

REVIEW OF THE CURRENT GLOBAL SITUATION OF HARMFUL AND USEFUL INSECT SPECIES PRESENT IN MAIZE CROPS AND POSSIBLE INTERACTIONS BETWEEN THEM

Maria Alina COSTEA, Ioana GROZEA

Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania"
Timisoara, Romania

Corresponding author: ioana.grozea@usab-tm.ro

Abstract. One of the most cultivated and productive cereal plants in the world was and is corn. Both globally and at European level, maize cultivation occupies important areas. Romania is one of the corn exporting countries in the world, so it is important to protect this crop from all biotic factors (which can be controlled) including harmful insects that occupy a major place in reducing production. Another perspective is the existence of useful species and their use as a method of biological control through exploitation. In this paper we intended to bring to attention the species of insects that reduce the productive capacity of this plant. As a study method, we used bibliographic and webographic analysis, so we extracted the most important documentary sources, which could be the basis for future research in doctoral training. Among the important pests worldwide and implicitly in our country are: *Ostrinia nubilalis* (corn borer), *Diabrotica virgifera* Le Conte (western corn rootworm), *Helicoverpa armigera* (cob earworm) and *Rhopalosiphum maidis* (corn aphid). From the literature we extracted the potential ones to appear in the culture or experimental plots: *Coccinella* sp, *Trichogramma ostriniae*, *Argiope* sp. and *Chrysopa carnea*. Knowledge of the current situation is essential in the correct identification of target species and in the adequacy of measures focusing on non-polluting ones.

Keywords: Insect, harmful, useful, corn, global situation, interactions.

INTRODUCTION

The top of the most productive continents includes America, then Asia, Europe and Africa. In America, the largest producers are: the United States, China, Brazil and Argentina, which provide more than 2 thirds of global production.

In Asia, the first place is occupied by China, followed by India and Indonesia and in Europe Ukraine is notable. At European level France, Romania, Russia and Hungary play an important role in the export of corn (MCCORMICK, 2017).

Biotic factors that can affect corn production include pests, diseases and weeds.

Among the harmful insects, *Ostrinia nubilalis* (Lepidoptera: Crambidae) is known as one of the most important pests of corn (GROZEA ET AL, 2019). This species known as the corn borer is native to Europe, but later spread to in North Africa, North America, Canada and today according to those found in the literature is present in all maize-producing countries (BERES, 2016).

Another species found in all corn-growing regions is the species *Diabrotica virgifera virgifera* Le Conte (Coleoptera: Chrysomelidae) or the western worm of corn roots or western corn rootworm (WCR), as it is called in the literature. It first appeared in America and then spread to Europe, beginning in 1992. According to some authors, it entered in 1990, and after others in 1992, however, it is assumed that it entered in 1992 through the import of seeds (CAMPRAG, 1995). At present, there are currently widely used chemical solutions but fewer applicable biological solutions, the most common of which are coloured and pheromone traps (GROZEA, 2003; KRITIKOS ET AL., 2012).

MATERIAL AND METHODS

Through this paper, I set out to review the most important harmful species in maize crops, globally, in Europe and nationally. For this I consulted 30 references from different bibliographic and webographic sources. The most used search engine was Google where I found professional articles and sites. I also had at my disposal the university library but also the books present in the discipline of Entomology. The references were categorized: printed scientific articles, online scientific articles, printed books, newsletters on websites. The most common language for presenting references was English, Romanian but also some in Serbian.

RESULTS AND DISCUSSION

From the analysis of the sources and references found we found that the most common species are: *Ostrinia nubilalis* (corn borer), *Diabrotica virgifera* Le Conte (western corn rootworm) (Grozea, 2010), *Helicoverpa armigera* (cob worm) and *Rhopalosiphum maidis* (aphid maize), *Coccinella sp*, *Trichogramma ostriniae*, *Argiope sp.* and *Chrysopa carnea* (GROZEA ET AL, 2008). The first four were species of phytophagous insects, which feed on plant parts of corn (aerial or underground) (CARDE, 2003) and the last 4 were carnivorous species, predators that consume other species of insects, we consider them useful.

The latest update of the CABI database (2021) suggests that their presence globally but also continental (table 1). Thus, *Ostrinia* is currently present in maize crops in North America, Africa, Asia and Europe.

Table 1

The current global status of common pests in maize and their predators

Continent	The pest in the corn culture-abbreviation popular name*			
	Status **/****/*****			
	CB*	WCR*	CW*	AM*
America	***	***	***	***
Africa	****	*	***	***
Asia	****	*	***	***
Australia	**	*	***	***
Europe	***	***	****	***
New Zealand	**	*	***	***

*CB-Corn borer; WCR-Western corn rootworm; CW-Cob worm, AM-Aphid maize

absent; *present - widespread/everywhere; ****present- limited spread, did not cover the whole continent

Continent	The pest in the corn culture-abbreviation popular name*			
	Status **/****/*****			
	As*	Lb*	Pw*	Cs*
America	**	***	****	***
Africa	****	****	****	****
Asia	****	***	****	***
Australia	**	****	**	**
Europe	***	***	**	***
New Zealand	**	****	**	***

*AB- Argiope sp.; Lb-ladybugs, Pw-parasitic wasp; Cs- Chrysopa sp.

absent; *present - widespread/everywhere; ****present- limited spread, did not cover the whole continent

WCR is present everywhere in North America with spread everywhere and also in Europe, where the status is diverse from extension to eradication, as proof that many control attempts have been made that have led to the change of the present state to eradication. *Helicoverpa* (CW) is present in all continents, sometimes with limits of spread sometimes with total coverage of a

continent (SOSA-GOMEZ ET AL, 2016) as well as aphids (AM) by specificity *Rhopalosiphum maidis* which is found in all areas of the globe with a wide spread status (table 1).

The weaving spider, Argiope b., has been less studied but still some recent data from 2021 exist and they offer a global distribution of their presence in Europe, Asia and Africa (CERA, 2018). Ladybugs (Lb) by specificity those of Coccinella because they are frequent in Romania as a reference area, they are present everywhere in Europe, America and Asia but also in areas of South America and North Africa (table 1). Parasitic wasps (Wp), with reference in this paper to the species *Trichogramma ostrinae* are present in small regions of North America, Africa and Asia. Chrysopa (Cs) with the representative of Chrysopa c. is widespread in Europe, Asia and America and present but not everywhere in Africa and South America.

The most common species harmful to maize crops and which significantly affects world maize production has been shown to be the corn borer (*Ostrinia nubilalis* Hübner) (CABI, 2021). This has acquired resistance to chemicals over time, being few effective products today, traps and hybrids are more widely used. In 2014, several US researchers demonstrated that the use of traps (coloured and pheromone) is extremely effective and is an extremely efficient alternative non-pollutant vs chemicals, especially in combating the larval stage (BOHNENBLUST ET AL, 2014).

The second most common species, in the last 10 years in Europe but also earlier around the 2000s (MIRONOVIC, 2002) implicitly in Romania was found to be the western worm (*Diabrotica virgifera*) which has a very high capacity to move, of a few km in every year, in the adult stage, therefore in the assessments of the population level the researchers focused on the evolution of the adult (ONSTAD ET AL, 2020).

Their recognition was made especially through the harmful stage; in the Ostrinia species the larval stage is the identifiable one (FROLOV ET AL, 2007) while in the Diabrotica species both stages can be recognized in culture, both the adult and larval stage, there being a double attack (BACA ET AL, 2002).

Helicoverpa armigera (Hüb.) (Lepidoptera: Noctuidae) has been considered for some regions of the world (South America) an extremely difficult species to manage in an integrated way due to its high polyphagism and resistance to insecticides. The results of studies in Brazil, from different places have shown that the insect (in the larval stage) can be controlled temporarily or by using resistant hybrids, knowing that the most important biotechnological crop is Bt corn (JOSE ET AL, 2020).

Corn leaf aphids (*Rhopalosiphum maidis* Fitch) (Aphididae: Homoptera) are known as cosmopolitan species recorded on many grass species, of which corn is considered the preferred host as mentioned by BING ET AL. (2001). Disadvantages in control population have been shown to be the fact that the species is parthenogenetic and entirely viviparous but also the obvious damage that occurs when the population is large and accumulates on corn leaves (KHURSHID, 2013).

Among the predatory species, with the role of predator of harmful insects (figure 1), the most common proved to be coccinellids and spiders. Their evolution in maize crops in Romania was first achieved in 1999 (BAICU, 1999) and later taken over by others (SIMERIA, 2001; GROZEA ET AL, 2008) presented this evolution but also the complete set of predators (zoophages) found in various areas with corn.

Research conducted on the Asian continent has revealed the presence of many species of spiders from the families Lycosidae, Gnaphosidae, Oxyopidae and others but which are not present in areas of Europe or other continents (SARANYAK ET AL., 2018).

In addition, a number of other zoophages have been analysed and included in particular for Diabrotica species. Thus, TOTH ET AL (2001) demonstrated that *Theridion impressum* (Araneae:

Theridiidae) is a very important predatory spider in the numerical reduction of adults and implicitly of the attack on corn silk.

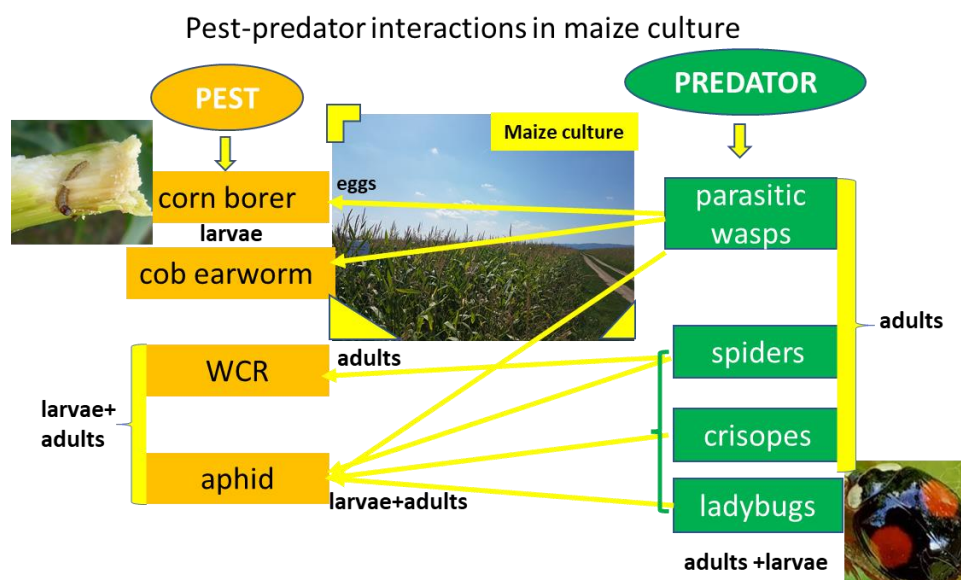


Fig. 1. Possible interactions between pests and predators in maize crops, useful links for control by exploiting natural enemies

Other studies show that treatment with *Bacillus thuringiensis* and *Bacillus popilliae* by application to the food substrate did not lead to an increase in adult mortality (SUTTER, 1991) compared to the trials of MACINTOSH ET AL (1990) which showed that *Diabrotica virgifera virgifera* Le Conte is not sensitive to Bacillus t.

Other researchers talk in their work about the interactions between aphids and chrysopes and the latter are considered biological agents in the control of many species of aphids in most crops in which they are present, including corn crops. Also, effective interactions in the biological control of aphids by spiders has been demonstrated by WYSS ET AL. (1995).

The presence of parasitic wasps of the genus *Trichogramma* may reduce the number of eggs laid by adults of *Ostrinia nubilalis* and *Helicoverpa armigera* (WYCLIFFE, 1997; CARVALHO, 2017).

Other species from the groups of ladybugs besides the common ones such as *Harmonia* (harlequin ladybugs) or subspecies of parasitic wasps of the genus *Trichogramma* (like *T. evanescens*) were considered in addition to those initially found as important, but to avoid redundancy we represented one species from each other.

Regarding the set of pests present, they may be similar in corn crops but the situation is different in the case of predators of these pests that may be different even between neighbouring continents.

CONCLUSIONS

Globally, 4 species of harmful insects and 4 species of predatory insects that can populate corn crops have been identified. When their populations are at a high level and the

damage to plants is great. Population reduction is an important target so that they are kept below the damage threshold. There are solutions to reduce them by various methods, mostly chemical but also non-polluting alternatives including the use of traps, the use of resistant hybrids and the exploitation of predators or zoophages considered useful organisms.

ACKNOWLEDGEMENT

We would like to thank the authors who responded to our request to send us articles where we only had open access to abstracts.

BIBLIOGRAPHY

- .BAČA F. I., VIDENOVIC V. Z., ERSKI P. Z., KISS J., EDWARDS R.C. (2002). Abundance of WCR *Diabrotica virgifera virgifera* Le Conte beetles during the first year of continuous maize cropping depending on the sowing date and the FAO maturity group, Plant Protection Society of Serbia, 9th IWGO *Diabrotica* Subgroup Meeting and 8th EPPO ad hoc Panel, Book of abstract, Belgrade, 3-5 Nov. 2002. 63-64.
- BAICU T., SĂVESCU (1986). Sisteme de combatere integrată a bolilor și dăunătorilor pe cultive. Editura Ceres, București. 263 p.
- BERES P.K., PRUSZYŃSKI G. (2008). Pest management in integrated maize production. *Acta Scientiarum Polonorum Series Agriculture*. 7(4):19-32.
- BING J. W., GUTHIRE W. D., DISKE F.F., OBRYCKI J.J. (1990). Relation of corn leaf aphid (Homoptera: Aphididae) colonization to Dimboia content in maize inbred lines. *Journal of Economical Entomology*. 83(4):1626-1632.
- BOHNENBLUST E., BREINING J., SHAFFER J., FLEISCHER S., ROTH G., TOOKER J. (2014). Current European corn borer, *Ostrinia nubilalis*, injury levels in the Northeastern United States and the value of Bt field corn. *Pest Management Science*. 70 (11): 1711-1719.
- CABI REPORT, (2021). Invasive Species Compendium and other pests. <https://www.cabi.org/isc/datasheet>.
- CAMPBELL D., BACA F., SEKULIC R. (1995). *Diabrotica virgifera* nova stetocina kukuruza u Jugoslaviji, Zbornik radova, Beograd, IX Savetovanje agronoma i tehnologa, Smederevo. 45-50.
- CARDÉ R.T. (2003). *Encyclopaedia of insects*. Academic Press, Amsterdam, Boston, London, New York. 1266 p.
- CARVALHO G.S, SILVA L.B, VERAS M.S, CARNEIRO E., LAYRA M., REIS S.S. (2017). Biological parameters of three *Trichogramma pretiosum* strains (Riley, 1879) (Hymenoptera: Trichogrammatidae) on eggs *Helicoverpa armigera* (Hübner, 1805) (Lepidoptera: Noctuidae). *Acta Scientiarum. Biological Sciences*. vol. 39, no. 3, pp. 349-355.
- CERA I. (2018). The checklist of Latvian spiders (Arachnida:Araneae). *Environmental and Experimental Biology* 16: 139-152.
- FROLOV A., BOURGUET D., PONSARD S. (2007). Reconsidering the taxonomy of several *Ostrinia* species in the light of reproductive isolation: A tale for Ernst Mayr. *Biological Journal of the Linnean Society*. 91(1):49-72. doi: 10.1111/j.1095-8312.2007.00779.x.
- GROZEA I. (2003). Some aspects of corn plants damaged by *Diabrotica virgifera virgifera* Le Conte species. *USAMVB, Scientific Paper of Agriculture*. 35:503-507.
- GROZEA I., CARABET A., CHIRITA R., BADEA A.M. (2008). *Entomofagii din culturile de cereale*. Editura Mirton, Timișoara. 204 p.
- GROZEA I. (2010). Western Corn Rootworm (WCR), *Diabrotica virgifera virgifera* Le Conte-Several Years of Research in Western Part of Romania. *Bulletin USAMV-Agriculture*. 67(1): 122-129.
- GROZEA I., HORGOS H., STEF R., CARABET A., VIRTEIU A.M., BUTNARIU M., MOLNAR L. (2019). Assessment of population density of insect species called "species problem", in lots with different maize hybrids. *Research Journal of Agricultural Science*. 51(1): 132-137.

- JOSÉ P. F. BENTIVENHA, SILVANA V. PAULA-MORAES, EDSON L. L. BALDIN, SPECHT A., IVANA F. DA SILVA, THOMAS E. HUNT. (2016). Battle in the New World: *Helicoverpa armigera* versus *Helicoverpa zea* (Lepidoptera: Noctuidae). *PlosOne*. 11(12):doi e0167182.
- KHURSHID I., JABIR A., ASAD A., GUL N. (2013). Population trend of corn leaf aphid (*Rhopalosiphum maidis*) with different chemical doses in three maize varieties. *Biological Diversity and Conservation*; 6/1:1-7. Available on https://www.researchgate.net/publication/236163550_Population_trend_of_corn_leaf_aphid_Rhopalosiphum_maidis [accessed Feb 22 2021].
- KRITICOS D. J., P. REYNAUD R.H.A. BAKER D.E. (2012). Estimating the global area of potential establishment for the western corn rootworm (*Diabrotica virgifera virgifera*) under rain-fed and irrigated agriculture. *OEPP/EPPO Bulletin*. 42(1): 56–64.
- MACINTOSH S.C., STONE T.B., SIMS S.R., HUNST P.L., GREENPLATE J.T., MARRONE P.G., PERLAK F.J., FISCHHOFF D.A., FUCHS R.L. (1990). Specificity and efficacy of purified *Bacillus thuringiensis* proteins against agronomically important insects. *Journal of Invertebrate Pathology*. 56, 2, 258-266.
- MCCORMICK SITE (2017). All the latest data on maize production around the world, available on <https://www.mccormick.it/as/all-the-latest-data-on-maize-production-around-the-world>, accessed on nov.21,2021.
- MIRONOVIĆ T. (2002). Monitoring the WCR (*Diabrotica virgifera virgifera* Le Conte) in the region of middle Banat, Plant Protection Society of Serbia, 9th IWGO *Diabrotica* Subgroup Meeting and 8th EPPO ad hoc Panel, Book of abstract, Belgrade, 3-5 Nov. p. 35.
- ONSTAD D.W., CAPRIO M.A., PAN Z. (2020). Models of *Diabrotica* Populations: Demography, Population Genetics, Geographic Spread, and Management. *Insects*. 11, 712. Available on <https://doi.org/10.3390/insects11100712>.
- SARANYAK V. S. L., SAMIAYYAN K., SHANMUGA PREMA MUPPUDATHI (2018). Diversity of predatory spider fauna in maize ecosystem. *Journal of Biological Control* 33(1):27-35. doi 10.18311/jbc/2019/22093.
- .SIMERIA GH., POPESCU GH., GIUCHICI C. (2001). *Combaterea biologică în „sens strict” a patogenilor și dăunătorilor plantelor*. Ed. Mirton Timișoara, ISBN 973-585-378-7. 147 p.
- SOSA-GÓMEZ [...], WILSON S., AZEVEDO-FILHO (2016). Timeline and geographical distribution of *Helicoverpa armigera* (Hübner) (Lepidoptera, Noctuidae: Heliethinae) in Brazil. *Revista Brasileira de Entomologia*. 60 (1) doi.org/10.1016/j.rbe.2015.09.008.
- SUTTER G.R., LANCE D.R. (1991). *New strategies for reducing insecticide use in the corn belt*, Washington. D.C., National Academy Press. 231-249.
- TÓTH F., TUSKA T., KISS J. (2001). Effect of *Theridion impressum* (Aranae: Theridiidae) on the silk clipping of *Diabrotica virgifera virgifera* adults in hybrid seed corn in Hungary, XXI IWGO Conference, VIII *Diabrotica* Subgroup Meeting, Legnaro-Padua-Venice-Italy. Oct.27. 89.
- TOTH M., BOZSIK A., FERENC S., AGOSTINO L., TABILIO M., VERDINELLI M., ZANDIGIACOMO P., JUDIT J., SZARUKAN I. (2006). Phenylacetaldehyde: A chemical attractant for common green lacewings (*Chrysoperla carnea*, Neuroptera: Chrysopidae). *European Journal of Entomology*. 103: 267–271.
- WYCLIFFE M.P. (1997). Evaluation of natural enemies of the European corn borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae). *Retrospective Theses and Dissertations*. 162 p.
- WYSS E., URS N., WOLFGANG N. (1995). The impact of spiders on aphid populations in a strip-managed apple orchard. *Journal of Applied Entomology*. 119(1-5):473-478.