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ANALYSIS OF THE RANGE OF PESTS AND THEIR EFFECT ON MAIZE PLANTS GROWING IN THE ORGANIC SYSTEM

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Abstract

Organically grown corn has attracted the attention of producers and traders and is increasingly in demand on the world market. With the expansion of this type of crop in which the use of pesticides is not allowed, the species of harmful insects have also multiplied. In this paper we set out to evaluate two lots of corn in western Romania, one with organic corn after 3 years of practice and another in the first year. Thus, we found that in the lot of 3 years under the organic system, the range of species was much more comprehensive and the population level of each species higher than in the lot in the first year. The active stages (as the case may be, of adults, larvae or nymphs) of the species of hemipteran, coleopteran and lepidopteran, which were the most frequent in the lots under observation, affected both the aerial and the underground part of the plants. The damages produced in the lot with 3 years affected the plants in vegetation (from the plant emergence until the maturity of the cob) in percentages of 17-18% as opposed to the damages from the lot in the first year in which the damages were of 5-7%. It is obvious that the longer the culture is on the same substrate, the more the pests become and produce damage with definite repercussions.

Key words: *corn, organic system, pests, range, damage.*

INTRODUCTION

Romania is considered one of the largest corn producing countries in the EU, according to the European Commission (2020). However, the occupation of agricultural areas with organic crops or ecologically it is quite low, somewhere at 8.5%, therefore, through the Action Plan for the development of organic production of the European Commission for a future period of 10 years, an extension of 25% is foreseen (Uros, 2021).

Sometimes the term "ecological" or" biological" is used in the literature (Stoleru & Sellitto, 2016). In essence, these synonyms express the same characteristics as for organic farming, which is considered to be an increasingly environmentally intensive production system worldwide (Willer et al., 2019). We chose to approach the term "organic" in this paper because it seemed closer to the culture of corn in vegetation.

Organic crops are very often associated with a lower yield on the same land area compared to the conventional system. However, a great advantage of this approach is to protect natural capital through the use of natural enemies, the use of natural fertilizers (by the contribution of nitrogen left by leguminous) and by minimizing tillage (Pretty & Bharucha, 2015).

Given the concern for increasing the cultivation of plants suitable for this system, we turned our attention to corn, which is considered profitable (Brock et al., 2021).

In order to have a holistic picture of all pests in a corn crop (regardless of the cultivation system) it is necessary to know where to focus at the plant level. In this sense, Ortega (1987) recommends an assessment of each essential organ, namely tassel, ear, stem, foliage, roots and seeds.

In organic systems, crops can be more difficult to manage in terms of pests due to the principles of organic farming, especially the limitation of the use of chemicals that have a much higher effectiveness compared to chemicals (Farag, 2019).

Broadly speaking, crop pests include insects, weeds, plant pathogens, insects, and other invertebrates or vertebrates (Ash, 2003). We will focus only on the group of insects, which are in fact the most common and diverse in organic farming (Gomiero et al., 2011) and implicitly in the cultivation of corn.

In addition to limiting the use of pesticides, practicing corn after corn (or monoculture) in large corn-producing areas facilitates the proliferation and growth of harmful insects (He et al., 2019; Piesik A. & Piesik D., 2021).
Among the harmful animals, arthropods and implicitly insects are the most present in corn crops, and the most representative species in Europe is by far *Ostrinia nubilalis*. This pyraustid lepidopterus occurs in any type of culture system and the damage it causes in the absence of adequate control measures reaches up to 30% (Stoleru & Sellitto, 2016).
For 27 years, corn crops in Romania have been affected by the chrysomelid species Diabrotica *virgifera* (Vonica, 1996; Grozea, 2010), another important pest for corn crops. Over time, various non-pollutant strategies have been developed to control this pest, most of them focusing on prevention, through monitoring, with using traps to catch beetles, both local (western part of the country) and national level (Hancu et al., 2001).
Aphids are very common hemipteran (suborder Homoptera) in most crops and other important crops (Wieczorek et al., 2019). They cause direct and indirect damage, leading to a decrease in yields in various ways. Among the common aphids of corn is *Rhopalosiphum maidis* which can develop high population densities that dehydrate and deprive the plants of nutrients, are also important vectors for viruses (Sorensen, 2009). All of these are difficult to control, especially in organic systems, where pesticides are restricted or banned, so they can be considered extremely dangerous. Through our study we aimed to see how the density increases in aphid populations over time without chemical control measures.
After Bailey (2007) corn can be attacked by a wide range of insects that can be major or minor as economic importance. Unlike the major pests who appear regularly, the minors appear irregularly and do not create problems every season.
In the present paper we aimed to analyse the evolution of densities in populations and the range of insect species in maize crops in organic system practiced for a short time or longer and the impact of damage on plant growth.

MATERIALS AND METHODS

The 2 lots with organically grown corn were established and maintained in 2 localities in western Romania (Figure 1), according to the principles of organic agriculture, no chemical element or aggressive method being present. The plot with corn after 1 year of practicing in organic system (Lot 1) was placed in Seleus (46°22'29.5"N 21°45'01.1"E) and the one with corn after 3 years of practice (Lot 2) placed in Sicula (46°30'03.9"N 21°46'51.8"E). There is a distance of 8 km between the 2 lots (locations), so there was no possibility of insect migration.
The size of the analysed area in each of the 2 locations was 9000 m^2 (100 m wide x 90 m long) out of a total compacted area of 7.5 hectares.
The maize hybrid used was of course untreated, namely Pioneer P9757 (FAO 370), which responds positively to any climatic and technological conditions.

Figure 1. a) Images from experimental lots; from the lot after 3 years of practicing the organic system in advanced vegetation (down, left) and the plot after 1 year of practicing the organic system in the emergent phase (down, right); yellow panel traps with attached pheromone (top, left) and detailed study for correct pest identification (top, right); b) Placement of lots and details of their locations (down, right)

In order to evaluate the harmful populations from the experimental lots, during the year 2021, we used 2 types of traps, both from the same producer (Csalomon, Budapest). Thus, for capturing adult beetles (Grozea, 2003) and hemipterans (larvae, nymphs and adults) a type of trap with coloured Panel and pheromone was installed and for adult lepidoptera we used box type traps.
Checking and reading the traps was done directly in the field, every 15 days during the vegetation period of the corn in June-September.

The assessment was made taking into account the stages of maize development according to the BBCH scale (Lancashire et al., 1991).
The monitoring of *Diabrotica* beetles (proven to be very suitable for capture by using traps) consisted of carrying out insect capture activities using sticky yellow panel pheromone traps (type Csalomon PAL) (Figure 1), from the Institute for Plant Protection, MTA ATK. Their principle of operation is based on attraction through chemical and visual stimuli and it catches females as well as males (Toth et al., 2007). Usually, these traps can catch other pests that are not specific to corn but can cause damage (Subchev et al., 2005; Toshova, 2017). Their location was made at a distance of 50 m, on the diagonals thus covering the central and lateral parts of the plot (Horgos & Grozea). The capture of aphids was also done by 2 Yellow Pan Traps (Moericke) effective in monitoring and control.
The sticky traps for coleopterans and hemipterans were placed in the crops on the 2 diagonals (134.5 m long/each diagonal) 3 traps/diagonal (of which 1 commune, central). These were changed every 3 weeks.
For lepidopteran, 2 box traps and 2 light traps were placed on the 2 diagonals, and these were changed every 4 weeks.
To assess the harmful stages in the soil, we used the method of evaluation in terms of direct observation on the root and plucking 10 out of 10 of the plant in a row. Thus, the larvae of genus *Agriotes*, *Diabrotica* or other species present at a given moment in the corn crops were quantified directly in the experimental field with the help of the portable magnifying glass.
In each lot, at the 10th plant on the growth row, at each trap reading, we also analysed the damage both aerially and at the root (uprooted plants). For the damage assessment, the mean values, the standard error (SE) and the median (statistical correlation) were established.

RESULTS AND DISCUSSIONS

Observations in different stages of maize growth in the 2 lots highlighted the presence of several harmful species belonging to the 3 major categories of insects. Thus, in the lot cultivated in organic system after 1 year, the following species were present: *Diabrotica virgifera, Tanymechus dilaticollis, Opatrum sabulosum, Oulema melanopus, Agriotes* sp. and *Phyllotreta vittula* (from Coleoptera) (Table 1). The same species were identified in the lot in the organic corn practiced for 3 years, plus the species *Chaetocnema tibialis*.

Table 1. Status of harmful coleopteran species in the 2 lots of organic maize (Lot 1-after 1 year of practicing of organic system and Lot 2-after 3 years) in correlation with the plant stages (BBCH code)

Harmful species identified in Lot 1 and Lot 2	Active stage of the pest/BBCH code	Status of pest development stages/ maize lots analyzed	
		Lot 1	Lot 2
Diabrotica virgifera	01:18 05: 51-59 06: 61-69 07: 71-75	+(A_t, L_s)	+(A_t, L_s)
Tanymechus dilaticolis	00:09	+ (A_o)	+ (A_o)
Opatrum sabulosum	00:09	+(A_o)	+(A_o)
Oulema melanopus	05: 51-59 06: 61-69	+(A_t, L_p)	+(A_t, L_p)
Agriotes sp.	00:03-09 01:10-18	+(L_s)	+(L_s)
Chaetocnema tibialis	01:11-18	-	+ (A_t)
Phyllotreta vittula	01:11-18	+ (A_t)	+ (A_t)

+/- Presence status; At-adult on traps; Ao- adult observed on plant or soil; Ls- larva in soil; Lp-larva on plant; BBCH code (after Lancashire et al., 1991);

From the group of hemiptera were identified the species *Rhopalosiphum maidis* and *Rhopalosiphum padi* (in the lot with organic corn after 1 year), and *Metcalfa pruinosa* and *Nezara viridula* (only in the lot with organic corn after 3 years). The species of aphids were present in both analysed lots (Table 2).

Table 2. Status of harmful hemipteran species in the 2 lots of organic maize (Lot 1-after 1 year of practicing of organic system and Lot 2-after 3 years) in correlation with the plant stages (BBCH code)

Harmful species identified in Lot 1 and Lot 2	Active stage of the pest/BBCH code	Status of pest development stages/maize lots analyzed	
		Lot 1	Lot 2
Rhopalosiphum maidis	01:14-19 05: 51-59 06: 61-69	+(N_t, A_t)*	+(N_t, A_t)*
Rhopalosiphum padi	01:14-19 05: 51-59 06: 61-69	+(Nt, At)*	+(N_t, A_t)*
Metcalfa pruinosa	05: 51-59	-	+(N_o, L_o)
Nezara viridula	06: 61-69 07: 71-73	-	+(A_o, N_o, L_o)

+/- Presence status; At/Nt-adult/nimph on trap; Ao/No/Lo-adult/larva/nimph observed on plant; *many asexual forms without wings and wings

In the study lot we observed nymphs and adults of *Metcalfa pruinosa* (Table 2), indeed in small numbers compared to the other main species of corn. We assume that they were only accidentally installed on the corn leaves, but it is not excluded that in the future an increasingly large population will develop.
We have the certainty that in the organic system, corn can be easily infested by insects that, even if they are not specific, can become predominant, even leading to significant damage. In fact, this species has been reported in a corn crop in Hungary a few years ago (Bozsik, 2015). We mention that so far, this flatid cicada has not been reported on corn plants in Romania only on the ornamental ones and some fruit and vine species (Vlad & Grozea, 2016).
Among the insects of the order Lepidoptera, we identified the species *Ostrinia nubilalis* and *Helicoverpa armigera*, present both lots and *Agrotis* sp. observed only in the lot after 3 years (Table 3).

Table 3. Status of harmful lepidopteran species in the 2 lots of organic maize (Lot 1-after 1 year of practicing of organic system and Lot 2-after 3 years) in correlation with the plant stages (BBCH code)

Harmful species identified in Lot 1 and Lot 2	Active stage of the pest/BBCH code	Status of pest development stages/ maize lots analyzed	
		Lot 1	Lot 2
Ostrinia nubilalis	01:14-19 05: 51-59 06: 61-69	+(A_t, L_p)	+(A_t, L_p)
Helicoverpa armigera	01:14-19 05: 51-59 06: 61-69	+(A_t, L_p)	+(A_t, L_p)
Agrotis sp.	01:14-19 05: 51-59 06: 61-69	-	+ (A_t)

+/- Presence status; At-adult on traps; Lp-larva on plant

Comparing the number of catches or individuals quantified in the 2 lots, we could find that in the lot with corn in the organic system practiced only 1 year the abundance of species was visibly lower than in the lot in which the organic system was practiced for 3 years. The highest values were recorded, for both lots, in the cases of *Diabrotica virgifera* (adult form) (1248 individuals/Lot 1 and 2277 ind./Lot 2) (Figure 2). Also, with a value over 500 ind. fleas from the genus *Phyllotreta* (648 ind./Lot 2) but also from the genus *Chaetocnema* with 567 ind./Lot2) were highlighted. The other beetle species had values below 500 ind./lots (Figure 2).

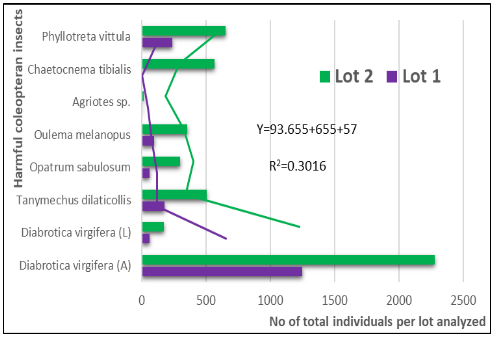

Figure 2. Comparative trends of catches of harmful coleopteran insects quantified in the 2 experimental corn lots (Lot 1-after 1 year of practicing of organic system and Lot 2-after 3 years)

And in terms of the abundance of hemipteran species, these were predominant in Lot 2 compared to Lot 1 (Figure 3). Aphid species such as *Rhopalosiphum maidis* recorded double values (2584 ind. in group 2) compared to Lot 1 (1161 ind.) and *R. padi* had a value of 1787 ind. in Lot 2 compared to Lot 1 (795 ind.) (Figure 3).

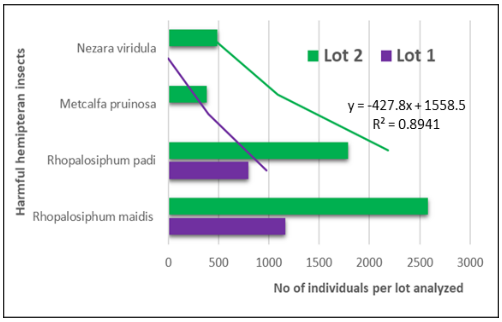

Figure 3. Comparative trends of catches of harmful hemipteran insects quantified in the 2 experimental corn lots (Lot 1-after 1 year of practicing of organic system and Lot 2-after 3 years)

Due to the abundance of lepidopteran insects in the 2 lots, the species of *Ostrinia nubilalis* (in adult form) was captured in higher values in Lot 2 (1268 ind.) than in Lot 1 (697 ind.) (Figure 4). In fact, in the case of *Helicoverpa a.* lepidopteran (adult) the situation was also similar (545 ind./Lot 2 and 269 ind./Lot 1) (Figure 4). Catches of the genus Agrotis were recorded only in Lot 2 (359 ind.).

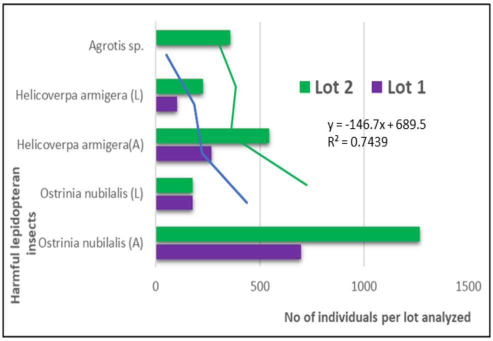

Figure 4. Comparative trends of catches of harmful lepidopteran insects quantified in the 2 experimental corn lots (Lot 1-after 1 year of practicing of organic system and Lot 2-after 3 years)

Analysing the bi-monthly evolution of beetle catches in the 2 lots, it can be seen in Figure 5 that in June-September the adults of Diabrotica had a maximum activity at the beginning of August (308 ind./Lot1; 561ind./Lot 2) while the larvae at the end of June (41 ind./Lot 1; 112 ind./Lot 2). Another chrysomelid (*Oulema m.*) recorded a maximum of activity at the end of July (60 ind./Lot 1; 168 ind./ Lot 2). *Phyllotreta v.* also entered the category of chrysomelids with a maximum of activity at the end of June (107 ind./Lot 1; 269 ind./Lot 2) and the species *Chaetocnema t.* with a maximum also in June (0 ind./Lot 1); 278 ind./Lot 2). Among the beetles active at the beginning of summer, immediately after the emergence of maize plants, we can mention *Tanymechus d.* with a maximum of activity at the beginning of June (100 ind./Lot 1; 279 ind./Lot 2) and similar *Opatrum s.* (32 ind./Lot1; 188 ind./Lot 2) (Figure 5).

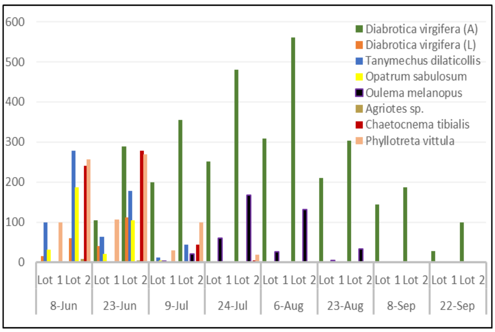

Figure 5. Bimonthly dynamics of harmful coleopteran insects (total caches of adults-A or larva-L) in the 2 lots cultivated in organic system practiced after 1 year and after 3 years

Agriotes larvae were only present in very small numbers, only 1 in Lot 1 and 9 in Lot 2 were observed, and the explanation could be the lack of water in the soil in spring-summer 2021.

The evolution of the bimonthly activity of hemipteran pests is given in Figure 6. It can be seen that the aphids are most active at the end of June when the maximum values were recorded, so for the species *Rhopalosiphum maidis* were captured in the period of maximum activity 420 ind./Lot 1 and 888 ind./Lot 2 and for *R. padi*, 277 ind./Lot 1 and 509 ind./Lot 2. The activity of *Metcalfa pruinosa* and *Nezara viridula* species was only in Lot 2, so for *M. pruinosa*, the maximum activity was registered at the end of June (101 ind.) and for N. *viridula* the maximum was at the end of August with 148 ind. (Figure 6).

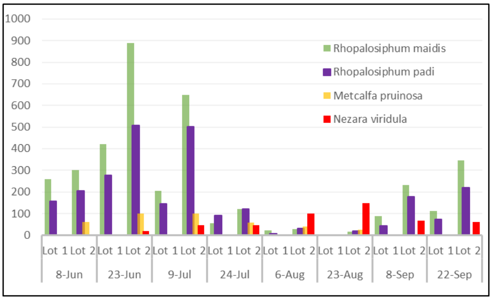

Figure 6. Bimonthly dynamics of harmful hemipteran insects (total caches) in the 2 lots cultivated in organic system practiced after 1 year and after 3 years

The maximum flight of the adult lepidoptera *Ostrinia n.* and *Helicoverpa a.* was achieved at the end of July with 246 ind./Lot 1 and 346 ind./Lot 2 and respectively 128 ind./Lot 1 and 280 ind./Lot 2 (Figure 7). Agrotis adults were quantified only for Lot 2 (where they were present) with maximum flight towards the end of August (132 ind.). The maximum activity of *O. nubilalis* larvae was at the beginning of August (88 ind./Lot 1; 88 ind./Lot 2) and of those of *H. armigera* at the end of July (128 ind./Lot1; 280 ind./ Lot 2) (Figure 7).

The percentage of attack produced by beetle pests had values of the average varied depending on the species and the stage of development for the 2 lots (Table 4). Thus, the adults of *D. virgifera* damaged approximately 10.5% in Lot 1 and 33.4% of the 500 analysed plants and those of *T. dilaticollis* about 12.3% of attacked plants in Lot 1 and 24.7% in Lot 2.

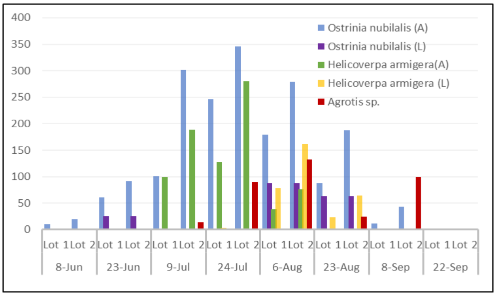

Figure 7. Bimonthly dynamics of harmful lepidopteran insects (total caches of adults-A or larva-L) in the 2 lots cultivated in organic system practiced after 1 year and after 3 years

Adults of *O. melanopus* affected 15.7% (in Lot 1) and 16.2% (in Lot 2) and *O. sabulosum* damaged 4.2% of plants/Lot 1 and 17%/Lot 2. Fleas from the genus Phyllotreta and Chaetocnema affected 4.0% of the plants analysed in Lot 1 and 17.8 % in Lot 2. At the root level, *Diabrotica* larvae caused damage to 3.1% of plants/Lot 1 and 11.4% of plants in Lot 2 (Table 4).

Table 4. Percentage of plant damage by harmful coleopteran in organic maize plots (L1 and L2)

Pest / Lots	Mean ± SE**		Median value	
	Lot 1	Lot 2	Lot 1	Lot 2
Diabrotica virgifera (A)	10.5±1.0	33.4±2.5	6.2	29.4
Diabrotica virgifera (L)	3.1±0.3	11.4±1.3	2.6	8.3
Tanymechus dilaticollis	12.3±2.6	24.7±2.1	9.5	19.1
Opatrum sabulosum	4.2±0.3	17.0±1.7	2.6	13.2
Oulema melanopus	5.7±0.7	16.2±1.9	8.1	9.3
Agriotes sp.	0.1±0.1	1.2±0.2	0.05	0.6
Chaetocnema tibialis	0	5.7±0.7	0	2.3
Phyllotreta vittula	4.0±0.7	17.8±1.0	1.5	13.6

*the standard error (SE)

The species *Chaetocnema tibialis* was observed on plants but also on weeds in lots and on traps, but we cannot comment on their damaging effects because only a few superficial individuals were observed on the leaves. According to Cagáň et al. (2006) these fleas are specific pests of weeds of the species *Amaranthus retoflexus* (very present in corn in the organic system).

The results on the effects of the damage on the plants produced by the hemipteran pests are presented in Table 5. The aphids from *R. maidis* species damaged the plants from the 2 lots in a percentage of 8.6% in Lot 1 and 15.5% in Lot 2. Those from *R. padi* species affected 6.5% of plants in Lot 1 and 17.1% in Lot 2. Stinky bugs of *N. viridula* attacked plants only in Lot 2 in a percentage of 5.6%, as well as *M. pruinosa* cicadas which affected 4.7% of plants from Lot 2 (Table 5).

Table 5. Percentage of plant damage by harmful hemipteran in organic maize plots (L1 and L2)

Pest / Lots	Mean ± SE		Median value	
	Lot 1	Lot 2	Lot 1	Lot 2
Rhopalosiphum maidis	8.6±1.2	15.5±1.4	4.0	10.1
Rhopalosiphum padi	6.5 ±0.9	17.1±1.0	4.2	12.8
Metcalfa pruinosa	0	4.7±0.4	0	1.8
Nezara viridula	0	5.6±0.8	0	2.1

*the standard error (SE)

Nezara viridula was observed only in isolated marginal areas of Lot 2 as well as Marcu (2018) who found 1 single outbreak in a mixed private garden.

We found in the second decade of August, 5 outbreaks of 7 plants with cobs in formation, full of larvae and nymphs, sometimes adults, then the number of individuals/outbreaks doubled in the third decade. The affected cobs could no longer be used due to the foul-smelling substance imprinted in the grains.

The effects of damaging the larvae of harmful lepidopteran in the experimental lots are shown in Table 6. There it can be seen that the larvae of *O. nubilalis* caused damage to 20.3% of the plants analysed in Lot 1 and 40.7% of the plants analysed in Lot 2.

The larvae of *H. armigera* caused damage in 11.5% of the plants under study in Lot 1 and 36.2% of the plants in Lot 2 (Table 6).

Table 6. Percentage of plant damage by harmful lepidopteran (larval active stage) in organic maize plots (L1 and L2)

Pest / Lots	Mean ± SE		Median value	
	Lot 1	Lot 2	Lot 1	Lot 2
Ostrinia nubilalis (L)	20.3±1.5	40.7±2.9	16.5	35.4
Helicoverpa armigera (L)	11.5±1.4	36.2±2.7	9.0	31.7

*the standard error (SE)

CONCLUSIONS

From the results presented in this paper we can conclude that in Lot 2 with maize grown organically after 3 years the diversity and abundance of harmful insects was clearly higher than in Lot 1 with maize grown organically after 1 year.

As repercussions of the feeding activity of coleopteran, hemipteran and lepidopteran insects in the experimental lots, we found that the damage percentage was almost 3 times higher in Lot 2 than in Lot1 (6.4%/Lot 1 and 17.8%/Lot 2).

All this entitles us to agree that organic corn attracts many pests, which multiply and affect the crop from the first year, especially if the crop is kept on the same land for 3 years.

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REFERENCES

Ash, G.J. (2003). *Pest and Disease Management*. 37 p.

Bailey, P.T., (2007). *Pests of field crops and pastures: identification and control*. CSIRO Publishing, 520 pages.

Bozsik, A. (2015). Host plant preference of Metcalfa pruinosa (Say, 1830) (Hemiptera: Flatidae) in the north of Hungary. *Acta Agraria Debreceniensi, 66*. 84–95. https://doi.org/10.34101/actaagrar/66/1897.

Brock, C., Jackson-Smith, D., Kumarappan, S., Culman, S., Herms, C., & Doohan D. (2021). Organic Corn Production Practices and Profitability in the Eastern U.S. Corn Belt. *Sustainability. 13*. 8682, https://doi.org/10.3390/su13168682.

Cagáň, Ľ., Tóth, P., Tóthová, M. (2006). Population dynamics of Chaetocnema tibialis Illiger and Phyllotreta vittula (Redtenbacher) on the weed Amaranthus retroflexus L. and cultivated Amaranthus caudatus L. *Plant Protection Science, 42*. 73–80.

European Commission Raport, (2020). *Commission Recommendations for Romania's PAC Strategic Plan*, https://data.consilium.europa.eu/doc/document/ST-14282-2020-ADD-21/ro/pdf.

Farag, H.A (2019). *Insect Pest Management in Organic Farming System*. In J. Moudrý, K. F. Mendes, J. Bernas, R. d. Silva, & R. N. de (Eds.), Multifunctionality and Impacts of Organic and Conventional Agriculture. IntechOpen. https://doi.org/10.5772/intechopen.84483.

Gomiero, T., Pimentel. D. & Maurizio, P. (2011). Environmental Impact of Different Agricultural Management Practices: Conventional vs. Organic Agriculture. *Critical Reviews in Plant Sciences, 30*(1), 95–124. Doi: 10.1080/07352689.2011.554355.

Grozea, I. (2003). Distribution of Diabrotica virgifera virgifera Le Conte adults on corn plants, during of the day. *Bulletin of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca*, Proceedings Paper, volume 59, 233-234.

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.

He, H., Liu, L., Munir, S., Bashir, N.H, Wang, Y., Jing Yang, Li, C., (2019). Crop diversity and pest management in sustainable agriculture. *Journal of Integrative Agriculture, 18*(9), 1945–1952.

Horgos, H., & Grozea, I. (2020). The current assessment of the structure of *Diabrotica virgifera* (Coleoptera: Chrysomelidae) populations and the possible correlation of adult coloristic with the type and composition of ingested maize plants. *Romanian Agricultural Research, 37*. 197–210.

Lancashire, P. D., Bleiholder, H., Langelüddecke, P., Stauss, R., Van Den Boom, T., Weber, E., Witzen-Berger, A. (1991). An uniform decimal code for growth stages of crops and weeds. *Annals of Applied Biology, 119*. 561–601.

Marcu, 2018. Evaluarea populațională a speciei invazive Nezara viridula în sud-vestul României şi limitarea extinderii prin strategii de combatere non-poluante. Teza de doctorat, BUASVMT,158 p.

Ortega, A. (1987). *Insect pests of maize: A guide of field identification.* Mexico, D.F.: CIMMYT, ISBN 968-6127-07-0.

Pălăgesiu, I., Grozea, I., & Hâncu, M. (2001). Evolution of the pest *Diabrotica virgifera virgifera* Le Conte in the Timis district. In *Proceedings XXI IWGO Conference, VIII Diabrotica Subgroup Meeting*, Padva, Italy (Vol. 27, pp. 139–149).

Piesik, A.W, Piesik, D., (2021). Diversity of species and the occurrence and development of a specialized pest population-a Review article. *Agriculture, 11*. 16. https://doi.org/10.3390/agriculture11010016.

Pretty, J., & Bharucha, Z.P. (2015). Integrated Pest Management for Sustainable Intensification of Agriculture in Asia and Africa. *Insects, 6*(1), 152–182, https://doi.org/10.3390/insects6010152.

Sorensen, J.T., (2009). *Aphids in book Encyclopedia of Insects (Second Edition)*, Editor(s): Vincent H. Resh, Ring T. Cardé, Academic Press, 27–31.

Stoleru, V., & Sellitto, V. M. (2016). *Pest Control in Organic Systems.* In H. K. Gill, & G. Goyal (Eds.), Integrated Pest Management (IPM): Environmentally Sound Pest Management. IntechOpen. https://doi.org/10.5772/64457.

Subchev, M., Toshova, T., Furlan, L., & Tóth, M. (2005). Click beetles (Coleoptera: Elateridae), and their seasonal swarming as established by pheromone traps in different plant habitats in Bulgaria: 2. Maize. *Acta Zoologica Bulgarica, 57*(3), 321–332.

Toshova, T.B, Velchev, D.I., Abaev, V.D., Kalushkov, P.K., Orgován, T., Lohonyai, Z., TóthM., & Sándor Koczor, S. (2017). Nontarget Coleoptera Species Captured in Coloured Sticky Traps in Maize Crops in Bulgaria. *Acta Zoologica Bulgarica Suppl., 9*. 237–246.

Uros, B., (2021). *EU action plan for organic farming*. NAT-VII/019.COR-2021-01968-00-00-DT-TRA (EN) 1/5.

Vlad, M., & Grozea, I. (2016). Host plant species of the cicada *Metcalfa pruinosa* in Romania. *Bulletin UASVM series Agriculture, 73*(1), 131–137.

Vonica, I., (1996). Monitoring of Diabrotica virgifera virgifera Le Conte in Romania. *IWGO Newsletter, 16*. 2–15.

Wieczorek, K., Fulcher, T.K. & Chłond, D. (2019). The composition of the aphid fauna (Insecta, Hemiptera) of the Royal Botanic Gardens, Kew. Sci Rep 9, 10000. https://doi.org/10.1038/s41598-019-46441-z.

Willer, H., Lernoud, J., & Kemper, L. (2019*). The World of Organic Agriculture*, eds H. Willer and J. Lernoud. Frick: FiBL. http://www.organic-world.net/yearbook/yearbook-2018.html.