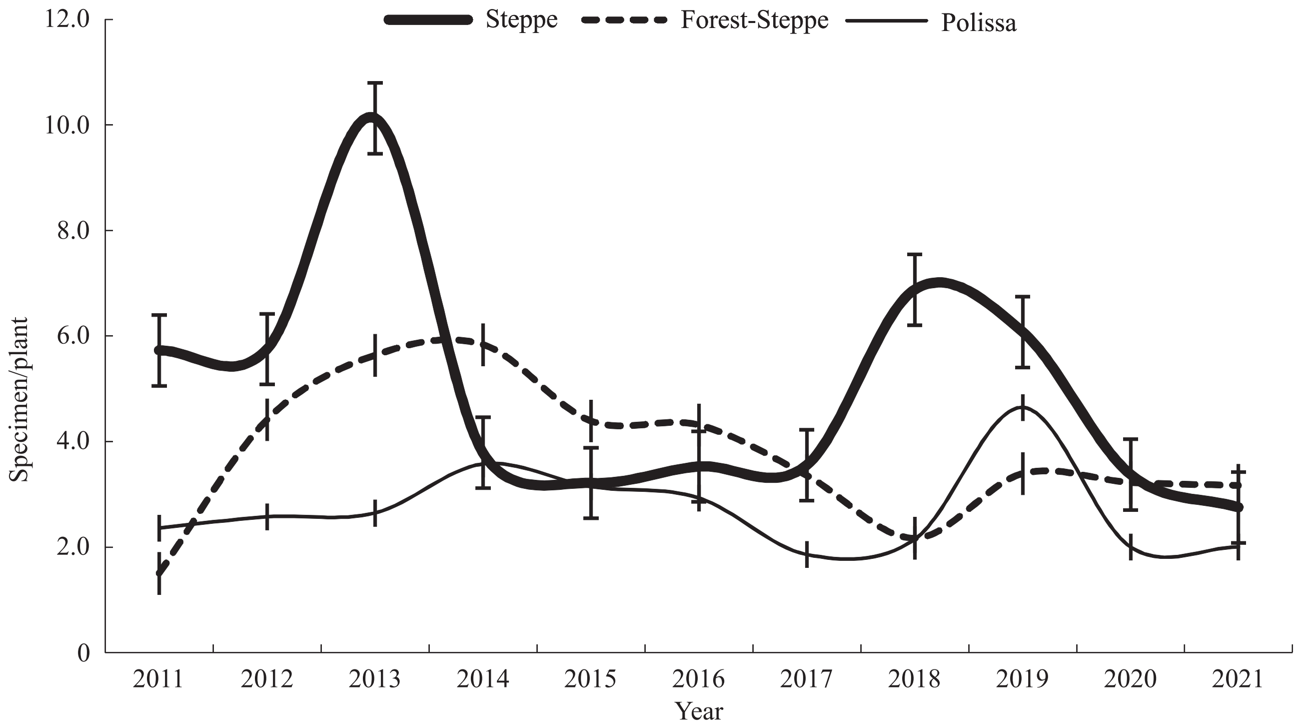

Fig. 7. The longterm population dynamics of spring grain aphid *Schizaphis graminum* in different natural and climatic zones of Ukraine

2019, the increase in the number of aphids up to 6–7 specimens/plant was registered again. Later, the number of aphids decreased almost twice. In the Forest-Steppe, from 2011 to 2021, a conspicuous fluctuation in the population density was registered within the range of 1.5–6 specimens/plant. The maximum population density was registered in 2014, and the minimum – in 2011.

During the monitoring period, the abundance of aphids in Polissya was more or less stable and fluctuated between 1.85–4.43 specimens/plant, with the minimum registered in 2017, and the maximum – in 2019.

The number of insect pests in agrocenoses is known to depend considerably on weather conditions and the level of plant protection (Shrestha, 2019). Temperature

The correlation coefficients between pest population density and the sum of effective temperatures in terms of natural and climatic zones (2005–2021)

Pests	Steppe	Forest-Steppe	Polissya
	SET		
Ostrinia nubilalis Hübner, 1796 (the European corn borer)	0.014 weak	–0.159 weak	–0.207 weak
Click beetles (Insecta: Coleoptera: Elateridae); Darkling beetles (Insecta: Coleoptera: Tenebrionidae)	–0.111 weak	0.124 weak	–0.268 weak
Cutworms (Lepidoptera: Noctuidae)	–0.206 weak	–0.309* moderate	0.191 weak
Tanymecus dilaticollis Gyllenhal, 1834 (maize leaf weevil)	0.335* moderate	–	–
Helicoverpa armigera Hübner, 1808 (cotton bollworm)	–0.018 weak	–0.259 weak	–0.489* moderate
Schizaphis graminum Rondani, 1852 (spring grain aphid)	0.134 weak	–0.080 weak	0.529* moderate

Note. * – the correlation coefficients are statistically significant (p ≤ 0.05).

is considered one of the most relevant factors, affecting the distribution and character of the abundance of plant pests because of the physiological limitations of each species (Sanchez-Bayoa et al, 2019). To determine the impact of the climatic component on the abundance of the main corn pests, we analyzed the correlations between the dynamics in population density of corn insect pests and the sums of effective temperatures in different natural and climatic zones of Ukraine (**Table**).

The results of the analysis demonstrated that the correlation between the population density of the European corn borer, click beetles, darkling beetles, and the sum of effective temperatures was weak and unreliable in all natural and climatic zones of Ukraine. Cutworms demonstrated a reliable moderate reverse correlation between the population density and the sum of heat for the Forest-Steppe. The cutworms reacted to the increase in the sum of heat by decreasing their number. In other natural and climatic zones, the correlation was unreliable and weak.

The maize leaf weevil demonstrated a direct, reliable moderate correlation between the population size and the sum of heat in the Steppe. The pest reacted to the rise in the sum of heat by the increase in its number. In other zones, the correlation was absent. The dynamics in the number of cotton bollworms in Polissya was in reliable moderate correlation with the sum of heat. The correlation was reversed – the population reacted to the increase in heat with the decrease in its size. The dynamics in the number of spring grain aphids demonstrated a reliable moderate direct correlation with the sum of effective temperatures in Polissya. The correlation was found to be weak in other zones.

DISCUSSION

The conclusions of our investigations are in agreement with the results of the simulation of the impact of climate change on corn pests (Deutsch et al, 2018). It is known that the reaction of different insect species to climate change depends on their specific physiological and ecologic features, seasonal cycle, trophic relations, etc. (Sanchez-Bayoa et al, 2019). At the same time, in addition to temperature, many different factors, acting cumulatively, impact the size of insect pest populations. In agroecosystems, such stress factors as tilling, insecticides, and herbicides always pose a threat to insects. It is incredibly complicated to single out the "weight" of different factors and to determine the key ones in the monitoring process. There is considerable uncertainty regarding the relative importance of these factors, their interaction, and temporary and spatial variations of their intensity (Wagner et al, 2021). Hallmann et al (2021) noted in their review of the decrease in the mass of insect species in the nature reserves of Germany that "no simple reason was found, and weather conditions, land utilization, and altered environmental characteristics cannot explain the general decrease in the number of species..." Del-Claro et al (2021) stated that the current state of insect populations was conditioned by "a magnitude of factors, most probably related to the destruction of the environment, deforestation, fragmentation, urbanization, and agriculture". At present, there is no data for time series regarding many groups of insects and geographic regions to form reliable conclusions (Harvey et al, 2020). Therefore, it is unreasonable to generalize the problem and say that "all insects decrease in their number everywhere" because some groups of insects and geographic regions suffer from it. In contrast, the number of some insects increases (Van Klink et al, 2020), which impacts the level of the threat that they pose as pests. For instance, 41 % of all investigated insect species tended to increase their harmfulness in response to a rise in temperature, and only 4 % had a decrease. Most investigated species (55 %) demonstrated mixed response. It means that due to climate warming, the number of different species of insect pests may either increase or decrease. In general, the analysis demonstrated that it is quite not easy to predict the impact of climate warming on insect-phytophages (Lampert et al, 2023), considering the impossibility of using control variants of experiments in field conditions.

Under the instability of the phytosanitary situation in Ukraine due to climate warming, the reasonability of chemical protection for corn fields should be defined only by the results of entomological monitoring and the evaluation of the indices of possible yield loss due to a complex of pests based on economic thresholds of the harmfulness of each species.

At present, climate change does not affect corn production in Ukraine yet. It is proven by the enlargement of corn cultivation fields and its higher yield (Plantation of Ukraine, 2022). In our opinion, the impact of warming on insect pests may also be manifested indirectly via microevolutionary shifts in the quality of fodder plants. For instance, there is a clear correlation between the changes in the incidence of some alleles of certain loci in the groups of wheat varieties and temperature changes in the process of selection (Kozub et al, 2020). In our opinion, significant changes in the state of pest populations should be expected if the sum of temperatures during the vegetation period will affect considerably the quantity and quality of cultivated plants production.

The decrease in the insects population density and diversity may lead to an imminent crisis, caused by losses of ecosystem services. Therefore, the scientists working in the field of nature protection call for efficient measures to raise public awareness about possible mitigation of the impact of anthropogenic factors on biodiversity (Lampert P et al, 2023).

CONCLUSIONS

The results of correlational analysis of the population densities of the main corn pests against the background of climate warming demonstrated that climate change has not considerably affected the abundance of the European corn borer as well as click beetles and darkling beetles in all the natural and climatic zones of Ukraine yet. Cutworms demonstrated a reliable moderate reverse correlation between the population density and the sum of heat only in the Forest-Steppe. The cutworms reacted to the increase in the sum of heat by decreasing theirs number, which may be explained by the increase in the temperature in the upper soil layers.

The number of maize leaf weevils had a direct, reliable moderate correlation with the sum of heat in the Steppe. The pest reacted to the rise in the sum of heat by increasing its number. The population density of cotton bollworms in Polissya was in reliable moderate correlation with the sum of heat. The dynamics in the abundance of spring grain aphids demonstrated a reliable moderate direct correlation with the sum of effective temperatures in Polissya. The heat rise led to an increase in the number of pests.

Climate change in Ukraine does not affect considerably the population density of the main corn pests yet: the correlation coefficients in the "population size–sum of heat" system did not exceed such values as weak, moderate, and conspicuous.

The changes in the density of pest populations should be expected if the sum of temperatures during the vegetation period will affect considerably the quantity and quality of cultivated plants production. Yet the results of the studies on long-term dynamics in the main pest populations under climate change provide ground for a considerable enhancement of the reliability of phytosanitary predictions.

The reasonability of chemical protection for corn crops should be defined only by the results of entomological monitoring and the evaluation of the possible yield loss caused by a complex of pests based on economic thresholds of the harmfulness of each species.

Adherence to ethical principles. This article does not contain any studies with human participants and animals performed by any of the authors.

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Динаміка популяцій комах-шкідників кукурудзи в Україні в умовах зміни клімату

О. І. Борзих, Л. А. Янсе, *В. М. Чайка,
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Мета. Виявити особливості багаторічної динаміки чисельності основних комах-шкідників кукурудзи в різних природно-кліматичних зонах України в умовах змін клімату. **Методи.** Польовий, спостереження, математичні. Використано матеріали фітосанітарного ентомологічного моніторингу Державної служби України з питань безпечності харчових продуктів та захисту споживачів (2005–2021 рр.) у базових 161 господарствах регіонів України за допомогою методологічно стандартизованих щорічних обліків основних шкідливих організмів агроценозів (Borzykh et 2018). Досліджено 6 груп основних комах-шкідників кукурудзи: стебловий (кукурудзяний) метелик (*Ostrinia nubilalis* Hübner), дротяники (Elateridae) та несправжні дротяники (Tenebrionidae), підгризаючі совки (Noctuida), південний сірий довгоносик (*Tanymecus dilaticollis* Gyllenhal, бавовникова совка (*Helicoverpa armigera* Hübner), звичайна злакова попелиця (*Schizaphis graminum*) Rondani. Для аналізу кліматичних параметрів використано базу даних Гідрометеоцентру України (2005–2021 рр.). Статистичний аналіз даних виконали на базі MS Excel, лінійний кореляційно-регресійний аналіз проводили за Пірсоном, для оцінки достовірності (вірогідності) коефіцієнтів кореляції застосовували критерій Стьюдента. **Результати.** Результати кореляційного аналізу стану популяцій основних комах-шкідників кукурудзи засвідчили, що зміна клімату поки що суттєво не вплинула на чисельність кукурудзяного стеблового метелика, а також дротяників і несправжніх дротяників в усіх природно-кліматичних зонах України. Доведено достовірну помірну зворотну кореляцію (r = –0,309) між чисельністю підгризаючих совок і сумою ефективних температур (СЕТ) тільки для умов лісостепової зони – за зростання СЕТ чисельність цих комах була меншою. Чисельність південного сірого довгоносики мала пряму достовірну помірну кореляцію (r = 0,335) з СЕТ у степовій зоні, зокрема, на зростання СЕТ шкідник відповідав збільшенням чисельності. Чисельність бавовникової совки в зоні Полісся достовірно помірно корелює (r = –0,489) з СЕТ. Чисельність злакових попелиць достовірно помітно прямо корелювала (r = = 0,529) з СЕТ у зоні Полісся: за збільшення СЕТ зростала чисельність цих шкідників. **Висновки.** Зміни клімату поки що істотно не впливають на стан популяцій основних комах-шкідників кукурудзи в усіх природно-кліматичних зонах України: встановлена кореляції між чисельністю комах-шкідників і СЕТ, яка не перевищували значень: слабка, помірна та помітна. Істотних змін стану популяцій комах-шкідників слід очікувати за умов, коли сума ефективних температур у період вегетації буде суттєво впливати на продуктивність і кормову якість культурних рослин.

Ключові слова: кукурудза, комахи-шкідники, динаміка чисельності популяцій, зміни клімату, сума ефективних температур, кореляційні зв'язки.

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