

# DYNAMICS OF DISTRIBUTION

## of the Western Corn Rootworm (*Diabrotica virgifera virgifera* Le Conte) in Ternopil region during 2016–2020

**Goal.** To analyze the distribution of the Western Corn Rootworm (*Diabrotica virgifera virgifera* Le Conte) in the Ternopil region during 2016–2020. **Methods.** To generalize the results of phytosanitary monitoring of the spread of the regulated harmful organism on the territory of Ukraine and on the territory of Ternopil region according to the data provided by The Department of Phytosanitary Safety of Main Administration of State Service of Ukraine on Food Safety and Consumer Protection (SSUFSCP) in Ternopil region. **Results.** In 2019 the area of *D. virgifera virgifera* distribution in Ukraine has increased 1.4 times compared to 2016, and the area of its distribution has expanded. Since *D. virgifera virgifera* was registered in the Ternopil region, the area of affected has increased by approximately 100 hectares per each year. The average annual temperature apparently contributed to the adaptation and the spread of *D. virgifera virgifera* throughout the region in 2016–2020, and the winter temperature were suitable for the wintering of the eggs. **Conclusions.** The western corn rootworm belongs to the quarantine organisms. It needs the use all phytosanitary measures for the containment and restriction of its distribution in the territory of the Ternopil region. According to the average spread of this pest (40–50 km/year), the further expansion of its population in other regions of Ukraine is predicted. The climatic conditions in the Ternopil region and the available fodder base will promote the development of *D. virgifera virgifera*.

***Diabrotica virgifera virgifera* (Le Conte, 1868); quarantine organism; pest population; the spread of pest**

Biological invasion has been going on for millennia, but increasing globalization in recent decades has accelerated it. Invasive insect species reduce crop yields, increase

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production costs, and increase the cost of controlling the spread of the pest worldwide [1]. Transport and international trade contribute to the spread of invasive species. In Ukraine, crops damage more than three thousand species of animals from different systematic groups, and about 480 species are marked by significant damage, the vast majority of which (≈90%) belong to the class Insecta [2]. Due to the high invasiveness of these pests, preventive measures should be taken at the local, regional and international levels and should include both pre-invasive (mainly preventive) and post-invasive measures.

The basis of integrated systems of plant protection against pests is the forecast of phytosanitary condition of crops, the main task of which is early assessment of the degree of threat to the crop from pests, justification

of optimal timing of environmental measures and their effective plant protection measures. In order to effectively control the number of pests, it is necessary to have information on the current state of populations provided by constant phytosanitary monitoring. Therefore, it is important to monitor the distribution of quarantine species, in particular, Insecta species, determine the nature of their distribution, the reasons for the increase in numbers and, based on this, develop measures to limit further resettlement. Harmfulness of a particular species is determined by the conditions prevailing in the spring-summer period, and is reduced by a set of measures aimed primarily at preventing their mass spread.

The Western Corn Rootworm (*Diabrotica virgifera virgifera* (Le Conte, 1868)) belongs to the Gallerucinae subfamily, the Chrysomelidae family, the Coleoptera family, and the Insecta class. Adults of males have a length of 4.4–6.6 mm, females — 4.2–6.8 mm. The wings are golden (yellow-green, green-brown, black or light green). In females, the upper wing has three longitudinal stripes of green or brown color, the abdomen is larger, the tendrils are shorter; in males it is dark without stripes, on the tops it is light yellow or golden, the abdomen is blunt, the tendrils are longer [3]. *D. virgifera virgifera* is a limited oligophage in the larval phase, which can successfully develop on 22 plants of the Poaceae family [3]. Adult beetles are polyphagous that feed on pollen, immature grains and leaves of corn, uterine columns [4]. This pest is considered the most serious pest of corn in the United States and Canada, and the loss is estimated at \$ 1 billion per year [5]. Mass yield of the pest occurs at the beginning of flowering corn. Beetles are able to fly 40–100 km per season (even 125 km when growing corn in monoculture), and

the average speed of the pest in the presence of natural barriers and the alternation of corn with fields of other crops — 20 km/h [3]. *D. virgifera virgifera* develops in one generation per year.

The aim of the study. To analyze the distribution of *Diabrotica virgifera virgifera* Le Conte in Ternopil region during 2016—2020.

**Research methodology.** The research included generalization of the results of phytosanitary monitoring of the spread of the regulated pest *D. virgifera virgifera* on the territory of Ukraine and Ternopil region according to the Department of Phytosanitary Safety of the Main Department of the State Food and Consumer Service in Ternopil region during 2016—2020. Crops were surveyed three times during each month (beginning, middle, end) of the study year (during June — September). Monitoring was carried out by route surveys and using synthetic sex pheromones in maize crops. State phytosanitary inspectors inspected pheromone traps with a sample of insects on filter paper, in a test tube or Petri dish. Insects and pheromone traps were transferred to the Ternopil Regional Phytosanitary Laboratory State Institution to determine the species composition. Insect species were identified by determinants. The obtained results of observations and accounting were processed by widely tested methods of biological and agronomic statistics.

The calculation of weighted averages of probability of penetration (PP), probability of acclimatization (PA), potential economic harm (PEH), probability of introduction (PI) and potential loss (PL) was carried out according to the formulas [6]:

$$PP = [\sum_{i=1}^n a_i w_i] / \sum_{i=1}^n w_i$$

$$PA = [\sum_{i=1}^n a_i w_i] / \sum_{i=1}^n w_i$$

$$PEH = [\sum_{i=1}^n a_i w_i] / \sum_{i=1}^n w_i$$

$$PL = PP \times PA / 100;$$

$$PL = PP \times PA \times PEH / 100,$$

де  $w_i$  — question factor,  $a_i$  — score.

**Research results.** *D. virgifera virgifera* was first discovered in 2001 by inspecting corn crops in seven settlements of Berehiv and Vynohradiv districts of Zakarpattia region. After analyzing the data from 2016 to 2019, we recorded a growing trend in the spread of the western corn beetle (WCB) in Ukraine. The area inha-

bited by the pest in 2019 increased 1.4 times compared to 2016. According to the State Food and Consumer Services (as of January 1, 2019) *D. virgifera virgifera* was found in 15 regions of Ukraine (Fig. 1).

In the Ternopil region, the pest was first identified in 2008 in crops in Monastyrysky, Terebovlya and Chortkiv districts [3]. During the period 2016—2020, when the pest was registered within the Ternopil region, an increase in the area of settlement by about 100 hectares each year was noted. As of January 1, 2021, the area inhabited by WCB is 7.990 hectares. The linear trend line also confirms the tendency to increase the area inhabited by this dangerous pest. The value of the reliability of the approximation is  $R^2 = 0.9966$ , so the smoothing can be considered reliable (Fig. 2).

As of 01.01.2017, WCB was identified in 12 districts of Ternopil region (Fig. 3). In 2017, in addition to Berezhany, Borshchiv, Buchach, Husiatyn, Zalishchyk, Koziv, Monastyry, Pidvolochysk, Pidhayets, Terebovlya, Ternopil and Chortkiv

districts, the pest was found in corn crops in Lanovets district, and in 2018, also in corn crops in the territory of Shumsky district. Due to the presence of a regulated pest, in order to prevent its further spread, a quarantine regime was introduced in the areas where *D. virgifera virgifera* was detected. For example, a quarantine regime has been introduced: in the village of Onyshkivtsi of Shumsky district on the area of 100 hectares (Order of the head of Shumsky district state administration of August 27, 2018 № 253-od «On the introduction of a quarantine regime for the western corn beetle»); in the village Brykiv of Shumsky district on the area of 125 hectares (Order of the head of Shumsky district state administration of Ternopil region from September 20, 2019 № 188-od «About introduction of the quarantine mode concerning the western corn beetle»); in the village of Tovste, Zalishchyk district, on an area of 125 hectares (Order of the Head of the district state administration of September 21, 2020 № 258/01-16.1 «On the introduction of a quarantine re-

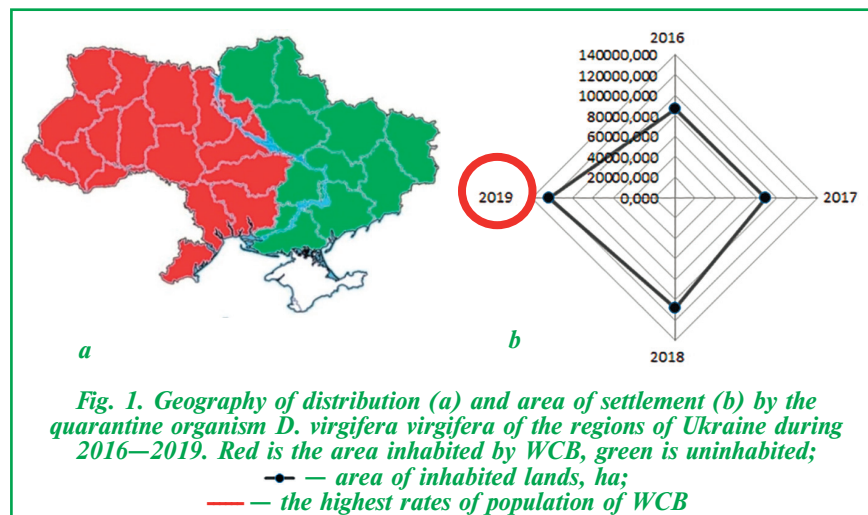


Fig. 1. Geography of distribution (a) and area of settlement (b) by the quarantine organism *D. virgifera virgifera* of the regions of Ukraine during 2016—2019. Red is the area inhabited by WCB, green is uninhabited; — — area of inhabited lands, ha; — — the highest rates of population of WCB

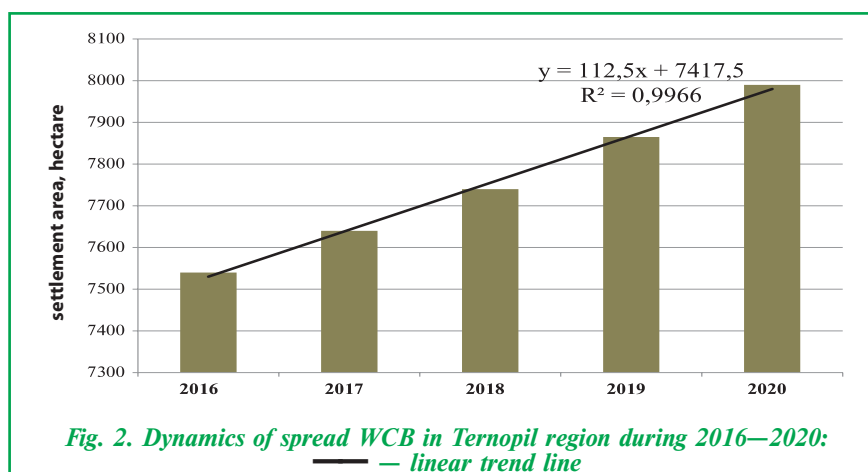


Fig. 2. Dynamics of spread WCB in Ternopil region during 2016—2020: — — linear trend line

gime for the western corn beetle»). The largest areas of pest infestation were found in Buchach, Chortkiv, Terebovlya and Ternopil districts (1115–1250 ha). During the years of observation, no outbreaks of *D. virgifera virgifera* were registered in Zboriv, Zbarazh and Kremenets districts of Ternopil region.

According to the State Statistics Service of Ukraine of the Main Department of Statistics in Ternopil region, the sown area of corn for grain in 2020 increased 1.44 times compared to 2019. As of 2019–2020, Ternopil region was one of the regions with the highest yield of corn (9.2 t/ha) [7]. Based on the above, monitoring of the main pests of this crop is necessary to maintain the level of yield at the appropriate level.

It should be borne in mind that the distribution and adaptation of WCB depends on the temperature conditions of the region. To determine the possibility of adaptation and spread of WCB in the Ternopil region, temperature conditions over the past five years were analyzed and found that the average annual temperatures of 2016–2020 ranged from 8.7 to 9.6°C and, apparently, contributed to the adaptation and spread of the pest the whole area. According to Edwards et al. (1996) The most active spread of the pest

occurs at average monthly air temperatures of 18–26°C from mid-July to early September. The average monthly temperatures in July–August (the period of mass flight of adults) were 19.3–19.9°C and probably had a positive effect on the spread of *D. virgifera virgifera* [9]. Winter temperatures (December – February) of Ternopil region in the studied period were –6.1 – + 2.8°C. From the literature it is known that the eggs of diabrotica have high frost resistance and can withstand temperatures down to –10°C, so these temperatures were favorable for wintering pest eggs. It is known that the female WCB eggs at temperatures above 10°C in the surface layer of the soil at the base of the plant stem, preferring moist areas. In the spring of 2016–2020, the temperature was favorable for the development of pest eggs, and also contributed to their development precipitation (22–28% of the total precipitation for the year, except in 2016 – 43%). In 2020, there was a decrease in the number and harmfulness of WCB larvae on corn roots in the habitats, which is primarily due to the high supply of soil moisture. Such conditions contributed to faster rooting of plants, in contrast to 2019, when the plants were in conditions of insufficient soil moisture and there was a death of 2.5% of corn plants.

In the centers of the spread of WCB in maize crops, the beginning of the flight of beetles was recorded on July 24, 2020 in the phase of ejection of the panicle (this is much later than in 2019). *D. virgifera virgifera* was found in maize crops in September. Weather conditions this month contributed to the laying of eggs by the pest. According to the Forecast of phytosanitary condition of agrocenoses of Ternopil region and recommendations on protection of agricultural plants from pests, diseases and weeds in 2021, compiled by the Department of Phytosanitary Safety of the Main Department of the State Food and Consumer Service in Ternopil region.

The conducted quantitative analysis determined (PP = 423/76 = 5,568; PA = 603/91 = 6,626; PEH = 687/125 = 5,496; PL = 5,568 × 6,626/100 = 0,369; PL = 5,568 × 6,626 × 5,496/100 = 2,028) quite high values of probability of penetration (for quarantine species – ≥4.86), acclimatization (for quarantine species – ≥5.10) and potentially economic harm of *D. virgifera virgifera* (for quarantine species – ≥3.42). The potential harm is 2,028 (for quarantine species – ≥1,3) [10]. Quantitative analysis of the possibility of acclimatization and spread of WCB confirmed its quarantine status and showed the need for phytosanitary measures to curb and limit its spread throughout the Ternopil region. The high degree of acclimatization (6,626) and naturalization of the species on the territory of Ukraine in the future may lead to even greater losses in crop yields and reduce the biodiversity of phytocenoses. It is established that the climatic conditions of the region and the sufficient amount of fodder base will promote the development of *D. virgifera virgifera*, so the pest will not only survive but also increase in number.

From the literature it is known that one of the ways to limit the spread of *D. virgifera virgifera* is to observe crop rotations (it is recommended to sow perennial grasses, cereals, legumes, etc., in which corn returns to the field no earlier than three years) [11]. Integrated plant protection systems must be used to protect against this pest. Effective treatment of plants with chemicals against adults, as well as during sowing the introduction of drugs into the soil against larvae [3].

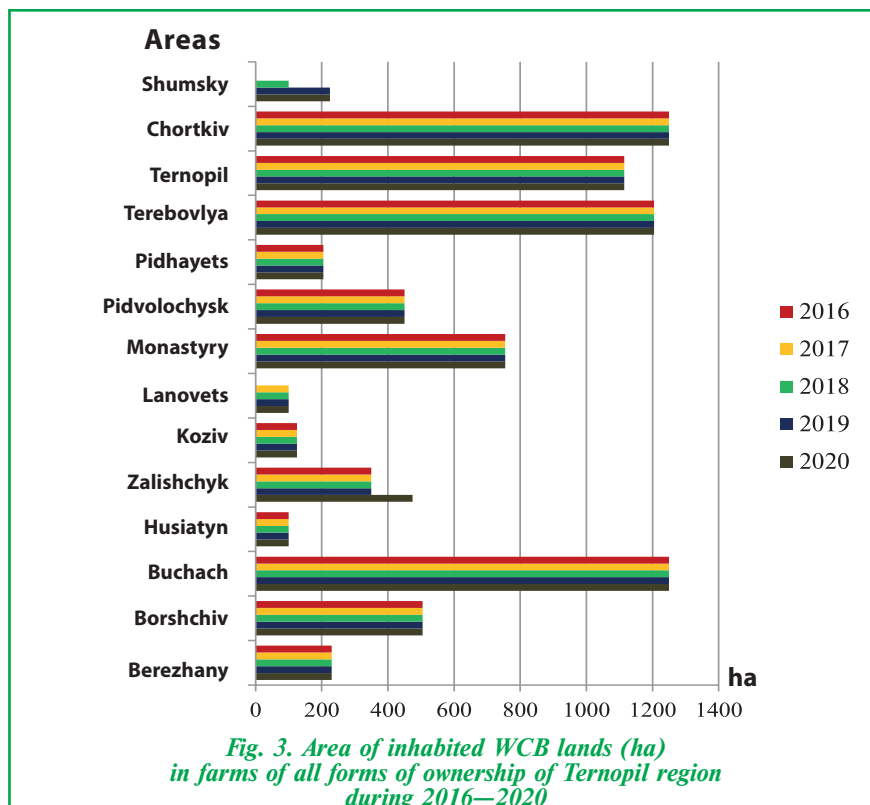


Fig. 3. Area of inhabited WCB lands (ha) in farms of all forms of ownership of Ternopil region during 2016–2020

## CONCLUSIONS

The amount of inhabited WCB area in Ukraine in 2019 increased 1.4 times compared to 2016. The average annual temperature, apparently, contributed to the adaptation and spread of the pest throughout the region in 2016–2020, and winter temperatures were favorable for overwintering eggs. *D. virgifera virgifera* belongs to quarantine organisms and requires the application of phytosanitary measures to control and limit the spread of the Ternopil region. It is shown that climatic conditions and the available fodder base within the region will promote the development of *D. virgifera virgifera*, so it will not only survive but also increase its population.

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- Динаміка поширення західного кукурудзяного жука (*Diabrotica virgifera virgifera* Le Conte) на Тернопільщині впродовж 2016–2020 рр.**
- Мета.** Проаналізувати поширення західного кукурудзяного жука (*Diabrotica virgifera virgifera* Le Conte) на території Тернопільської області впродовж 2016–2020 рр. **Методи.** Узагальнення результатів фітосанітарного моніторингу регульованого шкідливого організму на території України та Тернопільської області за даними Управління фітосанітарної безпеки Головного управління Держпродспоживслужби в Тернопільській області. **Результати.** Досліджено динаміку чисельності *D. virgifera virgifera* з огляду на хронологію заселеності цим шкідником районів Тернопільської області. Обсяг заселеної західним кукурудзяним жуком площі в Україні у 2019 р. збільшився у 1,4 раза порівняно з 2016 р., а також розширився ареал його поширення. За п'ять років, коли *D. virgifera virgifera* реєстрували в межах Тернопільської області, відзначено збільшення площі заселення приблизно на 100 га кожного року. Середньорічні температурні показники, очевидно, сприяли адаптації й поширенню шкідника всією областю у 2016–2020 рр., а зимові температурні показники були сприятливими для зимівлі яєць. **Висновки.** Західний кукурудзяний жук належить до карантинних організмів і потребує застосування фітосанітарних заходів щодо стримування й обмеження його поширення. Враховуючи середню швидкість розповсюдження шкідника (40–50 км/рік), можна прогнозувати подальше розширення площі його заселення в інших областях України. Встановлено, що в межах Тернопільської області кліматичні умови і наявна кормова база сприятимуть розвитку *D. virgifera virgifera*, тому шкідник буде не лише виживати, а й збільшувати чисельність.
- Diabrotica virgifera virgifera* (Le Conte, 1868); карантинний організм; чисельність шкідника; поширення шкідника**
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- Динамика распространения западного кукурузного жука (*Diabrotica virgifera virgifera* Le Conte) на Тернопольщине в 2016–2020 гг.**
- Цель.** Проанализировать распространение западного кукурузного жука (*Diabrotica virgifera virgifera* Le Conte) на территории Тернопольской области в течение 2016–2020 гг. **Методы.** Обобщение результатов фитосанитарного мониторинга распространения регулируемого вредного организма на территории Украины и Тернопольской области по данным Управления фитосанитарной безопасности Главного управления Госпродпотребслужбы Тернопольской области. **Результаты.** Изучена динамика численности *D. virgifera virgifera* с учетом хронологии заселенности этим вредителем районов Тернопольской области. Площадь, заселенная западным кукурузным жуком, в Украине в 2019 г. увеличилась в 1,4 раза по сравнению с 2016 г., а также расширился ареал его распространения. За пять лет, когда *D. virgifera virgifera* регистрировали в пределах Тернопольской области, площадь заселения увеличилась примерно на 100 га ежегодно. Среднегодовые температурные показатели, очевидно, способствовали адаптации и

распространению вредителя всей областью в 2016—2020 гг., а зимние температурные показатели были подходящими для зимовки яиц. **Выводы.** Западный кукурузный жук относится к карантинным организмам и требует применения фитосанитарных мероприятий по сдерживанию и ограничению его распространения по территории Тернопольской области.

Учитывая среднюю скорость распространения этого вредителя (40—50 км/год), можно прогнозировать дальнейшее расширение площади его заселения и в других областях Украины. Установлено, что в пределах Тернопольской области климатические условия и имеющаяся кормовая база способствуют развитию *D. virgifera virgifera*, поэтому вредитель будет не

только выживать, но и увеличивать численность.

***Diabrotica virgifera virgifera* (Le Conte, 1868); карантинный организм; численность вредителя; распространение вредителя**

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