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ECOLOGICAL DIVERSITY OF THE EPIGEAL INVERTEBRATE FAUNA FROM AN EXPERIMENTAL BELL PEPPER CROP AT SCDL BUZĂU – ROMANIA

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Abstract

Ecological diversity is an important parameter in assessing the state of an ecological system. This paper presents the results of a study conducted in 2019-2020 on the abundance and ecological diversity of useful and harmful insect communities from an experimental crop of bell pepper organized at the Research-Development Station for Vegetable Growing Buzău. The experiment included five variants in four replications disposed in completed randomized block, untreated, diatomite in three doses (52.5 g, 105 g, 210 g) and Trichoderma asperellum Td85 strain. The diatomite is of autochthonous from the Pătârlagele deposit and the antagonistic fungus Trichoderma from the microorganism collection of the Research and Development Institute for Plant Protection Bucharest. Samples were collected every two weeks by the Barber soil trap method. Data collected in experimental crop of bell pepper under this study revealed a total of 1,455 individuals in 2019 and 1,634 in 2020, respectively, belonging to 124 species, 104 genera, 58 families, 17 orders, 8 classes and 3 phyla. The ecological diversity of present species was estimated using the diversity indexes, Margalef, Menhinick, Shannon-Wiener and Simpson.

Key words*: diatomite, pepper, soil fauna, Trichoderma.*

INTRODUCTION

Bell pepper (*Capsicum annuum* L.), also known as sweet pepper, is one of the most important vegetable crops in Romania cultivated in the field and protected areas, as well. At the level of 2018 the total pepper cultivated area was 18 000 ha with a production of 229 mil kg, which makes to rank Romania 15th in the world (AgroStandard, 2020). Like all vegetables, bell pepper is a valorous natural source of vitamins and minerals good for human health. It is contains fibres, too.

Bell pepper crop is a suitable host for a range of pests and diseases with a severe negative impact on plants and fruits, the most common being aphids (*Aulacorthum solani*, *Macrosiphum euphorbiae*, *Myzus persicae*), tobacco trips (*Thrips tabaci* Lind), two-spotted spider mite (*Tetranychus urticae* Koch), corn earworm (*Helicoverpa armigera* Hbn.), greenhouse whitefly (*Trialeurodes vaporariorum* Westw) *Bemisia tabaci* and the southern green stink bugs (*Nezara viridula*) *Halyomorpha halysand, Pectobacterium* sp., *Alternaria* spp. (Boiu-Sicuia et al, 2017). In context of the current climatic change expressed by high temperatures and deficit of precipitation, the incidence of diseases and pest attack on plants is increasing. Although chemical products are a rapid and effective means, they cause many unwanted side effects such as pest resistance and toxic residues in fruit production. It is therefore highly necessary to find and implement new means of plant protection to replace chemicals as much as possible, being at the same time environmentaly friendly and to ensure stable, sustainable and helthy productions.

The diatomaceous earth and *Trichoderma* species can become good candidates to obtain nontoxic insecticides. As literature reveals the products based on diatomaceous earth and *Trichoderma* have become increasingly used in recent years in ecological and integrated pest management both in the field, protected areas and storehouses (Petrisor et al., 2019).

Diatomaceous earth is an inert dust rich in silicon dioxide present in fresh-water or marine environments as well as in terrestrial ecosystems (Zeni et al., 2021) that kills insects by penetrating their epicuticles. *Trichoderma*

spp. is also present in soil and interact with plants resulting in beneficial effects such as stimulation of plant defence, development of roots, promotion of plant growth (Petrisor et al., 2019).

Epigeal fauna is an important component of the total fauna community and by its diversity plays an essential role in the functioning of the ecosystems. Some of the species have characteristics of bioindicators that offer important information about the quality of environment (Cunha, 2021).

In this study there are presented data on the ecological diversity of the epigeal invertebrate fauna collected in an experimental bell pepper crop conducted in a cropping system with medicinal plants and integrated pest management, that included treatments based on diatomaceous earth and *Trichoderma asperellum*. These data complement those previously published in Florescu et al., 2021.

MATERIALS AND METHODS

Location and area of the study. The experimental bell paper (*Capsicum annuum* L.), was set up in the field of the Vegetable Research and Development Station in Buzău County (S-E Romania). The varieties used were Buzau 10 in 2019 and Cantemir in 2020. Five variants of four replicates each were organized following randomized block method. Area of one replicate was 7mp. Variants consisted of V_1 (untreated), V_2 (52.5 g diatomaceous earth), V_3 (105 g diatomaceous earth), V_4 (210 g diatomaceous earth) and V_5 (bioinoculant *Trichoderma asperellum* Td85 strain). Diatomaceous earth was local product obtained from Pătârlagele deposit (Buzău County) and the antagonistic fungus was provided from the collection of microorganism of the Research and Development Institute for Plant Protection.

Technology and treatments applied. The diatomaceous earth was used as (i) powder applied after planting along the row of pepper plants in June and (ii) dispersion applied on soil and plants in vegetative season in July (Florescu et al., 2021). The pepper plants were accompanied by medicinal plants (marygolds and litchi tomato) produced at the VRDS Buzau.

Insect trapping. The mobile fauna on the soil surface was collected using the soil traps method. We used Barber type traps installed in the soil, four traps in each variant, from June to October each year. A trap consisted of a 400 ml glass jar introduced into the soil with the opening at the ground level. The recipients were filled in a proportion of 50-70% with 4% dish soap solution. The entomophaunistic material was collected every two weeks and conserved in 70% alcohol and analysed in the laboratory. Species identification was performed under stereomicroscop SZ 61 Olympus by the second author of this paper.

Statistical interpretation of data. To estimate the diversity of species we follow two types of diversity indices which are commonly used in ecological studies.

The Margalef and Menhinick species diversity indices include the richness species and total abundance. Margalef index (D_{Mg}) is given by the formula: $D_{Mg}= \frac{S-1}{\text{Ln N}}$, where S is number of species and N is total number of individuals in the sample (Margalef, 1968). Menhinick index (Whittaker, 1977) was calculated using formula: $D_{Mn}=\frac{S}{\sqrt{N}}$.

The Shannon-Wiener and Simpson indexes consider both species richness and species evenness. The formula for Shannon-Wiener diversity index (Shannon & Weaver, 1949) was: $H' = \sum_{i=1}^{R} p_i \, ln \, p_i$, where: p_i is relative abundance of all species. Simpson index was defined as in the formula $D = 1 - \sum_{i=1}^{S} p_i^2$ (Preda, 2020).

RESULTS AND DISCUSSIONS

In this paper it is assessed the diversity of the invertebrates species mobile on the soil surface collected in the experimental pepper crop in which treatments with products based on diatomaceous earth and Trichoderma were applied to improve the status of plants and control pests. The fauna of invertebrates obtained in the present experiment was analysed in terms of taxonomic structure, numerical density and relative abundance as well as ecological parameters and the results were included in a previously reported study (Florescu et al., 2021).

In present paper there are presented the results regarding the diversity of epigeal invertebrate fauna collected in the same experimental pepper crop, following various species diversity indices. The total fauna (pest and useful) of epigeal invertebrates investigated area counted a number of 1,455 individuals in 2019 and 1,634 in 2020 (Figure 1). The invertebrates in 2019 belonged to 117 species distributed in 93 genera, 55 families, 17 orders, 7 classes and 3 phyla and those in 2020 belonged to 124 species distributed in 104 genera, 58 families, 17 orders, 8 classes and 3 phyla.

The annual relative abundances distributed by principal orders is presented in the graph in Figure 2.

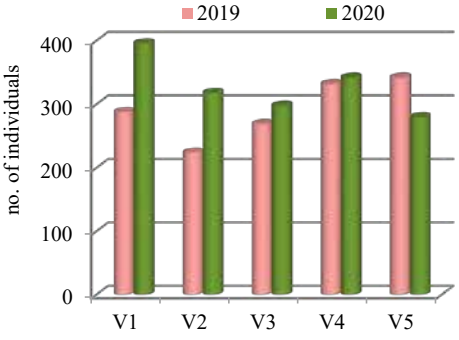

Figure 1. Abundance of total fauna in pepper crop

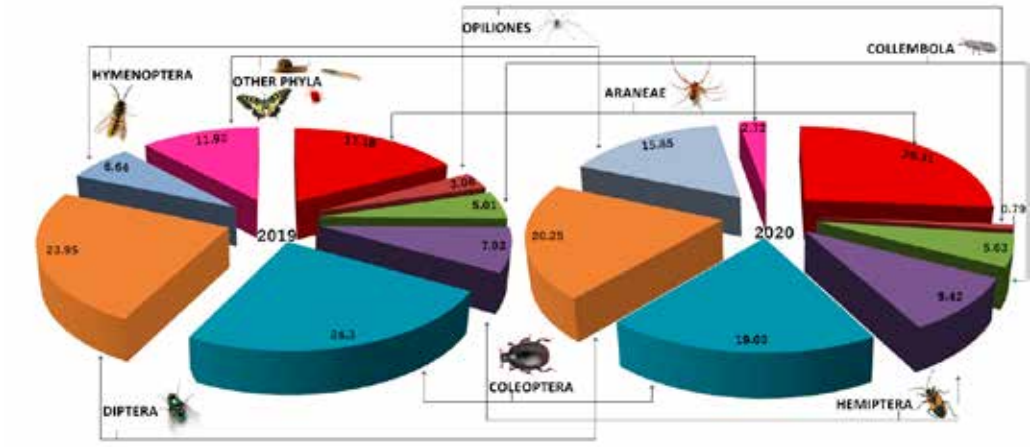

Figure 2. The most abundant order of species in useful and harmful fauna in the years 2019 and 2020

The highest values of relative abundance in 2019 were reached by the species of Coleoptera order (24.3%) followed by Diptera (23.95%) and Aranea (17.18%). In 2020, Aranea was found to be most abundant (26.31%) followed by Diptera (20.25%), Coleoptera (19.03%) and Hymenoptera (15.85%).

The species diversity. Four important indexes measuring ecological diversity of species communities were calculated in this study using excel calculation sheets.

The synthetic data, distinctly on functional groups and treatments, are presented in Tables 1 and 2.

Table 1. Species diversity indices of mobile invertebrate pest fauna in experimental pepper crop

Index values/Year	2019					2020				
	V_1	V_2	V_3	V_4	V_5	V_1	V_2	V_3	V_4	V_5
No of individuals (N)	119	68	60	134	124	84	81	74	94	71
No of species (S)	30	19	13	28	23	16	21	21	18	16
Margalef index (D_{Mg})	6.08	4.28	2.93	5.52	4.56	3.39	4.56	3.70	3.74	2.81
Menhinick index (D_{Mn})	2.75	2.30	1.68	2.42	2.07	1.75	2.33	2.44	1.86	1.90
Shannon-Wiener (H')	2.60	2.28	1.69	2.75	2.49	2.41	2.40	2.34	2.35	2.07
Evenness (E_H)	0.76	0.77	0.66	0.81	0.79	0.87	0.79	0.76	0.81	0.74
Simpson index (D)	0.87	0.83	0.71	0.89	0.87	0.88	0.85	0.83	0.86	0.81
Evenness (E_{1-D})	0.13	0.18	0.31	0.11	0.14	0.13	0.16	0.18	0.15	0.20

Table 2. Species diversity indices of mobile invertebrate useful fauna in experimental pepper crop

Index values /Year	2019					2020				
	V_1	V_2	V_3	V_4	V_5	V_1	V_2	V_3	V_4	V_5
No of individuals (N)	169	156	209	198	218	312	237	224	248	209
No of species (S)	47	40	35	38	39	34	36	44	50	41
Margalef index (D_{Mg})	8.97	7.72	6.37	7.01	7.06	5.75	6.41	7.95	8.89	7.49
Menhinick index D_{Mn})	3.62	3.20	2.42	2.70	2.64	1.92	2.34	2.94	3.18	2.84
Shannon-Wiener (H')	3.04	2.97	2.64	2.73	2.19	2.60	2.52	2.78	2.81	2.36
Evenness (E_H)	0.78	0.80	0.74	0.75	2.59	0.73	0.70	0.73	0.71	0.63
Simpson index (D)	0.90	0.97	0.87	0.97	0.89	0.84	0.84	0.98	0.99	0.99
Evenness (E_{1-D})	0.10	0.03	0.13	0.03	0.11	0.16	0.16	0.02	0.01	0.01

The number of individuals and richness of species differed both between functional groups, pest and useful fauna, but also between treatments. The highest values were in pest fauna in both year of observation. The highest total number of species was found in untreated variant (77 species) in 2019 and in 210 g diatomaceous earth treatment (68 species) in 2020, while the lowest was found in 105 g diatomaceous earth variant (48 species) in 2019 and untreated variant (50 species) in 2020. No relation was observed between number of species and increased number of individuals among the treatments.

The Margalef richnness index (D_{Mg}) whose calculation was based on the number of species and abundance showed the highest values. At the experiment level, the values of this index were higher for useful fauna than for pest fauna in the 2-year study and higher in 2019 than in 2020 in both functional categories, between 5.75 and 8.98 and between 2.93 and 6.08 respectively. Among treatments, the values of D_{Mg} lower than 3 were found in 2019 in variants corresponding to 105 g diatomaceous earth and bioinoculant *Trichoderma asperellum* and lower than 6 were found in 105 g diatomaceous earth and untreated variants.

The Menhinick index which depend as the Margalef index on the species richness in connection to number of specimens, showed values with similar fluctuations.

The Shannon-Wiener diversity index is the most used to estimate the diversity of a community of species (plants or animals) at the level of ecological systems in a specific area or habitat. This index depends on both species richness and the uniformity of species distribution in the total number of individuals in the sample. The values of Shannon-Wiener index increases with the number of species and evenness. Therefore, the communities with a large number of species that are uniform distributed are the most diverse (Spellerberg, 2003). In present study, the Shannon-Wiener index expressed a good diversity of the invertebrate epigeal fauna in a stable state in crop variants in both years, ranging in 2019 from 1.69 to 2.75 for pest fauna and from 2.07 to 2.42 for useful fauna, and in 2020 from 2.19 to 3.04 for pest fauna and from 2.36 to 2.81 for useful fauna. The presented values of Shannon-Wiener diversity index may suggest that the interventions with diatomaceous earth and fungus inoculant in experimental pepper crop don't seem to affect the community of epigeal invertebrates.

The Simpson diversity index presented high values in the present study, from 0.71 to 0.97 in 2019 and from 0.81 to 0.99 in 2020 revealing a good quality of species diversity in the epigeal fauna present in experimented pepper crop.

CONCLUSIONS

The present study represent an important step in the examination and estimation of the ecological diversity of epigeal invertebrates in pepper crop.

The values of the species diversity indices based on the species richness relative to number of specimens as well as on the species richness and the uniformity of species distribution in the total number of individuals in the sample, suggest that diversity of epigeal invertebrates in pepper crop in not affected by treatments with diatomaceous earth and fungus inoculant used experimentally in pepper crop.

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