3 MAJOR INSECT PESTS OF CORN CROPS IN WESTERN ROMANIA - IMPACT OF CHANGING CLIMATIC FACTORS ON ABUNDANCE AND POPULATION DYNAMICS

C. BUJORA[1], Roxana MĂRIUȚĂ[1], Diana ARSINE[1],Codruța CHIȘ[2]
Ana – Maria VÎRTEIU[3*], Ioana GROZEA[3]
[1]Plant Protection Bachelor Programme, University of Life Science"King Mihai I" from Timisoara
[2]Department of Sustainable Development and Environmental Engineering, University of Life Science"King Mihai I" from Timisoara
[3]Department of Biology and Plant Protection, University of Life Science"King Mihai I" from Timisoara
[*]Corresponding author: anamariavarteiu@usab-tm.ro; ioana_entomol@yahoo.com

Abstract. *Climate change can have a negative impact on the agricultural sector through an increase in pest damage to crops. Insects are the most common arthropod pests of corn, with 3 species causing by far the most damage in Europe: Ostrinia nubilalis, Helicoverpa armigera and Diabrotica v. virgifera. The rate of development of the three pests could be accelerated in a warmer climate, leading to an earlier development of the first generations and an increase in the number of generations per year. In this study, the evolution of population densities of three pest species in corn crops in Western Romania was analyzed. To evaluate population dynamics, experimental plots were established in Clarii Vii (Jimbolia) in 2022. 3 types of Csalomon traps were used: VARL +, RAG, PALz were used. With a maximum density of 359.6 adults per trap, the highest density was recorded for Diabrotica v. virgifera, which showed only one generation per year. In addition, the data revealed the existence of two defined generations for the two lepidoptera (Ostrinia n., Helicoverpa a.) examined.The actual amount of heat required for the flight of these two moths was reached at different times, on 17 June and 6 August for Ostrinia n., and on 23 June and 6 August for Helicoverpa a. The flight diagrams clearly show a clear increase in the number of specimens with increasing temperatures. The changes in the number of individuals of the 3 insect pests that were studied showed a significant correlation with the abiotic factors.*

Keywords*: pests, corn, climatic factors, abundance, population dynamics*

INTRODUCTION

As the world's population grows, so does the demand for crop production and, as a result, global agricultural production will most likely have to double by 2050 in order to meet this kind of growth in demand (SKENDŽIĆ et al., 2021). Agriculture is one of the economic sectors most vulnerable to climate change, which has both positive and negative impacts on agricultural systems, with negative impacts outweighing positive ones (CARTER et al., 2018).

Climate change over the last decade has led scientists to focus intensively on how climate change affects agricultural production. The increase in temperature, but in particular the changes in precipitation patterns, are the most important limiting factors, together with diseases and pests (PRAKASH et al., 2014).

Research (GROZEA et al., 2008; HARVEY et al., 2023) has shown that rising temperatures accelerate the development, distribution, behaviour and consumption of pests, causing population dynamics to change, but precipitation represents the limiting factor in spreading these pests. Tropical and subtropical areas, where pests are already at optimum development, are expected to see a decrease in population growth rates, while temperate areas are expected to see an increase in population levels of the major pests (DEUTSCH et al., 2018).

A change in the importance of precipitation has been observed in recent years, with most events showing a decreasing frequency but increasing intensity, favouring the occurrence of droughts or floods (SKENDŽIĆ et al., 2021). So what are the implications for insects? Heavy rainfall alone can lead to flooding or to water stagnating for long periods of time, which reduces the survival rate of soil insects (both adults and immature stages), but also has a negative effect, increasing diapause; it also means that eggs, larvae and even adult phytophagous insects are washed away (in the case of heavy rainfall) (CHEN et al., 2019). In addition, the reduced production of secondary metabolites that have a defensive function in drought-stressed plants makes them more susceptible to insect attack (WAR et al., 2012). In this context, the monitoring of the dynamics of pest populations in the conditions of their occurrence in a constantly changing climate is very important.

The world's corn production is under pressure, with losses of more than 40% of production due to pests, year on year (GROZEA & COSTEA, 2022). Regarding corn grown in the western part of Romania, 3 pests, *Ostrinia nubilalis* (STEF et al., 2020), *Helicoverpa armigera* (VIRTEIU et al., 2021) and *Diabrotica virgifera virgifera* (PĂLĂGEȘIU et al., 2001; GROZEA, 2003, 2010), play a key role in the potential long-term impacts of climate change on productivity.

The ecological responses of the 3 pests to recent climate change are already visible and are mainly associated with the increase in temperature and the lack of rainfall from 2021 onwards, causing major imbalances in the corn crop and leading to extremely high populations of these pests with significant production losses, that may exceed 20% of the production (COSTEA et al., 2022, 2023). Therefore, as the conditions of their occurrence have changed at a high rate, the aim of this paper was to monitor the 3 target pests through the lens of abundance and population dynamics.

MATERIAL AND METHODS

The research was carried out in 2022 and the experimental plots were located in the western part of Romania, in Timiș County, Clarii Vii (Jimbolia) (45°49′44.7″N 20°48′24.6″E).

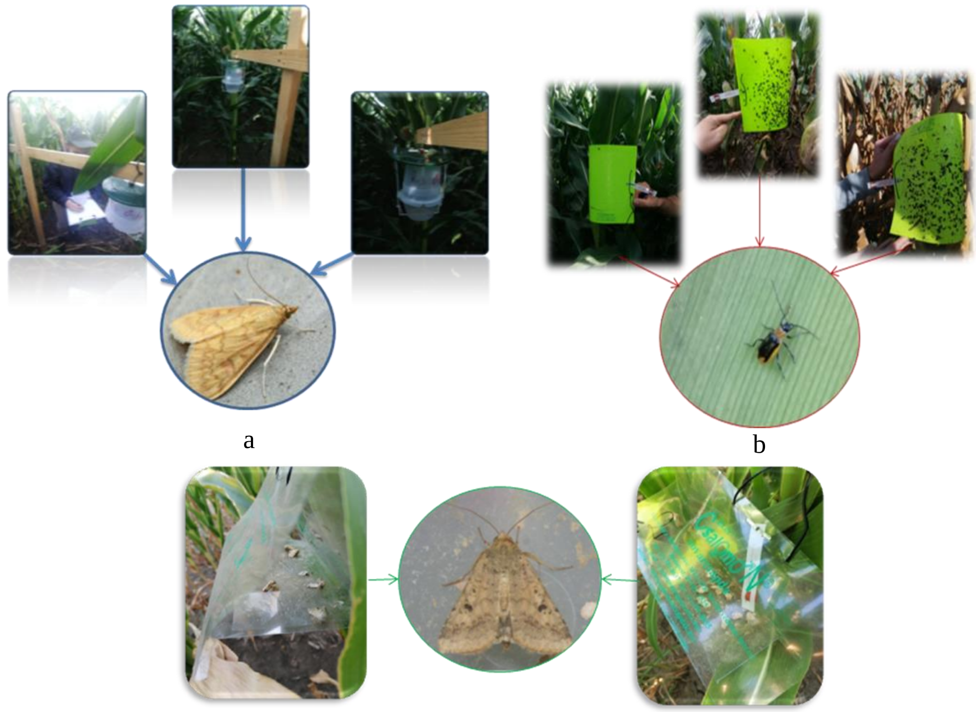
The locality is situated in the Banat pPain, at the junction of the Timiș and Mureș Plains, in the so-called Jimbolia – Bulgăruș Plain. It has the character of a low, tubular plain, whose main characteristic is the homogeneity of the loess deposits. The pedophreatic level is between 2 and 3 m. Because of its depth, but also because of the good permeability of the soils and rocks on which it is formed, the area of this plain does not present immediate risks of flooding.

According to Koppen's climatic maps (1931), the western part of Timis County belongs to province "C" - humid temperate climate, subprovince "f" - with sufficient rain or snow throughout the year, region "a" - the temperature of the warmest month exceeds 22°C, and subregion "x" - maximum precipitation occurs at the beginning of summer. The climate is characterised by an average temperature of 10.7 °C and an average rainfall of 570 mm per year.

The crop is owned by a private agricultural firm, WestLand Company SRL. The total experimental fields are of : 64,134 m2. DEKALB DKC 4598 maize hybrid was used.

In order to determine the population dynamics of these 3 important pests, monitoring was carried out between May and September 2022 by placing Csalomon pheromone traps: - VARL+ - for *O. nubilalis* (figure 1 a), PALz - for *D. virgifera virgifera* (figure 1 b) and RAG - for *H. armigera* (figure 1 c) in the experimental plot.

The traps were installed on 23 May 2022 at a rate of 2 traps per hectare, the readings were taken every 7 days and the change of the sexual pheromone was carried out at an interval of 4 weeks.



c

Figure 1. Aspects from the experimental fields: a – Csalomon – VARL+ pheromone traps for *O. nubilalis*; b - PALz pheromone traps for *D. virgifera virgifera*; c - RAG pheromone traps for *H. armigera* (photos by Vîrteiu, 2022)

RESULTS AND DISCUSSIONS

Observations in the experimental field of Clarii Vii (Jimbolia) revealed the presence of several harmful species, 3 of which have an impact on the quantity and quality of the harvest: *Ostrinia nubilalis*, *Helicoverpa armigera* and *Diabrotica virgifera virgifera.*

The climatic conditions during the flight of the 3 pests studied are particularly important as they have a critical influence on the appearance of the first adults, the duration and intensity of the flight and the survival of the immature stages, important for yield losses. In 2022 in the pheromonal traps, the average number of *Ostrinia nubilalis* moths summed up to 238.4, in the case of *Helicoverpa armigera* the average number of moths was lower, summed up to 156.2, and the highest average number was in the case of *Diabrotica virgifera virgifera*, summed up to 3395.4 adult beetles.

The first individuals appeared in the week 23rd - 27th May (BBCH maize 6 - 8 leaves) with an average of 9.2 adults/trap/day for *O. nubilalis*, 8.6 adults/trap/day for *H. armigera*; and the first individuals of *D. v. virgifera* appeared on 17th June with an average of 56.3 adults/trap/day.

The maximum abundance of the first generation was reached on 17 June for *O. nubilalis* (15.8 adults/trap/day) and on 23 June for *H. armigera* (11.1 adults/trap/day). With an average of 19.8 adults/trap/day for *O. nubilalis* and 13.8 for *H. armigera*, the maximum threshold for the second generation is reached on 6 August 2022. The species *D. v. virgifera*, which has only one generation/year, reaches the maximum on 8 September 2022 with an average of 359.6 adults/trap/day (figure 2).

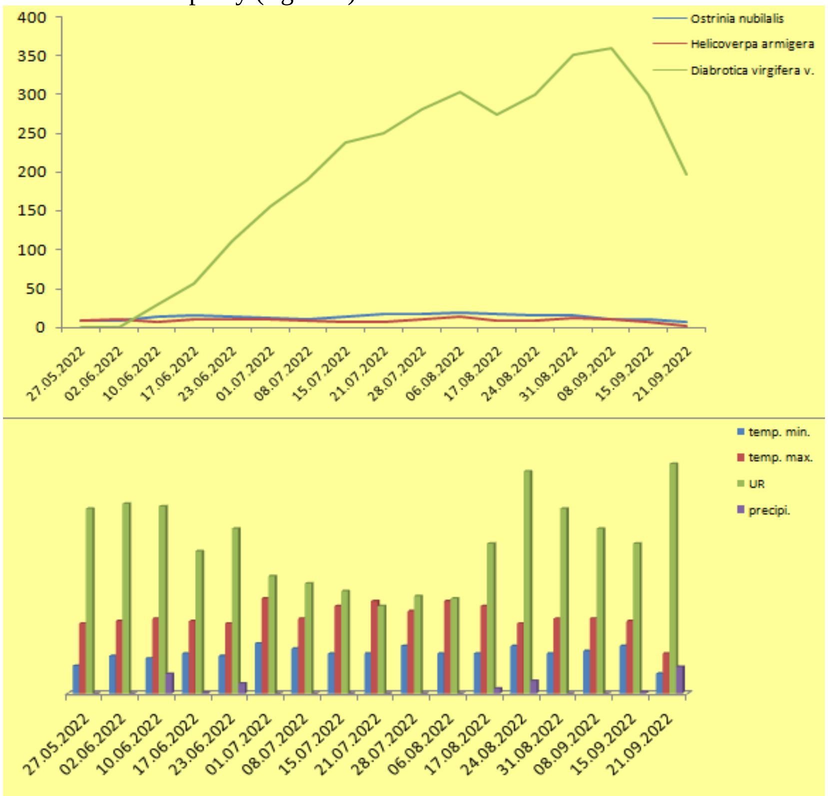


Figure 2. Population dynamics of major insect pest in corn, Clarii Vii (Jimbolia), 2022

The results obtained regarding the dynamics of the *Ostrinia nubilalis* populations are in agreement with those of URSACHE et al. (2020), who highlighted two complete generations, with the first individuals being collected from mid-May/early June and continuing without interruption until the end of September; the maximum of the flight curve varies according to the climatology of the area studied, during the active vegetation period of the crop. According to the study conducted by TROTUS et al. (2018), in the southern part of the country, the flight of *O. nubilalis* adults began from the middle of June until the end of July, with the maximum flight of the first generation being recorded at the end of June. As far as the second generation is concerned, the flight was extended to the whole month of August, with the maximum flight being recorded in the middle of this month.

In the case of the species *Helicoverpa armigera*, the results with regard to the dynamics of the species are in line with those of PĂLEGEȘIU et al. (2004, 2007), who highlighted 2 complete generations and the third partial generation in the climatic conditions of the western plains. ROȘCA (2012) emphasized that the highest incidence of the pest was at the end of July - beginning of August, results similar to those emphasized in the present study.

Based on the data obtained on the population dynamics of *D.v. virgifera*, we can observe a change regarding the time of catching the large number of specimens, which is in early September, compared to the research carried out by Grozea et al. (2009), who obtained a maximum number of catches in mid-August, with moderate temperature values (22.36°C) and moderate precipitation values (25.9 l/m2). However, the research carried out by CIOBANU et al. (2011) highlighted that in the climatic conditions of the northwestern area of Romania, the influence of temperature and precipitation brought significant changes regarding the maximum number of specimens collected, but also regarding the moment of catching the maximum number of specimens.Thus, according to these data, the higher number of adults was recorded in maize monoculture in July with an average of about 41.7 and 53.9 adults/day compared to August when the values were 16.2 - 29.4 and September with values of 8.23 - 8.25 adults/day.

On the basis of our data, we can highlight a very serious influence of the air temperature and the rainfall on the flight dynamics of the 3 pests under study. Dry and warm conditions favour the pest's population growth (PRAKASH et al., 2014).

The adult population of the moth *O. nubilalis* showed a non - significant positive correlation with the maximum and minimum air temperature with r = 0.431 and r = 0.228, respectively (Figure 3). The correlation between adult population and relative humidity was also found to be positive and significant (r=-0.277). It was non-significantly correlated with rainfalls. The results are in line with those of URSACHE et al. (2020), who point out that the summer months, which were characterized by warmer temperatures and/or excessively dry rainfall, led to changes in the bioecology of the species, with an explosive appearance of moths in August, increasing flight intensities and a peak flight in the middle or at the end of the month.

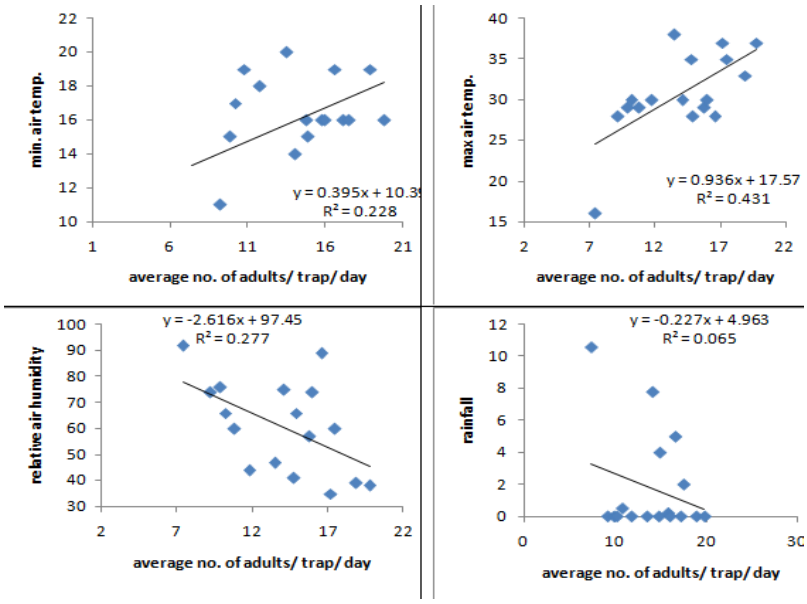


Figure 3. Relationships between the average number of adults of *Ostrinia n*. and climatic factors

The results of the present study showed that the occurrence in the samples of adult populations of *H. armigera* had a positive, non-significant correlation with minimum temperature (r=0.358) and with maximum temperature (r=0.205). Relative humidity was the other most important factor closely associated with pest activity. The correlation with relative humidity was r=0.105. The positive, significant correlation was found in the case of precipitation (figure 4). Our results are similar to those of BRAHMAN et al. (2018), who reported a positive correlation with maximum and minimum temperature (r = 0.017), also with relative humidity (r = 0.339), and an non - significant negative correlation with precipitation; while BANGALE et al. (2019) found that incidence was positively correlated with relative humidity and negatively correlated with maximum temperature.

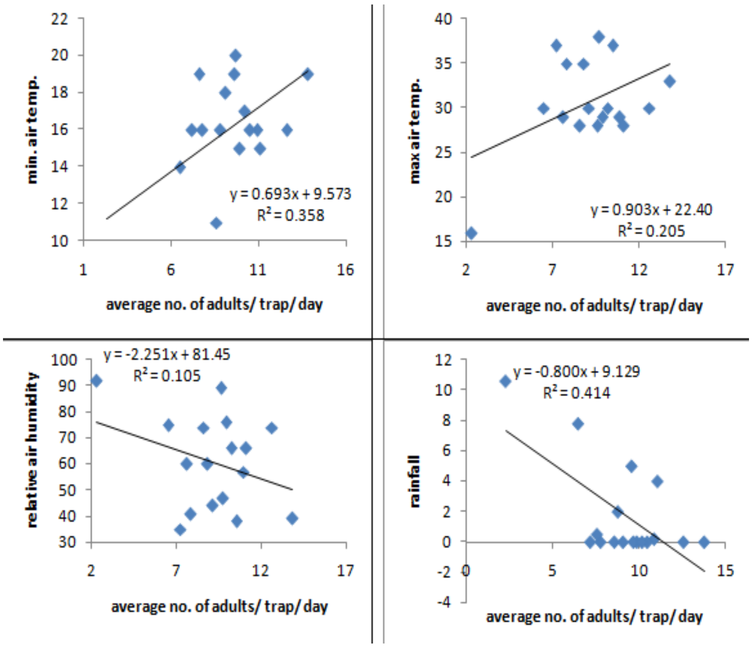


Figure 4. Relationships between the average number of adults of *Helicoverpa a*. and climatic factors

Moreover, in our studies, we also observed that the number of D.v. virgifera adults caught in pheromone traps (daily mean) had a significant positive correlation with minimum air temperature (r=0.358), and non-significant correlation with all other weather parameters (figure 5).

Similar results were obtained by Grozea et al. (2009, 2010), who demonstrated a positive correlations between air temperature (daily mean) and the number of adults trapped, and also considered that rainfall was an important factor influencing adult dynamics in corn fields, with a reduction in the number of adults as rainfall increased. In general, we can mention that values of temperature between 20°C and 25°C have a positive influence on the flight of adults, accompanied by moderate values of rainfall.

Regression analysis of the population dynamics of the 3 pests studied showed the significant effect of climatic factors on the incidence and dynamics of adult populations, which can reach up to 61%.

The emergence date of the adults is correlated with the environmental factors at different temperature levels and it is not necessary to have a correlation with the phenology of the corn plants. Abiotic factors such as climatic factors influence the flight of adults .The air temperature, rainfall and relative humidity can seriously influence the flight dynamics of the adult pests.

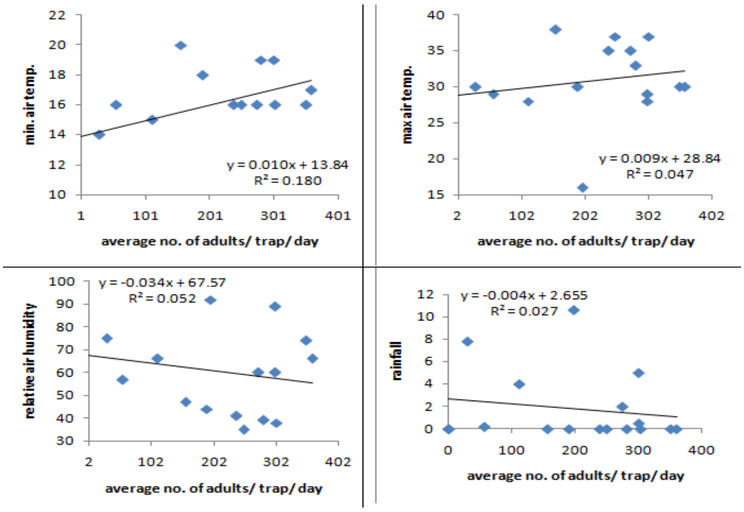


Figure 5. Relationships between the average number of adults of *Diabrotica v. v.* and climatic factors

CONCLUSIONS

Diabrotica v. virgifera reaches higher thresholds than the other two monitored pests (*Ostrinia nubilalis* and *Helicoverpa armigera*).

In the three species studied, there is an almost perfect synchronisation of the first generation with the optimal temperature threshold, which is specific to the biology of the insect.

The results of the present study showed that occurrence had a positive, non-significant correlation with minimum and maximum temperature. Relative humidity was the other most important factor that was closely related to the activity of the pests. In the case of precipitation, a positive, significant correlation was found.

These mechanisms have evolved over time as a result of the need for constant adaptation of the insects to climate change.

ACKNOWLEDGEMENTS

This work was financially supported by S.C. WestLand Company through the research project "Testing biopesticides to control main pests in agricultural crops" (no. 7386/17.12.2021).

BIBLIOGRAPHY

BANGALE S.A., PARMAR G.M., DHANDGE S.R., 2019 – Seasonal incidence of soybean defoliators and their correlation with weather parameters in kharif season. *Journal of Entomology and Zoology Studies*, 7(2): 1133-1136;

BRAHMAN S.K., SHARMA A.K., SINGH S., 2018 – Studies on insect-pests of soybean (Glycine max) with special reference to seasonal incidence of lepidopteran defoliators. *Journal of Pharmacognosy and Phytochemistry*, 7(1): 1808-1811;

CARTER C., CUI X., GHANEM D., MÉREL P., 2018 - Identifying the economic impacts of climate change on agriculture. *Annual Review of Resource Economics*, 10:361-380, DOI: 10.1146/annurev-resource100517-022938

CHEN C., HARVEY J.A., BIERE A., GOLS R., 2019 – Rain downpours affect survival and development of insect herbivores: the specter of climate change? *Ecology*, 100(11): e02819. DOI: 10.1002/ecy.2819;

COSTEA M. – A., GROZEA I., 2022 - Analysis of the range of pests and their effect on maize plants growing in the organic system. *Scientific Papers. Series A. Agronomy*, Vol. 65(1): 258 – 265;

COSTEA M. A, KONJEVIĆ A., GROZEA I., 2023 - Biological solutions for the management of pests in corn crops. *AgroLife Scientific Journal*, 12 (1): 62 – 71;

CIOBANU C., CIOBANU GH., DOMUȚA C., ȘANDOR M., DOMUTA C.G., ALBU R., VUȘCAN A., POPOV C., 2011 - The influence of ecological factors from North-Western Part of Romania on Diabrotica virgifera virgifera Le Conte (Western root corn worm) species. *Natural Resources and Sustainable Development*, 1: 89 – 96;

DEUTSCH C.A., TEWKSBURY J.J., TIGCHELAAR M., BATTISTI D.S., MERRILL S.C., HUEY R.B., NAYLOR R.L., 2018 – Increase in crop losses to insect pests in a warming climate. *Science*, 361:916–919;

GROZEA I., 2003 – *Biologia, ecologia şi combaterea viermelui vestic al rădăcinilor de porumb (Diabrotica virgifera virgifera Le Conte) în condiţiile Câmpiei de Vest*, Teză de doctorat, USAB Timişoara;

GROZEA I, CARABET A, CHIRITA R, BADEA AM., 2008 – Natural enemies in control of invasive species Diabrotica virgifera Virgifera from maize crops. *Communications in Agricultural and Applied Biological Sciences*, 73(3):501-508;

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., COSTEA M.A., 2022 - Management of the Western Corn Rootworm (*D. v. virgifera*) in Corn Cultivation System, *Universal Journal of Agricultural Research*, 10(5): 501-513, DOI: 10.13189/ujar.2022.100505;

HARVEY J. A., TOUGERON K., GOLS R., HEINEN R., ABARCA M., ABRAM P. K., BASSET Y., BERG M., BOGGS C., BRODEUR J., CARDOSO P., DE BOER J. G., DE SNOO G. R., DEACON C., DELL J. E., DESNEUX N., DILLON M. E., DUFFY G. A., DYER L. A., ... CHOWN S. L., 2023 – Scientists' warning on climate change and insects. *Ecological Monographs*, 93(1): e1553. DOI:10.1002/ecm.1553;

PRAKASH A., RAO J., MUKHERJEE A.K., BERLINER J., POKHARE S.S., ADAK T., MUNDA S., SHASHANK P.R., 2014 – *Climate Change: Impact on Crop Pests*; Applied Zoologists Research Association (AZRA), Central Rice Research Institute: Odisha, India;

PĂLĂGESIU I., GROZEA I. & HÂNCU M., 2001 – Evolution of the pest *Diabrotica virgifera virgifera* Le Conte in the Timis district. *Proceedings XXI IWGO Conference*, VIII Diabrotica Subgroup Meeting, Padva, Italy, 27:139-149;

PĂLĂGEȘIU I., ANDRU M., PĂLĂGEȘIU T., 2004 – Investigations concerning the attack by *Helicoverpa armigera* Hbn (*Noctuidae, Lepidoptera*), in maize. Lucrări ştiinţifice, Facultatea de Agricultură 36: 468-473;

PĂLĂGEȘIU I., STAN N., PRUNAR F., COȘTIUG E., 2007 – Investigations concerning the spreading, biology, ecology and control of american bollworm *Helicoverpa armigera* Hbn. Lucrări ştiinţifice, Facultatea de Agricultură. 39(2): 451-457

ROȘCA I., 2012 – Preliminary study regarding importance of species *Helicoverpa armigera* Hb. for maize culture in Romania, *Scientific Papers, USAMV Bucharest*, Series A, 52: 424 -426;

SKENDŽIĆ S., ZOVKO M., ŽIVKOVIĆ I.P., LEŠIĆ V., LEMIĆ D., 2021 – The impact of climate change on agricultural insect pests. *Insects*, 12:440, DOI:10.3390/ insects12050440;

ȘTEF R., CARABET A., GROZEA I., CHIFAN R., ȘTEF R., FLORIAN T., 2020 - Efficacy assessment of synthesis pyrethroids on *Ostrinia nubilalis* (Hübner) population reduction from corn agro-ecosystem. Scientific Papers. Series A. Agronomy, 63 (1): 554 – 561;

URSACHE P. – L., TALMACIU M., TROTUȘ E., ISTICIOAI S. – F., AMARGHIOALEI G. - R., 2020 - Research on the flight dynamics of *Ostrinia nubilalis* in maize crops under conditions of the Central part of Moldova, Romania, Romanian Journal for Plant Protection, 13:80 – 85, DOI: 10.54574/RJPP.13.13

VÎRTEIU A. – M., GROZEA I., STEF R., VLAD M., DOBRIN I., 2015 – Faunistic study of ladybirds (*Coleoptera: Coccinellidae*) in the Banat region, Romania. *Bulletin USAMV series Agriculture* 72(2): 576-581. DOI: 10.15835/buasvmcn-agr:11489;

VIRTEIU A.- M., SEIBERT A.- M., ȘTEF R., CĂRĂBEȚ A., CHIȘ C., GROZEA I., 2021 – Is *Helicoverpa armigera* (*Lepidoptera: Noctuidae*) a key pest in Western Romanian paprika pepper crops? *Romanian Journal for Plant Protection*, 14: 75 – 84. DOI: 10.54574/RJPP.14.09;

WAR A.R., PAULRAJ M.G., AHMAD T., AHADBUHROO A., HUSSAIN B., IGNACIMUTHU S. & CHAND SHARMA H., 2012 – Mechanismsof plant defense against insect herbivores. *Plant Signaling & Behavior*, 7:10, 1306-1320. DOI:10.4161/psb.21663;