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Monitoring and Managing Pests in Conventional and Organic Corn through Environmentally Friendly Approaches

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ABSTRACT

Pests in corn crops are continuously increasing and diversifying from year to year and for them large amounts of insecticides are used with polluting effects on the environment and harmful to health. So, through this study we set out to see what is the density of pests (using traps to attract and catch) in 2 culture systems (organic and conventional) and to try to find solutions that are friendly to the environment and at the same time with minimal effort and effect durable. In this sense, 4 plots in 2 localities in western Romania (Arad County) were organized for 3 years (2021-2023) both in the open field for monitoring activities of pests and natural enemies and in cages for the interaction report between them and also for evaluating the effectiveness of 2 common bioinsecticides. The monitoring results showed that the pests had a high diversity and a high numerical level of Hemiptera, Coleoptera and Lepidoptera (as target organisms), especially in the organic plots. The predominant natural enemies were from the genera Sphaerophoria, Harmonia, Lysiphlebus, Argiope, Chrysoperla and Coccinella among many others with average values over 100 and a good potential interaction ratio (natural enemies - pests) (1:13.94). The best variant related to the efficiency of bioinsecticides was BB (1)-HD, studies proving that a higher dose is more effective. All, the use of traps (attract-catch), as well as the exploitation of natural enemies and the application of bioinsecticides can constitute biological solutions available to agricultural farmers.

Keywords: organic, conventional, corn, maize, pests, traps, natural enemies, bioinsecticides.

INTRODUCTION

Pest control approaches in the organic and conventional corn culture are discussed separately and take into account the environment and biodiversity (Beres and Pruszyński, 2008; Gomiero et al., 2011; Sivcev et al., 2012; Fathipour and Maleknia, 2016). However, there is also a common approach, such as prevention through agricultural practices (such as crop rotation, the preceding plant, row covers or the choice of hybrids) applicable to both systems in the first part of the management (Boisclair and Estevez, 2006).

The excessive application of synthetic pesticides leads to disastrous effects for the environment, the texture of the soil or for human health, as such overapplication is avoided and alternatives such as organic or biopesticides are required (Šunjka and Mechora, 2022; Ayilara et al., 2023; Petcu et al., 2023).

In case of organic agricultural systems, there is a wide variety of entomophagous arthropods and implicitly a better management of pests than in the conventional system, because the lack of synthetic pesticides increases the reserve of beneficial organisms (Nicolopoulou-Stamati, 2016). Also in the organic one, biopesticides, plant extract or the use of traps can be applied (Roh et al., 2007; Chakoosari, 2013; Rauch et al., 2016; Horgos and Grozea, 2020; Georgescu et al., 2022).

In conventional system, on the other hand, the use of synthetic pesticides is allowed (Ştef et al., 2020), so the possibility that the beneficial organisms will be killed together with the harmful ones is quite high. So practically the management can be done through all the practices applicable to the organic system plus pesticides less exploitation of natural enemies (Braley, 2021).

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Frequent pests in conventional and organic corn in Eastern Europe are variable depending on various abiotic factors mainly, but also taking into account the practice of a certain culture system for various periods or hybrids used (Grozea et al., 2019, 2021). Among the most common species with an impact on the corn production of the eastern countries and implicitly Romania is the corn borer (*Ostrinia nubilalis*), cob earworm (*Helicoverpa armigera*), corn aphid (*Rhopalosiphum maidis*), western corn rootworm (*Diabrotica virgifera Le Conte*) and maize leaf weevil (*Tanymecus dilaticollis*) (Ortega, 1987; Muresan and Mustea, 1995; Khurshid et al., 2013; Georgescu et al., 2016, 2019; Manole et al., 2017; Costea and Grozea, 2022).

In Europe, corn crops are frequently attacked by various pests, but the coleopteran *Diabrotica virgifera virgifera* is much discussed lately due to its economic importance (Ferracini et al., 2021) and the attention it received in the period 1990-2010 (Grozea, 2003; Toepfer and Kuhlmann, 2004; Moeser and Vidal, 2005) and then practically disappearing from the attention of authorized bodies. In reality it was present in crops in Europe and continued to cause great damage although it was not quantified in the period 2011-2020 (Schaub et al., 2011, Bazok et al., 2021). However, at the level of Romania, the restricted research carried out in 2015-2018 shows that there was concern in the sphere of monitoring at regional level (Horgos and Grozea, 2020), then again in the period 2021-2023 (Costea and Grozea, 2021, 2022).

The longer the maintenance period of the organic system is, the more the number of pests increases and so do their natural enemies. Also, we need to consider the large proportion of corn crop in Romanian agriculture for conventional and increasing organic cultivated area (Dragomir et al., 2022). Previous research has shown that numerous natural enemies were present that to some extent can keep the targeted pests under control (Toepfer and Kuhlmann, 2004; Costea et al., 2023). Spiders and coccinellids are by far the most frequent (Daniel, 2021; Cruz, 2022). Among the spiders, the frequency of species from the genera: Argiope, Philodromus, Theridion Tibellus and Xysticus, and was found on the aerial part (at the level of leaves, stem, cobs, silk and panicle) (Nyffeler and Benz, 1987; Toth et al., 2005). Two species of coccinellids from the genera Coccinella and Harmonia were also frequent in the organic system. Other natural enemies were identified from the genus Trichograma, Chrysoperla, Orius or Nabis (Carvalho et al., 2017; Costea et al., 2023).

By this work, we have proposed to evaluate 2 corn cultivation systems (conventional and organic) from the perspective of the possibilities of efficient management of problematic pests for the western area of Romania, taking into account the available methods in a context of as little environmental pollution as possible with special attention for organic crop.

MATERIAL AND METHODS

Organization of experimental fields

Study area was located in Western Romania, in Arad County, more precisely in 2 localities (Seleus and Sicula), between them being 9 km distance (Figure 1c). In order to monitor the pests and then to evaluate the effectiveness of the non-polluting methods of their management, we went through several stages of activities in 4 experimental plots, over a period of 3 years (2021-2023). In each locality (representing a repetition, R1 and R2) 2 plots were established (one conventional and one organic) (Figure 1a, b).

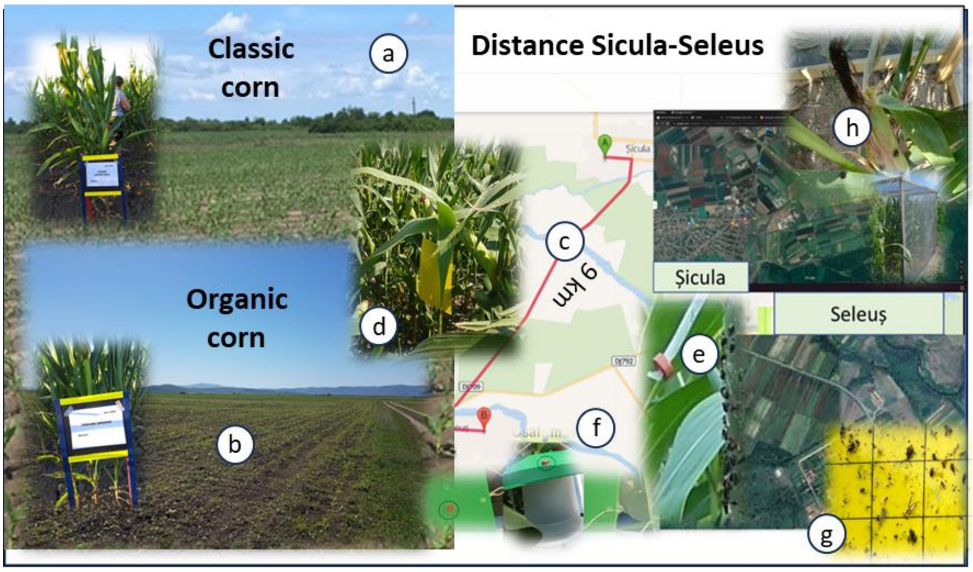

Figure 1. Study places - characteristics and organization
a. conventional plots; b. organic plots; c. distances between places (between localities of Sicula and Seleus);
d, e, f, g. traps for capturing pests; h. cages for testing in the field

Total area cultivated with corn was approximately 30 ha in the town of Sicula and 7.5 ha in the town of Seleus belongs to 2 private agricultural companies. For the monitoring studies we have delimited 0.9 ha and for those evaluating the effectiveness of natural enemies and evaluating the effectiveness of bioinsecticides we have used 0.1 ha and 0.45 ha (Table 1).

The use of traps and others ways to attract pest insects and beneficial organisms

The traps used in pest monitoring were colored and uncolored, with pheromones, graded or ungraded, panel or box type all (Figure 1d, e, f, g) produced in the Plant Protection Institute in Budapest (Toth et al., 2003). Small and medium adult insects, 0.3-0.9 cm (some coleopterans, aphids, hemipterans, hymenopterans, dipterans, syrphids, neuropterans and others) were captured on the rectangular panels covered with glue. But the larger ones over 1.0 cm (large coleopterans, lepidopterans, some hymenopterans) were difficult to attach to the panels, so direct observation on the plants around the traps was actually the way of monitoring. Quantifications were made between June and September, twice a month and the traps changed monthly. Soil and plant samples were taken bimonthly (10 roots and 10 stems) in order to detect larvae and other relevant stages.

Table 1. Mean phenotypic data values

Locality/County	Repetition	Encode of plots	Type system	Analyzed surface (ha)*/**	Total cultivated area (ha)
Sicula/Arad	R1	Plot1cl-sic-R1	Conventional	0.1-0.45-0.9 ha	30 ha
		Plot2or-sic-R1	Organic	0.1-0.45-0.9 ha	
Seleus/Arad	R2	Plot1cl-sel-R2	Conventional	0.1-0.45-0.9 ha	7.5 ha
		Plot2or-sel-R2	Organic	0.1-0.45-0.9 ha	

* 2021-2022 - the surface subject to observations was 0.9 ha for the pest monitoring activity;
** 2022-2023 - the area subjected to observations was 0.1 and 0.45 ha for the evaluation of the effectiveness of bioinsecticides and the ratio of effectiveness of natural enemies-pests.

Use of field cages

Evaluation of interactions between natural enemies and pests

To see the efficiency of the predation or parasitism rate, 2 field cages were used in the 2 organic lots (Figure 1h). The cages were roomy enough for 5-6 corn plants and were made by hand (2/2 m) and placed in the corn crop in July. A 2:1 ratio of pests to their natural enemies was applied in the cages. The rate of predation or parasitism of the relevant pests was established at intervals of 7 days for 1 month. Access to the cages was made through a door with an opening and closing system.

Evaluation of the effectiveness of bioinsecticides

In the cages, two common and easily available bioinsecticides (1 based on *Bacillus thuringiensis* and 1 based on Spinosad) were tested in 3 different doses: low dose (LD). medium dose (MD) and high dose (HD). Checking and quantifying live pests was done at intervals of 3 days for 2 weeks after applying the solution.

Statistical analyzes

The raw data, both from monitoring quantifications and bioinsecticide tests, were statistically interpreted using the appropriate basic descriptive characteristics. The Duncan Test was analyzed for the given variables and approximate probabilities.

RESULTS AND DISCUSSION

Comparative numerical level of pests in conventional vs. organic plots

Pests caught on the traps or observed around them were identified from the categories of Hemiptera, Coleoptera and Lepidoptera. Of the total number of insect pests present in the conventional and organic corn plots, 41% were hemipterans, 40% were coleopterans and 19% were lepidopterans (Figure 2a). Among the observed individuals, some were classified as beneficial species called natural enemies. Of the total observed individuals, 18% were beneficial and the rest (82%) were harmful (Figure 2b).

The descriptive statistics on the categories of pests (regardless of repetitions) show for lepidopterans, minimum and maximum values from 159 to 2575 individuals/9000 m^2 with the maximum in Plot 2 (organic) in the first year of study (2021). For hemipterans, the maximum was also in 2021, plot 2 (5243) and the minimum in 2022, plot 1 (628). Regarding beetles (from Coleoptera), the recorded values were between 601 (in plot 1, 2022) and 4831 (in plot 2, 2021) (Figure 3).

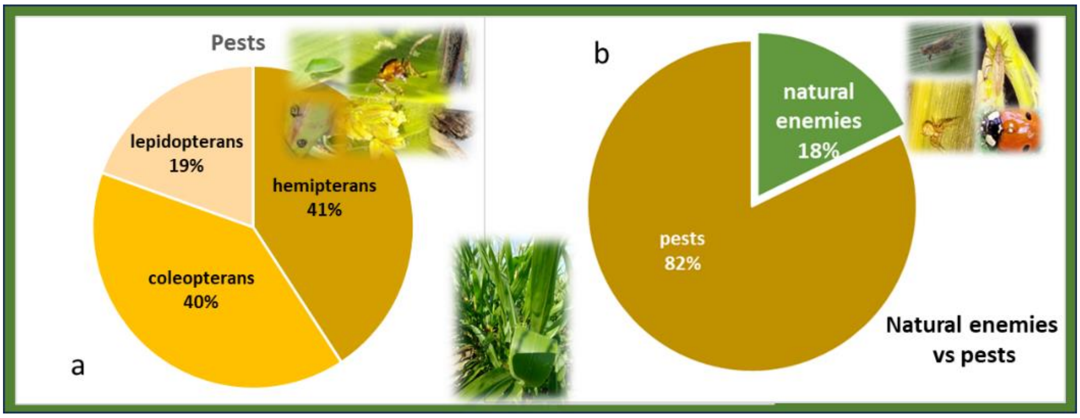

Figure 2. Species captured and observed in the conventional and organic corn plots;
a. proportion of pest categories; b. proportion of natural enemies vs pests in the plots under study

Applying the Duncan test, we found that between the organic variants with hemipterans, coleopterans (2022) and lepidopterans (2021) there are no significant differences (ab) (where $p>0.05$) (p=0.085101; =0.997310) and between all other variants (conventional vs organic) there are significant statistical differences (a/b) (where $p<0.05$) (p=0.009572; =0.038248) (a)(b) (Figure 3).

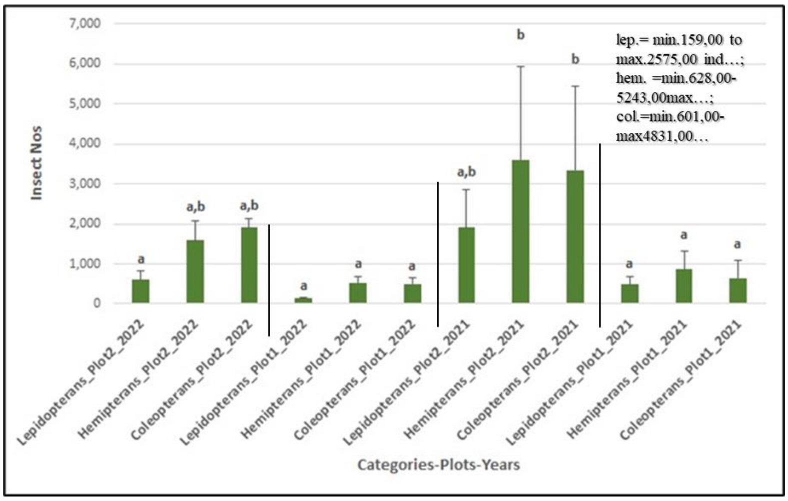

Figure 3. Comparisons by categories of pests between plots (Plot 2-organic vs Plot 1-conventional) regardless of repetitions for each study year (2021 and 2022, respectively)

A descriptive analysis of categories of pests, taking into account the repetition regardless of year, shows that the beetles predominated in organic corn (Plot 2) from Seleus locality (R2) (Plot2or-sel-R2) with an average of 3450.00 ind. and the other categories of target pests (Lepidoptera and Hemiptera) excelled in organic corn from Seleus (R2) with average values of 1665.00 and 3586.50 ind., respectively (Figure 4).

Homogenous groups (Duncan Test) show in Figure 4 that there are no statistically significant differences between average values of hemipterans from the organic corn from Sicula (Plot2_R1), the lepidoptera from the organic corn from Seleus (Plot2_R2) and coleopterans from organic maize from Sicula (Plot2_R1) (p=0.110680; =0.951101) (a,b) while between all the other variants (especial conventional variants) there are significant differences expressed by the p value (p=0.012650; =0.037956) (a)(b).

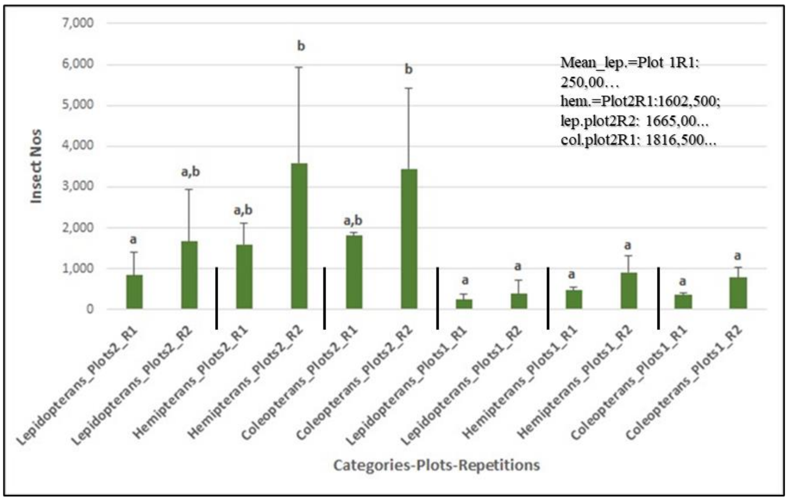

Figure 4. Comparisons by categories of pests between repetitions (R1 and R2) and plots (Plot 1 and Plot 2), regardless of the species and years of study

The most frequent pest species (out of 14 with positive values) in organic corn (Plot 2) regardless of repetitions and year of study were those of the genus Diabrotica (adults) (with a maximum of 2277.00 ind.), Rhopalosiphum (2584.00) and Ostrinia (1268.00). Between the species *Phyllotreta v.*, *Ostrinia n.* (a) and *Rhopalosiphum p.* there are no significant differences (p=0.050108; =0.330520) (a,b)(b,c) but between all other species and approximate probabilities there were significant differences (p=0.000064; =0.021201) (a)(b)(c) (Figure 5).

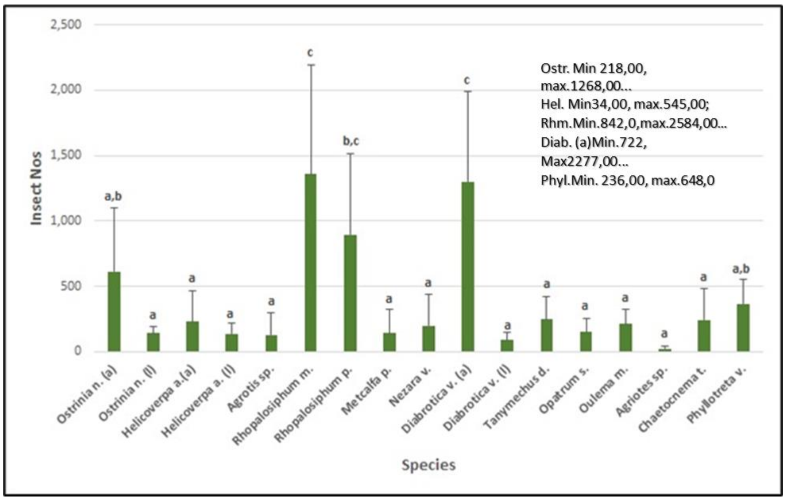

Figure 5. Comparisons between pest species only in Plot 2 with organic corn, regardless of repetitions and year of study

Numerical level of natural enemies in organic corn and their utility

Natural enemies (as benefic organisms) of the organic corn from 2 repetitions (as localities) and study years (2022-2023) differed in total numerical level, so in variants from Sicula/R1 in both years the highest average values were registered (162.733 ind./2022 and 125.533 ind./2023) compared to R2 (Seleus) 93.466 ind./2022 and 82.333 ind./2023. Significant differences existed only between the variants or_sic_R1_2022 and or_sel_R2_2023 and all approximate probabilities (where p=0.031881) (a)(b) while between the variants or_sic_R1_2023 or_sel_R2_2022 and their probabilities there were no statistically significant differences (p=0.056396; =0.742979) (a,b) (Figure 6).

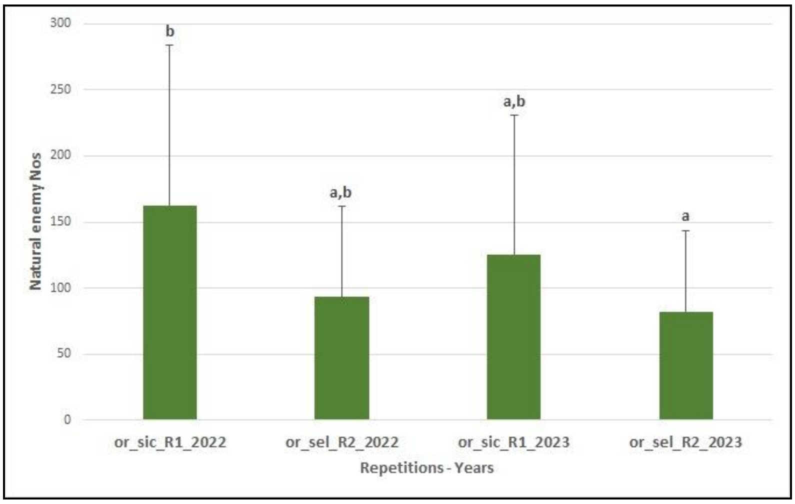

Figure 6. Comparisons of natural enemies in organic corn, between repetitions and years of study without taking into account the species

From total number of species identified in 2022 (15) (Figure 7), we followed the same ones in the following year (2023), having as a comparison the repetition (locality). So, we found predominant species from genera Sphaerophoria (441.5/R1; 249.0/R2), Harmonia (mean of 300.5 ind./R1; 131.5/R2), Lysiphlebus (249.0/R1; 195/R2), Argiope (206.0/R1), Chrysoperla (162/R1) and Coccinella (119.0/R1) with values over 100 ind. All other species had, in 2 repetitions, values lower than 100 ind. It is thus clear that in the locality of Sicula (R1) natural enemies were more frequent than in R2 (Seleus) and this helped us in the studies of interactions between them and pests in term of their usefulness in biological control. There were statistical differences between Trichograma(e) from R2(a), Harmonia (R1)(i), Sphaerophoria (R1)(d) and all approximate probabilities (p=0.000008; =0.049209/p=0.000008; =0.007949/ p=0.000008; =0.000061) while in all other variants and their probabilities there were no significant differences (p=0.051310; =0.987356) (ab)(cd)(gh)(hi)(abc)(cde)(bcd)(efg)(abcd)(def) (fgh) (Figure 7).

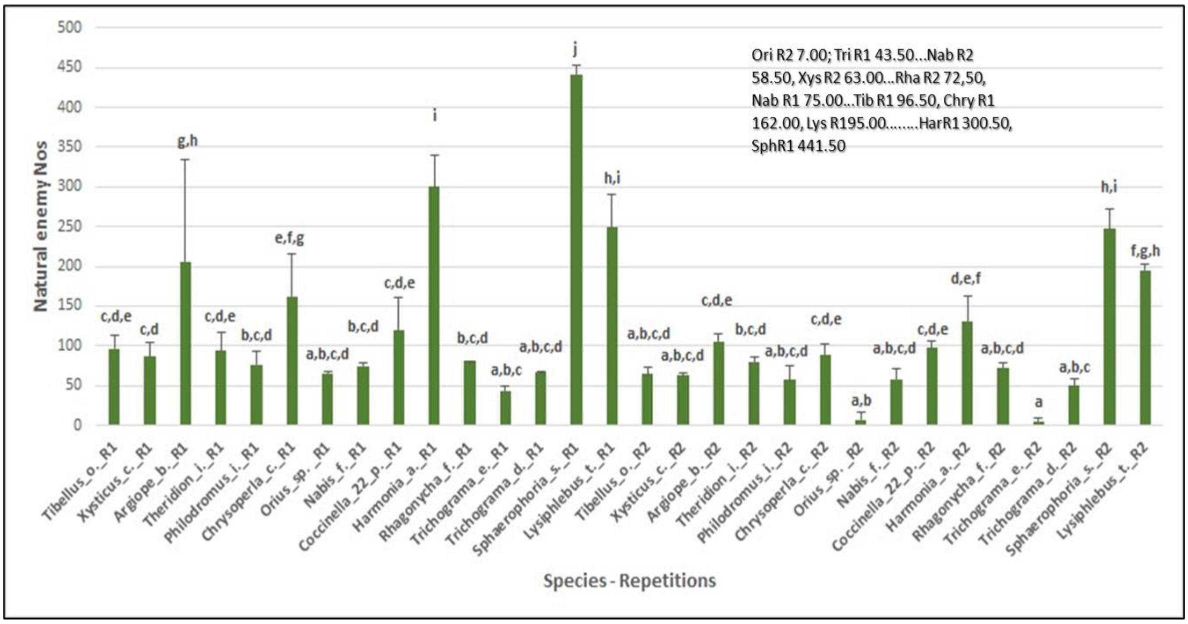

Figure 7. Comparisons between species and repetitions without taking into account the year of study

The natural enemy/pest interaction ratio in 2022, in the organic plots reporting the current numerical level, was a good one of 1:11.9 in Sicula (R1) and good enough with 1:19.94 in Seleus (R2). Regarding interaction ratio in cages, it was 1:10 in both localities with maximum efficiency. The percentage of effectiveness in reducing pests was very good, 45.7% (Table 2).

Table 2. The ratio of natural enemies - pests in the organic plots (Plot2) from 2 repetitions (R1 and R2)

Variant/organic plots (total area of 0.9 ha and cages of 4m^2/plot)		Average of all natural enemies regardless of species	Average of all pests regardless of species	Effectiveness ratio on analyzed area/cage
Plot 2	or_sic_R1_2022	180.5	2161.166	1:11.9
	or_sel_R2_2022	145.44	2900.50	1:19.94
C1+C2*	or_sic_R1_2022	5.0	50.0	1:10.0
C3+C4**	or_sel_R2_2022	5.0	50.0	
			Total ratio/plot	1:15.92
			Total ratio	1:13.94
		Effectiveness percentage in reducing pests 45.7%		

C1+C2* - cages C1 and C2 placed in organic plot from Sicula (or_sic_R1_2022);
C3+C4** - cages C3 and C4 placed in organic plot from Seleus (or_sel_R2_2022).

Evaluation of the efficiency of the application of bio-pesticides

To evaluate the performance of the biopesticides (Bactospeine and Laser), aphids, leaf beetles (chrysomelids) and Ostrinia larvae were considered based on the results with the high frequency of individuals in the plots with organic corn (plot 2).

The results in figure 8 show that the fewest aphids in life were in the version with Bactospeine (on *Bacillus thuringiensis*), high dose, BB(1)-HD (average of 28.2) and the most in the version with Laser, low dose BL(2)-LD (average of 35.4), which means that the higher the dose of bioinsecticide causes the lower the number of live aphids and vice versa. The best product proved to be Bactospeine with the fewest aphids alive after applying the biosolution. Distinct differences were highlighted between all variants and Control where p=0.000820, =0.000143, =0.000065, =0.001656, =0.001044, =0.001008 (a) (Figure 8).

The best variant related to the efficiency of bioinsecticides on crysomelids (in the adult stage) was also the one treated with Bactospeine, in high dose, BB(1)-HD (average of 20.0 live beetles) and the least effective was was the one with BL(2)-LD (24.8) (Figure 9).

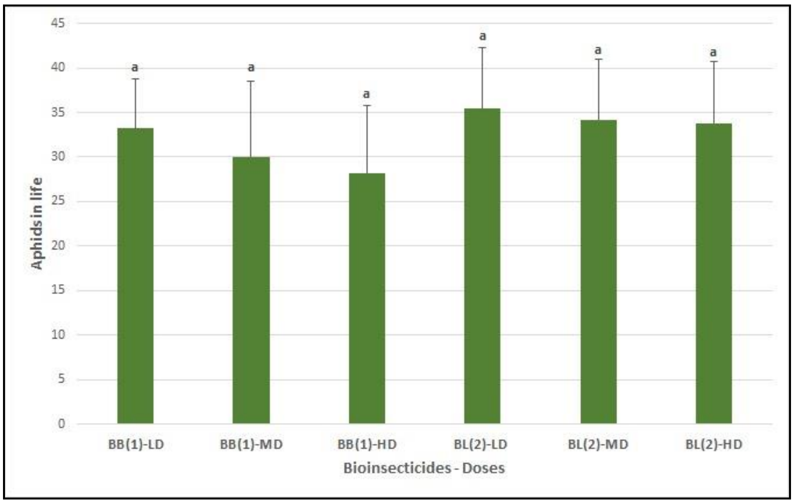

Figure 8. Comparisons of aphids in life in variants with organic corn treated with biopesticides Bactospeine and Laser in different doses (LD-high dose, MD-medium dose and HD-high dose)

Distinctly significant differences were recorded between all variants and the Control where p=0.000329; =0.000031; =0.000026; =0.002922, =0.000591; =0.000390 and between the variants BB(1)-MD and BL(2)-LD (p=0.022883 and between BB(1)-HD and BL(2)-LD and BL(2)-HD (p=0.010914; =0.049727)(a)(c). Among all other variants and approximate probabilities there were no statistically significant differences (ab)(abc)(bc) (Figure 9).

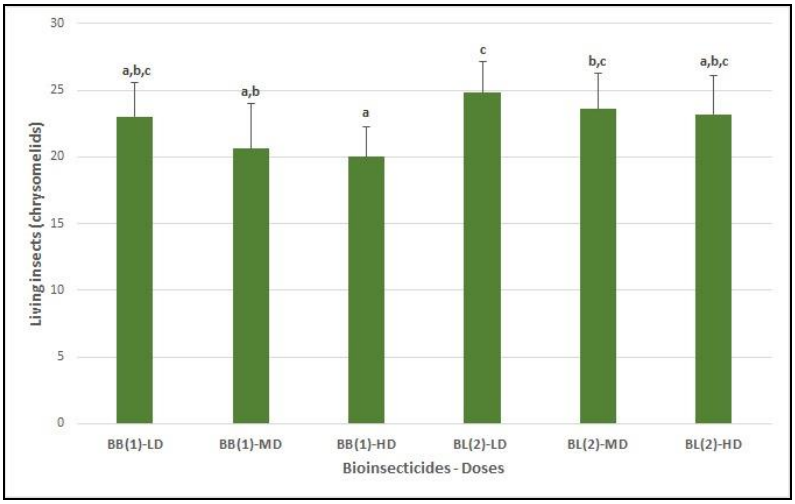

Figure 9. Comparisons of living insects (chrysomelids) in variants with organic corn treated with biopesticides Bactospeine and Laser in different doses (LD-high dose, MD-medium dose and HD-high dose)

The effectiveness of bioinsecticides on Ostrinia larvae was also high in the variant with BB(1)-HD with an average of 11.2 live larvae and less in the variant BL(2)-LD (21.2) (Figure 10).

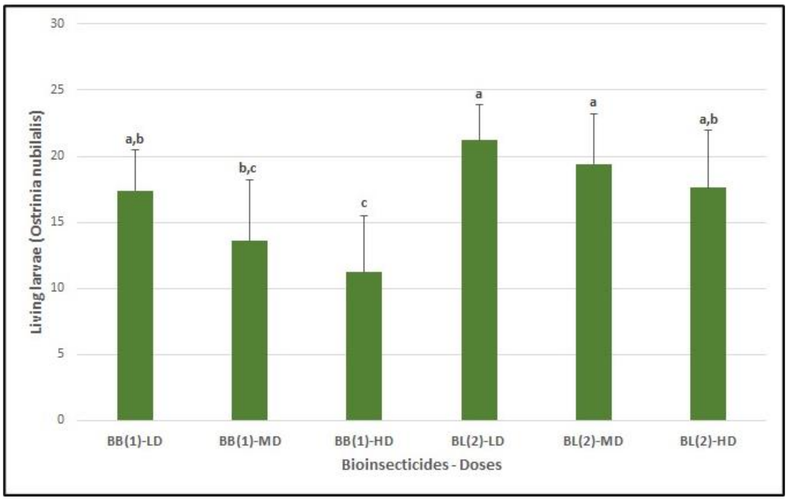

Figure 10. Comparisons of living larvae (*Ostrinia nubilalis*) in variants with organic corn treated with biopesticides Bactospeine and Laser in different doses (LD-high dose, MD-medium dose and HD-high dose)

Between all the treated variants and the Control, the differences were distinct (p=0.000044; =0.000027; =0.000024; =0.000688; =0.000151; =0.000066). Also, between BB(1)-MD variant and the BL(2)-LD (a) and BL (2)-MD (a) variants (p=0.004501; =0.024516) but also between BB(1)-HD (c) and BL (2)-LD (a) or BL(2)-MD (a) (p=0.000362; =0.002357). Between BB(1)-LD (ab) and BL(2)-HD (ab) and all approximate probabilities there were no significant differences (Figure 10). In all cases, through the application of the 2 bioproducts, an efficiency was found expressed by a reduced number of aphids alive at the highest dose of each. The more a product has a higher dose, the more effective it is, just like those found by Malinga and Laing (2022).

CONCLUSIONS

From results, the presence of numerous species of pests is evident, especially in the plots with organic corn, where no pesticides are applied compared to the conventional ones with pesticides. A good thing is that the presence of diversified and abundant natural enemies is high in these organic plots, which ensures a reduction in number of pests (up to 45%) as demonstrated. On the other hand, monitoring traps that attract and catch/kill pests at the same time is another way to control pests. Besides these, the application of bioinsecticides such as those based on *Bacillus thuringiensis* in high doses or in lower doses and repeated spraying can significantly reduce the level of pests in organic and conventional corn crops where all these methods can be applied and in addition the application of synthetic insecticides. The approaches by farmers are essential, in the sense that before the use of pesticides they can exhaust the non-polluting ways listed above and thus environmental pollution will certainly be reduced.

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