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THE IMPACT OF VARIOUS PEST CONTROL OPTIONS ON ARTHROPOD STRUCTURE AND DIVERSITY IN SWEET POTATO AGRO-ECOSYSTEM IN THE CONDITIONS OF SANDY SOILS FROM SOUTHERN ROMANIA

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Abstract

The paper aimed to evaluate the influence of three different pest control options (chemical, biological and a combination of them) on epigeic fauna diversity in the conditions of sandy soils from southern Romania in two succesive years (2021-2022), through the analysis of biological material resulting from the collection of samples in pitfall traps and direct observations at the foliage level. The arthropod fauna was represented by 69 species belonging to a number of 26 families and 13 taxonomic orders: Acarina, Araneae, Collembolla and the insect orders Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Neuroptera, Orthoptera and Thysanoptera. The composition of the fauna spectrum were dominated by Collembolla species in 2021 and Coleoptera species in 2022. The highest richness of species and values of Shannon-Wiener and Simpson diversity index were found in treatments with biological control either alone or in combination.

Key words*: arthropod structure, arthropod diversity, sweet potato, Southern Romania.*

INTRODUCTION

According to FAOSTAT (FAO, 2020) sweet potato (*Ipomoea batatas* L.) was ranked the fifth most important food crop worldwide after maize, rice, wheat and cassava. Sweet potatoes are more tolerant than other major crops to climate shocks and stresses, are fairly drought-tolerant, and do not need lots of organic matter or soils with high fertility levels. The sweet potato adaptability to all these factors, have aroused the interest for the introduction to culture on the sandy soil of the Dabuleni area from southern Romania (Diaconu et al., 2017), the researchers from Research and Development Station for Plant Culture on Sands Dabuleni (R.D.S.P.C.S.D. Dabuleni), Romania recently finalizing the culture technology, available now for local producers (Diaconu et al., 2018).

Crop monitoring for maintenance of crop health is essential to ensure high yield and quality of the sweet potato crops. Arthropod surveillance is mandatory in order to identify the spectrum of the species that can cause damage during vegetation period (Iamandei et al., 2014). On the other hand, soil arthropods might be affected by various management practices and play a relevant role as bioindicators of agroecosystem soil quality and health (Menta & Remelli, 2020). The study aim was to establish the arthropods fauna structure in sweet potato crop and to evaluate the influence of three different pest control interventions on epigeic fauna diversity in the conditions of sandy soils from southern Romania.

MATERIALS AND METHODS

The research was conducted in the experimental area of R.D.S.P.C.S.D. Dabuleni (N 43.80700, E 024.05516) in 2021 and 2022 sweet potato growing seasons. The experimental area was located on a typicallty sandy soil, with low fertility, protected with PE mulch, and set-up according to the method of subdivided plots. The crops preceding the sweet potato trial plots were: Sorghum

(*Sorghum bicolor* (L.) Moench) in 2021 and cowpea (*Vignia unguiculata* (L.) Walp) in 2022.

The surface of one treatment plot was 36 m.p. The sweet potato shoots, KSP1 variety, also obtained at S.C.D.C.P.N. Dabuleni greenhouse, were planted in field on last decade of May each year. The experimental treatments are described in Table 1.

Table 1. Experimental treatments used on sweet potato crop at R.D.S.P.C.S.D. Dabuleni in 2021 and 2022

Treatment number	Treatment description		
1	chemical treatment	chemical products, applied in vegetation	Cabrio top + Calypso 480 SC
2	biological treatment	biological insecticide and fungicide, applied at the soil preparation right before crop set-up in the field	Bio-insecticide based on *Metarhizium anisopliae* applied to the soil in a dose of 2.5 g/plant and incorporated immediately and granular product based on *Bacillus subtilis* - strain Dj3
3	complex treatment	mixed biological insect-fungicide + chemical in vegetation	Combination of treatment 2 + 1

The evaluation of the arthropod fauna present in the experimental plots organized at S.C.D.C.P.N Dăbuleni was carried out through the analysis of biological material resulting from the collection of samples in pitfall traps and direct observations at the foliage level. The soil fauna was monitored from May to August each year, using pitfall traps with formalin 4% as preservative solution. One pitfall trap per treatment plot was installed on the space between rows, left in the field for 7 days per months and afterwards the samples were transferred to Research and Development Institute for Plant Protection, Bucharest (R.D.I.P.P., Bucharest) entomology laboratory, where the collected material was washed and all the specimens where preserved in alcohol 70% for further analysis. Also, field observations of the arthropod populations were conducted at 4 week intervals when adults and larvae were counted on 100 sweet potato leaves per treatment. The specimens easily identified were left in the field and the rest were transferred to the R.D.I.P.P. entomology laboratory. The collected material was preserved in alcohol or dry and further processing of the samples consisted of sorting and identification of the arthropod fauna at the level of taxonomic group, family, genus or species. Data were tabulated and identified genera/species were listed. Total abundance and relative frequency were calculated for each sampling method in order to analyse the effects of the variants on arthropod faunal communities, for every year and overall experiment. Shannon-Wiener and Simpson diversity indices were calculated to interpret the results obtained in the edaphic entomofauna collection. Graphical representations and determination of diversity indices were performed using the Past 4.03 application (Hammer, 2018).

RESULTS AND DISCUSSIONS

The fauna of arthropods collected or identified by both methods in the experimental variants organized at S.C.D.C.P.N. Dăbuleni in 2021-2022 at the sweet potato crop was represented by 69 species belonging to a number of 26 families and 13 taxonomic orders: *Acarina, Araneae, Collembolla* and the insect orders *Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Neuroptera, Orthoptera and Thysanoptera* (Table 2). Sweet potato crops can be affected by over 270 species of pest insect's worldwide (Amalin and Vasquez, 1993). Previous data obtained in the Dabuleni area noticed the presence of 14 pest species out of fifty one identified in sweet potato crop (Iamandei et al., 2014).

The results of the arthropods monitoring in the experimental variants organized at S.C.D.C.P.N. Dăbuleni in 2021 shows a total of 48 species, 26 collected in pitfall traps and 26 observed directly on plant. Predators species were generally prevalent in visual observation (Table 2).

Table 2. The general structure of the arthropod species collected in the experimental treatments organized at S.C.D.C.P.N. Dabuleni in the years 2021-2022 to the sweet potato crops

	Taxonomic group/Order: Family	Species	2021		2022	
			Pitfal trap	Visual obser-vation	Pitfal trap	Visual obser-vation
1	*Acarina/ Trombidiformes Tetranychidae*	*Tetranychus urticae* Koch, 1836	+	+	-	+
2	*Araneae Lycosidae*	*Pardosa amentata* (Clerck, 1757)	+	+	-	+
3		*Alopecosa* sp.	-	+	-	+
4	*Collembola Entomobryidae*	*Entomobryia arborea* (Tulberg, 1871)	+	-	+	-
5		*Lepidocyrtus* sp.	-	-	+	-
6	*Collembolla Bourletiellidae*	*Bourletiella arvalis* (A.Fitch, 1863)	+	-	+	-
7	*Collembolla Sminthuridae*	*Sminthurus viridis* (Linnaeus, 1758)	+	-	+	-
8	*Hemiptera Aphididae*	*Aphis gossypi* (Glover, 1877)	-	+	-	+
9		*Aphis* sp.	-	-	-	+
10		*Aulacorthum solani* (Kaltenbach, 1843)	-	-	-	+
11		*Macrosiphum euphorbiae* (Thomas, 1878)	-	-	-	+
12	*Hemiptera Pyrrhocoridae*	*Pyrrhocoris* sp.	-	-	+	-
13	*Hemiptera Aleyrodidae*	*Trialeurodes vaporariorum* (Westwood, 1856)	-	+	-	+
14	*Hemiptera Anthocoridae*	*Anthocoris nemorum* (Linnaeus, 1761)	-	+	-	+
15		*Orius* sp.	-	-	-	+
16	*Hemiptera Pentatomidae*	*Nezara viridula* (Linnaeus, 1758)	-	+	-	+
17	*Thisanoptera Thripidae*	*Frankliniella occidentalis* (Pergande, 1895)	+	+	+	+
18	*Ortoptera Acrididae*	*Acrida hungarica* (*Herbst, 1786)*	-	+	-	+
19		*Calliptamus italicus* (Linnaeus, 1758)	-	+	-	+
20	*Dermaptera Forficulidae*	*Forficula auricularia* (Linnaeus, 1758)	+	-	+	-
21	*Mantodea Mantidae*	*Mantis religiosa* (Linnaeus, 1758)	-	+	-	+
22	*Coleoptera Chrysomelidae*	*Chaetocnema* sp.	+	+	-	+
23		*Phyllotreta atra* (Fabricius, 1775)	+	-	+	-
24		*Phyllotreta nemorum* (Linnaeus, 1758)	+	-	+	-
25	*Coleoptera Coccinellidae*	*Adalia bipunctata* (Linnaeus, 1758)	-	+	-	+
26		*Hippodamia variegata* (Goeze, 1777)	-	+	-	+
27		*Coccinella septempunctata* (Linnaeus, 1758)	-	+	+	+
28		*Coccinella quinquepunctata* (Linnaeus, 1758)	-	-	+	-
29		*Harmonia axyridis* (Pallas, 1773)	-	+	-	+
30		*Scymnus* sp.	-	-	-	+
31	*Coleoptera Anthicidae*	*Notoxus monoceros* (Linnaeus, 1760)	+	-	+	+
32		*Notoxus brachycerus* (Faldermann, 1837)	-	-	+	-
33	*Coleoptera Carabidae*	*Bembidion quadrimaculatum* (Linnaeus, 1760)	-	-	+	-
34		*Harpalus azureus* (Fabricius, 1775)	-	-	+	-
35		*Harpalus calceatus* (Duftschmid, 1812)	+	-	+	+

	Taxonomic group/Order: Family	Species	2021		2022	
			Pitfal trap	Visual obser-vation	Pitfal trap	Visual obser-vation
36		*Harpalus pubescens* (O.F.Müller, 1776)	-	-	+	-
37		*Harpalus tardus* (Panzer, 1796)	-	-	+	-
38		*Scarites terricola* (Bonelli, 1813)	-	-	+	-
39	*Coleoptera Curculionidae*	*Tychius* sp.	-	-	+	-
40	*Coleoptera Cryptophagidae*	*Cryptophagus* sp	-	-	+	-
41	*Coleoptera Elateridae*	*Agriotes obscurus* (Linnaeus, 1758)	-	+	-	+
42		*Drasterius bimaculatus* (Rossi, 1790)	+	-	+	-
43	*Coleoptera Latridiidae*	*Corticarina* sp.	+	-	+	-
44		*Latridius* sp.	-	-	-	+
45	*Coleoptera Scarabaeidae*	*Scarabaeus typhon* (Olivier, 1789)	+	-	-	+
46		*Scarabaeus* sp.	-	-	+	-
47		*Anomala vitis* (Fabricius, 1775)	-	-	+	+
48		*Pentodon idiota* (Herbst, 1789)	-	-	-	+
49		*Anoxia villosa* (Fabricius, 1781)	-	+	-	-
50	*Coleoptera Tenebrionidae*	*Blaps lethifera* (Marsham, 1802)	-	-	+	-
51		*Pedinus femoralis* (Linnaeus, 1767)	+	-	-	+
52	*Coleoptera Staphylinidae*	*Atheta myrmecobia* (Kraatz, 1856)	+	-	+	+
53	*Neuroptera Chrysopidae*	*Chrysoperla carnea* (Stephens, 1836)	-	+	-	+
54	*Hymenoptera Ichneumonidae*	*Ichneumon formosus* (Gravenhorst, 1829)	+	-	+	-
55	*Hymenoptera Formicidae*	*Formica fusca* (Linnaeus, 1758)	+	-	+	-
56		*Formica rufa* (Linnaeus, 1761)	+	-	+	-
57		*Myrmica rubra* (Linnaeus, 1758)	+	-	+	-
58	*Lepidoptera Sphingidae*	*Agrius convolvuli* (Linnaeus, 1758) adult	-	+	-	+
		Agrius convolvuli (Linnaeus, 1758) larvae	-	+	-	+
59	*Lepidoptera Noctuidae*	*Helicoverpa armigera* (Hübner, 1808) adult	-	+	-	+
		Helicoverpa armigera (Hübner, 1808) larvae	-	+	-	+
60		*Spodoptera exigua* (Hübner, 1808) adult	-	+	-	+
		Spodoptera exigua (Hübner, 1808) larva	-	-	-	+
61		*Hadena syriaca* (Osthelder, 1933) adult	-	+	-	+
62		*Autographa gamma* (Linnaeus, 1758) adult	-	-	-	+
63	*Lepidoptera Pyralidae*	*Loxostege sticticalis* (Linnaeus, 1761) adult	-	-	-	+
64	*Diptera Syrphidae*	*Episyrphus balteatus* (De Geer, 1776)	-	+	-	+
65	*Diptera Chloropidae*	*Elachiptera cornuta* (Fallén, 1820)	+	-	-	-
66		*Chlorops pumilionis* (Bjerkander, 1778)	+	-	-	-
67	*Diptera – Muscidae*	*Stomoxys calcitrans* (Linnaeus, 1758)	+	-	+	-
68		*Musca domestica* (De Geer, 1776)	+	-	+	-
69	*Diptera Sciaridae*	*Sciara analis* (Schiner, 1863)	+	-	-	-

Legend: "+" - present in samples; "-" absent in samples

Four species of aphids (*Aphis gossypii, Aulacorthum solani, Macrosiphum euphorbae* and *Aphis* sp.), one species of thrips (*Frankliniella occidentalis*) as well as whitefly, known vectors of sweetpotato blight, were observed on the crop foliage. During the course of the observations made at the foliage level, on leaves where there were colonies in the early stages of these vectors, the presence of a large number of beneficial species was noted.

The most frequent species were *Coccinella septempunctata, Adonia variegata, Adalia bipunctata, Harmonia axyridis* and the larvae of *Episyrphus balteatus* followed by spider mite species of the family *Lycosidae*. Also very abundant in the untreated version were the predatory bugs *Orius* sp. and *Anthocoris nemorum* (*Hemiptera: Anthocoridae*).

The use of the pitfall trap method allowed the capture of a large number of individuals of *Hymenoptera Formicidae* species and the identification of the predators *Atheta myrmecobia and Harpalus calceatus*. These species are between the main antagonists of aphids in the study area, contributing to the protection of sweet potato crops against viral diseases (Iamandei et al., 2014). A number of foliage pests such as *Chaetocnema* sp*., Notoxus monocerus and Tetranychus urticae* were also identified using Barber traps. Butterflies of the species *Hadena syriaca, Spodoptera exigua and Helicoverpa armigera* (*Noctuidae*) and the specific pest *Agrius convolvuli*, whose larvae were present on the foliage, were also captured and subsequently identified, with sporadic presence noted during direct observations.

The results of the arthropods monitoring in the experimental variants organized at S.C.D.C.P.N. Dăbuleni in 2022 shows a total of 65 species, 33 collected in pitfall traps and 41 observed directly on plant. The same four species of aphids (*Aphis gossypii, Aulacorthum solani, Macrosiphum euphorbiae* and *Aphis* sp.), *Frankliniella occidentalis* as well as whitefly, known vectors of sweetpotato blight, were noticed in 2022. During the observations made at foliage level, a large number of specimens of useful fauna species were observed on leaves where colonies of these species were present. The most frequent species were *Coccinella septempunctata, Adonia variegata, Adalia bipunctata, Harmonia axyridis*, and the larvae of *Episyrphus balteatus* followed by spider species of the family *Lycosidae*. The species *C. quincvepunctata* and *Scymnus* sp. were noticed for the first time in 2022 monitoring. Also very abundant in the biological treatment variant were the predatory bugs *Orius* sp. and *Anthocoris nemorum* (*Hemiptera:Anthocoridae*) but other predators such as *Mantis religiosa, Chrysoperla carnea* and the staphylinid *Atheta myrmecobia* were also recorded.

The noctuid species *Hadena syriaca, Spodoptera exigua, Autographa gamma and Helicoverpa armigera* were captured and during the first decade of August an intense flight of the species *Loxostege sticticalis* was recorded. As for the specific pest *Agrius convolvuli*, their larvae were present on the foliage, with sporadic presence noted during direct observations. The use of the pitfall trap method allowed the capture of a large number of individuals of *Hymenoptera Formicidae* species and the identification of predators of *Atheta myrmecobia* species and a number of 6 carabid species *which,* together with coccinellids and neuroptera, are the main aphid antagonists in the study area, indirectly contributing to the protection of sweet potato crops against viral diseases. A number of foliage pests such as *Chaetocnema* sp*., Notoxus monocerus, N. brachycerus and Tetranychus urticae* were also identified using pitfall traps.

Regarding the prevalence of epigean fauna identified from pitfall trap material, in 2021, the highest numerical abundance was recorded by *Collembolla*, followed by *Acarina* and *Coleoptera* (Figure 1 and Table 3). The abundance of species was higher in both variants with biological treatments. Also, the highest value of the Shannon-Wiener diversity index was recorded in treatment 3 (1.817), followed by treatment 2 (1.795), while the lowest in treatment 1 (1.55). The same trend was also recorded for the Simpson index, the highest value in treatment 3 (0.7996), followed by treatment 2 (0.7637), while the lowest in treatment 1 (0.7313). In the year 2022, the highest numerical abundance was recorded by *Coleoptera*, followed by *Hemiptera* and *Collembolla* (Figure 2 and Table 3).

Table 3. The abundance and diversity of the taxonomic groups collected using soil traps in the three treatment options organized at S.C.D.C.P.N. Dabuleni in the years 2021-2022 to the sweet potato crops

	V1		V2		V3		Total 2021		V1		V2		V3		Total 2022	
	A	F %	A	F %	A	F %	A	F %	A	F%	A	F%	A	F%	A	F%
Acarina	30	38.9	6	6.7	26	30.2	62	24.5	0	0	0	0	0	0	0	0
Araneae	2	2.60	7	7.8	5	5.8	14	5.53	3	9	9	18	3	6.38	15	11.5
Hemiptera	1	1.30	5	5.6	8	9.3	14	5.53	2	6	7	14	12	34.0	25	19.2
Dermaptera	1	1.30	5	5.6	2	2.3	8	3.16	1	3	3	6	0	0	4	3.1
Coleoptera	21	27.3	12	13.3	18	20.9	51	20.2	18	54	15	30	22	46.8	55	42.3
Hymenoptera	0	0.00	7	7.8	1	1.2	8	3.16	0		3	0	1	2.13	4	3.08
Orthoptera	2	2.60	1	1.1	1	1.2	4	1.58	1	3	1	6	0	0	3	2.31
Diptera	4	5.19	8	8.9	5	5.8	17	6.72	0	0	2	2	1	2.13	2	1.54
Thysanoptera	1	1.30	0	0.00	1	1.2	2	0.79	0	0	0	0	1	2.13	1	0.77
Collembola	15	19.5	39	43.33	19	22.1	73	28.8	8	24	10	4	3	6.38	21	16.15
Total	77	100	90	100	86	100	253	100	33	100	50	20	47	100	130	100
Shannon–Wiener index	1.553		1.795		1.817		1.85		0.342		0.544		0.4234		0.7707	
Simpson index	0.7313		0.7637		0.7996		0.8031		2.854		5.724		3.0280		3.963	
Species richness	20		24		22		**26**		21		30		27		**33**	

A-Abundance; F- relative frequency

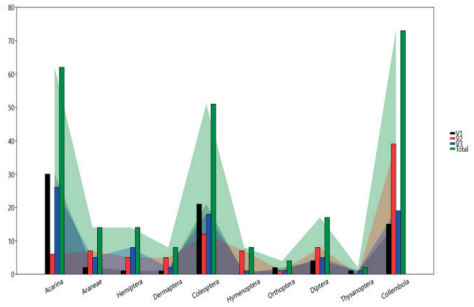

Figure 1. Abundance of epigean arthropod groups collected using soil traps in the three pest control options for sweet potato in 2021

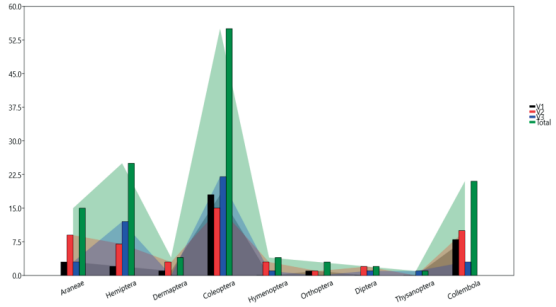

Figure 2. Abundance of epigean arthropod groups collected using soil traps in the three pest control options for sweet potato in 2022

In 2022, the abundance of epigeic species was higher in both variants with biological treatments. Also, the highest value of the Shannon-Wiener diversity index was recorded in variant 2 (0.5439), followed by variant 3 (0.42338), while the lowest in variant 1 (0.3414).

The same trend was also recorded for the Simpson index, with the highest value recorded in variant 2 (5.724), followed by variant 3 (3.028) and the lowest in variant 1 (2.854).

The species richness's was higher in treatments with biological control of the pest in both years of research.

Of the epigean invertebrates, *Coleoptera, Collembolla, Hemiptera* and *Aranea* were eudominant in all treatments, both years.

CONCLUSIONS

In the experimental conditions of 2021 and 2022, the diversity of arthropod species identified in the sweet potato crop in the experimental fields of S.C.D.C.P.N. Dăbuleni was represented by 69 species belonging to a number of 26 families and 13 taxonomic order.

In term of abundance, the composition of the sweet potato pest spectrum was dominated by coleopteran, with the genus *Notoxus* and *Drasterius bimaculatus* having the highest catches.

Damage caused by these pests can be significant in some years, and their aggregate presence can create a dangerous situation with undesirable effects in terms of yield and quality. Overall, data analysis showed that the incidence of crop-specific pest attack was sporadic, dangerous pests such as white grubs, wireworms, codling moth larvae and *A. convolvuli* had low numerical abundances.

The useful fauna has favorable activity conditions, successfully keeping the sweetpotato's virus-transmitting species under control. The presence of predator species from particular groups such as *Araneae, Carabidae, Coccinelidae, Chrysopidae, Syrphidae*, *Mantidae* and *Araneae* indicated the ecological balance, quality and sustainability of the variants consisting of biological treatments.

The three types of pest control interventions influenced structural biodiversity indices such as soil fauna abundance, specific arthropod richness and diversity in the batat crop during the 2021 and 2022 growing seasons and sandy soil conditions in Dabuleni.

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