COMPARATIVE STUDY OF CARABID BEETLES (CARABIDAE), CHILOPODS (CHILOPODA), TERRICOL PESTS AND SOIL-DWELLING MICROARTHROPOD ASSEMBLAGES ON MULCHED AND UNMULCHED POTATO PLOTS

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1 Introduction

The use of organic mulch in potato is often considered beneficial, as organic mulch improves the quantity (BHULLAR et al. 2015) and quality (DVOŘÁK et al. 2012) of yield, may provide shelter for the natural enemies of pests (BRUST et al. 2003), and may reduce the number of individuals of a major pest, the Colorado potato beetle (*Leptinotarsa decemlineata* Say) (DVOŘÁK et al. 2013).

Carabids are potentially of high value in pest control, since most species are either predators or omnivores (HENGEVELD 1980). Members of the order Chilopoda are predators as well (MINELLI 2011). Soil-dwelling organisms play an important role in making nutrients available within the soil, and they may enhance soil structure as well. When the soil is rich in living organisms, soil fertility increases. Human intervention, also called cultural intervention may make the conditions within the soil more suitable for these beneficial organisms (KEMENESY 1972).

1.1 Objectives

Relying on Barber pitfall traps and EDAPHOLOG® soil monitoring system and soil sampling, the basic aim of my study was to analyse the effect of hay and leaf litter mulch on certain arthropod taxa in home gardens. I wished to examine the influence of organic mulch on crop protection and production issues when home-grown potato is mulched with easily available organic mulching material. I wanted to shed light on the potential benefits and risks of mulching in the home garden environment.

My most important areas of interests were:

- What influence, if any at all, may hay and leaf litter mulch have on the spatial distribution of click beetles and of certain predators, namely carabid beetles and chilopods?
- What is the effect of hay mulch on potential prey items (microarthropods) of predators?
- Is there a difference among the species diversity of different microhabitats of the different soil surface treatments, namely barren soil and soil covered with hay mulch or with leaf litter?
- Do the dominant click beetle and carabid adults or chilopods show a preference towards any of the different microhabitats?
- Will the presence of hay and leaf litter mulch increase the frequency of rare species when compared to non-mulched plots?
- Which method is more suitable to measure the spatial distribution of microarthropods: soil sampling or soil probes?
- Will the presence of hay increase the number of individuals in the case of microarthropods when compared to non-mulched plots?
- What are the effects of leaf litter and hay mulch on potato yield? What effects do leaf litter and hay mulch have on the bore damage done by click beetle and hole damage by noctuid larvae or white grubs?

2 Materials and methods

2.1 Study locations and experimental design

Study location:

Foreword: as my research is closely related to the studies of Gergely Ambrus, working on his PhD thesis on the comparison of spider assemblages of mulched and non-mulched potato plots, our study locations are at least partly were the same. Our study areas belonged to seven locations of the following six settlements (Table 1).

I. Locations under the management of Gergely Ambrus. District: Rákoscsaba (town: Budapest, county: Pest); District Blaha, and the Experimental Station of the Szent István University (town: Gödöllő, county: Pest), the outskirts of Isaszeg (town: Isaszeg, county: Pest); a homestead in Nagyecsér (town: Mezőnagymihály, county: Borsod-Abaúj Zemplén). Sampling methods: Barber pitfall traps.

II. Locations under my management: Budaörs (county: Pest); Hidegkút (county: Veszprém). Sampling methods: between 2011 and 2013: Barber pitfall traps, while between 2014 and 2015: EDAPHOLOG® soil monitoring system and soil sampling.

Experimental design:

There were three treatments in four repetitions between 2011 and 2013 on locations Budaörs and Hidegkút with a total of 12 plots each measuring 3 x 4 m (Figures 1 and 2). The evaluation of tuber damage was based on the visual examination of harvested potato in the fall.

For 2014 and 2015 I only had one location left: Hidegkút (county: Veszprém). Potato was either mulched with hay or left non-mulched during these seasons. There were 6 plots of each treatment according the design described above.

Table 1 Detailed description of locations used in the study

Study year	Study location	Budapest (Rákoscsaba)	Budaörs	Gödöllő (District of Blaha)	Gödöllő (SZIE Experimental Station)	Hidegkút	Isaszeg	Nagyecsér
	Forecrop	Various horticultural crops	Grassland	Various horticultural crops	Potato, sunflower	Grassland	Grassland	Grassland
	Soil type	Brown forest soil with clay illuviations	Ramann brown forest soil	Ramann brown forest soil	Brown forest soil with clay illuviations	Ramann brown forest soil	Brown forest soil with clay illuviations	Steppe meadow soil and meadow solonetz
2011	Number of treatments	0	3	0	0	3	0	0
	Number of repetitions	0	4	0	0	4	0	0
	Number of plots × plot size	0	12 × 12 m²	0	0	12 × 12 m²	0	0
	Number of traps per plot	0	2	0	0	2	0	0
	Collected arthropod taxa	0	Carabid beetles, click beetles, chilopods	0	0	Carabid beetles, click beetles, chilopods	0	0
2012	Number of treatments	2	3	2	2	3	2	2
	Number of repetitions	1	4	1	1	4	1	1
	Number of plots × plot size	2 × 48 m²	12 × 12 m²	2 × 240 m²	2 × 132 m²	12 × 12 m²	2 × 28 m²	2 × 60 m²
	Number of traps per plot	5	2	9	7	2	4	6
	Collected arthropod taxa	Chilopods	Carabid beetles, click beetles, chilopods	Chilopods	Chilopods	Carabid beetles, click beetles, chilopod	Chilopods	Chilopods
2013	Number of treatments	0	3	2	2	3	2	2
	Number of repetitions	0	4	1	1	4	1	1
	Number of plots × plot size	0	12 × 12 m²	2 × 240 m²	2 ×132 m²	12×12 m²	2 × 28 m²	2 × 12 m²
	Number of traps per plot	0	2	9	7	2	4	4
	Collected arthropod taxa	0	Carabid beetles, click beetles, chilopods	Chilopods	Chilopods	Carabid beetles, click beetles, chilopod	Chilopods	Chilopods
2014-2015	Number of treatments	0	0	0	0	2	0	0
	Number of repetitions	0	0	0	0	6	0	0
	Number of plots × plot size	0	0	0	0	12 × 12 m²	0	0
	Number of traps per plot	0	0	0	0	1	0	0
	Number of soil samples per plot	0	0	0	0	2	0	0
	Collected arthropod taxa	0	0	0	0	microarthropods	0	0

2.2 Statistical analysis

Data were evaluated with one-way analysis of variance, Tukey post hoc test; Kruskal-Wallis probe with pairwise Mann-Whitney comparison with or without Bonferroni correction; principal component analysis (PCS); and paired t-tests. Data were obtained by using the following software items: R 3.4.4 (R CORE TEAM 2015), a Past3 (Paleontological Statistics Version 3.16 2017) and SPSS Statistics 20 2016. The log (x+1) transformation of the raw number of individuals was carried out and data were managed by using Microsoft Excel® software.

For statistical analysis, the total yearly capture of one plot of one location was considered a repetition. For the combined analysis of the total capture of locations Budaörs and Hidegkút, this implied 12 repetitions per macroarthropods (click beetles, carabid beetles and chilopods - there were 2 locations multiplied by 3 years multiplied by 4 plots per treatment; and microarthropods as well – there were 1 location multiplied by 2 years multiplied by 6 plots per treatment. In the case of locations managed by Gergely Ambrus, the number of repetitions was 9, with 4 locations multiplied by 2 years multiplied by 1 plot per treatment + 1 location multiplied by 1 year multiplied by 1 plot per treatment).

To compare the effect of treatments on the species diversity of carabid beetles I used the Rényi entropy function that is the generalization of the Shannon-Wiener diversity index (TÓTHMÉRÉSZ 1997, LÖVEI, 2005). Rényi entropy values were tested statistically in the case the following α parameters: α=0.01, α=1.01, α=2.01, α=3.01 and α=4.01.

3 Results

3.1 Carabid beetles

Pitfall traps collected 1636 individuals at Hidegkút and 1043 individuals at Budaörs between 2011 and 2013. Among the captured 46 species, 13 species were only found on mulched plots, whereas as low as only 6 was found on non-mulched control plots. The most aboundant species of the study areas, in order or decreasing frequency were *Harpalus rufipes* (De Geer, 1774), *H. tardus* (Panzer, 1797), *H. distinguendus* (Duftschmid, 1812) (Appendices, Figure 5), and *H. dimidiatus* (Rossi, 1790) at the Hidegkút location; whereas *Brachinus crepitans* (Linnaeus, 1758), *H. rufipes*, *H. distinguendus,* and *Ophonus azureus* (Fabricius, 1775) at the Budaörs location. There were 6 species where treatments clearly had an effect on the number of individuals. These species, in order of decreasing dominance were *H. rufipes*, *B. crepitans*, *Anchomenus dorsalis* (Pontoppidan, 1763), *Microlestes maurus* (Sturm, 1827), *Callistus lunatus* (Fabricius, 1775), and *B. explodens* (Duftschmid, 1812) (Table 2).

Testing the diversity values of the Rényi diversity profiles at scale parameters of α=0.01, α=1.01, α=2.01, α=3.01, α=4.01, it became evident that the two treatments influenced only species presented in low numbers, with a diversity profile range ($\alpha \leq 1.01$), whereas treatments had no effect on the diversity range of the dominant species.

Table 2. Number of carabid beetles captured by pitfall traps on mulched and non-mulched plots (Budaörs and Hidegkút, 2011–2013; L: leaf mulch; C: control; H: hay mulch; 1st group: species found only on mulched plots, 2nd group: species found in both mulched and control plots, 3rd group: species found only on the control plots; same letters indicate the lack of significant ($p<0.05$) difference; one-way ANOVA and a Tukey's post hoc test)

Species	**L**	**C**	**H**	**Total**
Abax parallelepipedus (Piller & Mitterpacher, 1783)	4	0	2	6
Amara similata (Gyllenhal, 1810)	1	0	0	1
Calathus erratus (Sahlberg, 1827)	1	0	1	2
Callistus lunatus (Fabricius, 1775)	**^{b}18**	**^{a}0**	**^{bc}27**	**45**
Carabus scabriusculus Olivier, 1795	0	0	1	1
Cicindela germanica Linnaeus, 1758	0	0	1	1
Harpalus pumilus Sturm, 1818	2	0	2	4
Ophonus laticollis Mannerheim, 1825	0	0	1	1
Ophonus rupicola (Sturm, 1818)	1	0	0	1
Poecilus cupreus (Linnaeus, 1758)	2	0	6	8
Syntomus pallipes (Dejean, 1825)	4	0	4	8
Trechus quadristriatus (Schrank, 1781)	2	0	1	3
Zabrus tenebrioides (Goeze, 1777)	1	0	3	4
Acupalpus meridianus (Linnaeus, 1761)	1	1	3	5
Amara aenea (De Geer, 1774)	6	6	8	20
Amara equestris (Duftschmid, 1812)	4	3	3	10
Anchomenus dorsalis (Pontoppidan, 1763)	**^{a}6**	**^{ab}8**	**^{b}80**	**94**
Brachinus crepitans (Linnaeus, 1758)	**^{ab}67**	**^{b}22**	**^{a}187**	**276**
Brachinus explodens Duftschmid, 1812	**^{a}0**	**^{ab}1**	**^{b}15**	**16**
Calathus fuscipes (Goeze, 1777)	22	14	35	71
Carabus coriaceus Linnaeus, 1758	23	13	20	56
Harpalus affinis (Schrank, 1781)	2	1	6	9
Harpalus albanicus Reitter,1900	2	3	1	6
Harpalus calceatus (Duftschmid, 1812)	15	5	16	36
Harpalus caspius (Steven, 1806)	59	41	51	151
Harpalus dimidiatus (Rossi, 1790)	64	25	54	143
Harpalus distinguendus (Duftschmid, 1812)	85	43	64	192
Harpalus griseus (Panzer, 1797)	55	29	39	123

Species	L	C	H	Total
Harpalus rubripes (Duftschmid, 1812)	3	6	0	9
Harpalus rufipes (De Geer, 1774)	**[ab]344**	**[a]187**	**[b]408**	**939**
Harpalus serripes (Quensel, 1806)	8	9	11	28
Harpalus smaragdinus (Duftschmid, 1812)	3	1	1	5
Harpalus tardus (Panzer, 1797)	76	49	61	186
Licinus cassideus (Fabricius, 1792)	1	2	5	8
Microlestes maurus (Sturm, 1827)	**[a]30**	**[ab]15**	**[b]9**	**54**
Ophonus azureus (Fabricius, 1775)	28	19	25	72
Ophonus cribricollis (Dejean, 1829)	11	10	16	37
Ophonus melletii (Heer, 1837)	1	2	0	3
Ophonus signaticornis (Duftschmid, 1812)	20	9	4	33
Pterostichus melas (Creutzer, 1799)	0	1	3	4
Calathus ambiguus (Paykull, 1790)	0	1	0	1
Cicindela campestris Linnaeus, 1758	0	1	0	1
Harpalus atratus Latreille, 1804	0	1	0	1
Ophonus diffinis (Dejean, 1829)	0	1	0	1
Ophonus rufibarbis (Fabricius, 1792)	0	1	0	1
Parophonus dejeani Csiki, 1932	0	3	0	3
Total number of individuals	[b]972	[a]533	[b]1174	2679
Number of species	35	33	36	46

(Table 2 continued)

3.2 Chilopods

271 chilopod individuals were captured by pitfall traps from the plots of the 7 locations. Dominant species of the order Lithobiomorpha were *Lithobius mutabilis* L. Koch, 1862, *L. forficatus* (Linnaeus, 1758), *L. lapidicola* Meinert, 1872, *L. parietum* Verhoeff, 1899, *L. erythrocephalus* C.L. Koch, 1847, *L. (Sigibius) microps* Meinert, 1868. In locations Budaörs and Hidegkút two species of the order Scolopendromorpha, *Cryptops anomalans* Newport, 1844 and *C. parisi* Brölemann, 1920 occurred, with relatively high abundance of *C. anomalans* individuals. Most common species of the order Geophilomorpha, *Clinopodes flavidus* C.L. Koch, 1847 and *Geophilus flavus* (De Geer, 1778) were found only on the control plots. Significant effect of mulching was found only in the case of *L. mutabilis* in Budaörsön and Hidegkút (Tables 3 and 4).

Table 3 Number of chilopod individuals captured by pitfall traps on mulched and non-mulched plots (Budaörs and Hidegkút, 2011–2013; L: leaf mulch; C: control; H: hay mulch; 1st group: species found only on mulched plots, 2nd group: species found on both mulched and control plots, 3rd group: species found only on the control plots; same letters indicate the lack of significant ($p<0.05$) difference; one-way ANOVA and a Tukey's post hoc test)

Species	**L**	**C**	**H**	**Total**
Cryptops parisi Brölemann, 1920	0	0	1	1
Dignathodon microcephalus (Lucas, 1846)	5	0	1	6
Lithobius erythrocephalus C.L. Koch, 1847	0	0	2	2
Cryptops anomalans Newport, 1844	3	3	7	13
Henia illyrica (Meinert, 1870)	0	1	1	2
Lithobius crassipes L. Koch, 1862	1	1	0	2
Lithobius forficatus (Linnaeus, 1758)	15	12	29	56
Lithobius mutabilis L. Koch, 1862	**^{ab}18**	**^{b}3**	**^{a}21**	**42**
Lithobius muticus C.L. Koch, 1847	0	1	1	2
Clinopodes flavidus C.L. Koch, 1847	0	2	0	2
Geophilus flavus (De Geer, 1778)	0	1	0	1
Total number of individuals	42	24	63	129
Number of species	5	8	8	11

Table 4 Number of chilopod individuals captured by pitfall traps on mulched and non-mulched plots (Budapest (Rákoscsaba), Gödöllő (Blaha district), Gödöllő (SZIE experimental field), Isaszeg, Nagyecsér, 2012–2013; L: leaf mulch; C: control; M: mulched; 1st group: species found on both mulched and control plots, 2nd group: species found only on the control plots)

Species	**C**	**M**	**Total**
Lamyctes emarginatus (Newport, 1844)	3	2	5
Lithobius erythrocephalus C.L. Koch, 1847	2	10	12
Lithobius forficatus (Linnaeus, 1758)	14	35	49
Lithobius lapidicola Meinert, 1872	1	5	6
Lithobius mutabilis L. Koch, 1862	20	44	64
Lithobius parietum Verhoeff, 1899	1	2	3
Lithobius (Sigibius) microps Meinert, 1868	1	0	1
Stenotaenia linearis (C.L. Koch, 1835)	2	0	2
Total number of individuals	44	98	142
Number of species	8	6	8

3.3 Elaterid beetles

A total of 261 individuals of 11 species were collected by pitfall traps. No significat effect of mulching was experienced (Table 5).

Table 5 Number of click beetles captured by pitfall traps on mulched and non-mulched plots (Budaörs and Hidegkút, 2011–2013; L: leaf mulch; C: control; H: hay mulch; 1st group: species found only on mulched plots, 2nd group: species found in both mulched and control plots)

Fajok	**L**	**C**	**H**	**Total**
Adrastus rachifer (Geoffroy, 1785)	1	0	0	1
Agriotes sputator (Linnaeus 1758)	1	0	2	3
Athous (Orthathous) bicolor (Goeze, 1777)	0	0	1	1
Cardiophorus erichsoni Buysson, 1901	1	0	0	1
Agriotes ustulatus (Schaller, 1783)	26	30	18	74
Agrypnus murinus (Linnaeus, 1758)	3	13	5	21
Drasterius bimaculatus (Rossi, 1790)	37	27	58	122
Hemicrepidius hirtus (Herbst, 1784)	9	8	6	23
Melanotus crassicollis (Erichson, 1841)	2	5	6	13
Athous (Athous) haemorrhoidalis (Fabricius, 1801)	0	1	0	1
Melanotus punctolineatus Pelerin, 1829	0	1	0	1
Total number of individuals	80	85	96	261
Number of species	8	7	7	11

3.4 Microarthropods

A total of 10779 microarthropod individuals were captured by the EDAPHOLOG® soil monitoring system, with 66% of the individuals from the hay mulched plots, and 34 % from the control plots. Significant ($p<0.05$) difference was found between the treatments in the case of the total catch, two collembolan orders (Entomobryomorpha and Poduromorpha), and dipteran larvae (Table 6).

A total of 8321 microarthropod individuals were captured by soil sampling, with 57 % of the individuals from the hay mulched plots, and 43 % from the control plots. Significant ($p<0.05$) difference was found between the treatments in the case of the orders Entomobryomorpha and Pauropoda (Table 7).

Table 6 Microarthropods captured with EDAPHOLOG® soil monitoring system on plots covered with hay mulch and on control plots (Hidegkút, 2014-2015; for all taxa, the average number of individuals ± standard error is presented, * refers to a significant ($p<0.05$) difference between data from mulched and non-mulched plots, analysed with Mann-Whitney U test)

Microarthropod taxa	Mulch	No mulch	p value
Acari	115,8±83,9	91,2±103,3	0,242
Araneae 5 mm <	0,3±0,7	0,3±0,9	0,799
Araneae 5 mm >	0,7±1,2	1±1,5	0,59
Blattaria	0,3±0,6	0±0	0,514
Chilopoda 5 mm <	0,9±1,4	0,6±1,2	0,63
Chilopoda 5 mm >	0±0	0,2±0,6	0,755
Cicada larvae	0±0	0±0	1
Coleoptera epigeic	30,2±16,1	20,5±9,9	0,128
Coleoptera euedaphic	0,3±0,9	0,3±0,9	0,755
Collembola Entomobriomorpha	324,9±266,3	124,8±93,9	0,024*
Collembola Poduromorpha	7,3±12,5	0,8±0,8	0,003*
Collembola Symphypleona	37,3±50,6	16,5±18,2	0,347
Diplopoda 5 mm <	0,9±2,3	1,1±1,2	0,242
Diplopoda 5 mm >	0±0	0,1±0,3	0,755
Diplura	0,8±1,2	0,5±0,7	0,887
Diptera adults	9,3±9,8	7,3±5,8	0,843
Diptera larvae	22,8±30,6	5,8±6,4	0,045*
Formicidae	11,8±22,6	8±7,6	0,671
Hemiptera, Cicada larvae excluded	0,5±1	0,8±1	0,378
Hymenoptera, Formicidae excluded	1,3±0,9	1,8±2,8	0,551
Isopoda	29,6±49,3	18,9±32,6	0,63
Orthoptera	0±0	0,1±0,3	0,755
Other holometamorph larvae	1±1,5	0,1±0,3	0,266
Pauropoda	0,1±0,3	0±0	0,755
Protura	0±0	0±0	1
Pseudoscorpiones	0,5±0,7	0,7±1,1	1
Psocoptera	0±0	0±0	1
Symphyla	0±0	0±0	1
Thysanoptera	0,2±0,4	0,1±0,3	0,755
Zygentomata	0±0	0,3±0,6	0,514

Table 7 Microarthropods collected with soil samples on plots covered with hay mulch and on control plots (Hidegkút, 2014-2015; for all taxa, the average number of individuals ± standard error is presented, * refers to a significant ($p<0.05$) difference between data from mulched and non-mulched plots, analysed with Mann-Whitney U test)

Microarthropod taxa	Mulch	No mulch	p value
Acari	266.1 ±	240.1 ± 54.6	0.932
Araneae 5 mm <	0.0 ±	0.1 ± 0.1	0.755
Araneae 5 mm >	0.0 ±	0.0 ± 0.0	1
Blattaria	0.0 ±	0.0 ± 0.0	1
Chilopoda 5 mm <	0.8 ±	0.7 ± 0.4	0.799
Chilopoda 5 mm >	0.2 ±	0.0 ± 0.0	0.514
Cicada larvae	0.1 ±	0.0 ± 0.0	0.755
Coleoptera epigeic	5.2 ±	5.9 ± 1.0	0.755
Coleoptera euedaphic	0.4 ±	0.0 ± 0.0	0.319
Collembola Entomobriomorpha	65.2 ±	11.4 ± 2.0	<0.001*
Collembola Poduromorpha	18.5 ±	11.8 ± 7.0	0.028*
Collembola Symphypleona	3.5 ±	4.1 ± 2.1	0.887
Diplopoda 5 mm <	0.7 ±	0.3 ± 0.2	0.671
Diplopoda 5 mm >	0.1 ±	0.0 ± 0.0	0.755
Diplura	0.6 ±	0.1 ± 0.1	0.16
Diptera adults	0.2 ±	0.1 ± 0.1	0.755
Diptera larvae	1.1 ±	1.3 ± 0.7	0.551
Formicidae	0.8 ±	6.1 ± 5.0	0.319
Hemiptera, Cicada larvae excluded	0.3 ±	2.8 ± 2.7	0.799
Hymenoptera Formicidae excluded	0.0 ±	0.1 ± 0.1	0.755
Isopoda	0.0 ±	0.0 ± 0.0	1
Orthoptera	0.0 ±	0.0 ± 0.0	1
Other holometamorph larvae	0.0 ±	0.0 ± 0.0	1
Pauropoda	21.0 ±	9.3 ± 3.6	0.033*
Protura	0.1 ±	0.0 ± 0.0	0.755
Pseudoscorpiones	5.4 ±	1.8 ± 0.8	0.378
Psocoptera	0.4 ±	0.5 ± 0.2	0.755
Symphyla	3.9 ±	2.4 ± 0.7	0.319
Thysanoptera	0.0 ±	0.3 ± 0.1	0.319
Zygentomata	0.0 ±	0.0 ± 0.0	1

3.1 Potato yield

In 2011-2013, total potato yield on locations Hidegkút and Budaörs was 396.17 kg. 38 % of this was produced on plots covered with leaf litter, about 42 % on plots covered with hay mulch, and about 20 % on plots with no cover at all. The differences between the average yield of mulched and non-mulched plots were siginificant ($p=0.038$).

The total amount of tubers harvested from plots mulched with leaf litter was 152.78 kg. About 82 % of that amount was intact, and the rest damaged. Half of them, which is 9 % of the total tuber quantity, had hole damages due to the presence of noctuid larvae and white grubs, and there were bores within the remaining 9 % due to wireworms. In the case of hay mulch, with a total yield of 165.84 kg, about 65 % of the tubers were intact, 22 % had holes and 13 % had bores in them. On the control plots (a total of 77.55 kg) about 70 % of the tubers were intact, 11 % had holes and 19 % of them had bores.

The proportion of healthy tubers was significantly ($p<0.05$) higher and the proportion of hole damage was lower with leaf litter mulch. On plots with hay mulch the proportion of tubers with bore damages was significantly higher ($p<0.05$). At the same time, none of the treatments had a significant effect on the proportion of bore damages.

3.2 New scientific results

- According to the results of pitfall traps, both hay and leaf litter mulch increases the number of individuals of carabid assemblages, but the difference is significant only in the case of hay mulch.
- Mulching has a positive effect on the number of individuals in the case of the following carabid species: *Anchomenus dorsalis, Brachinus crepitans, B. explodens, Callistus lunatus, Harpalus rufipes* and *Microlestes maurus.*
- When compared to non-mulched plots, hay and leaf litter mulch increases the species diversity of rare carabid species, while these organic mulching materials have no effect on the species diversity of dominant species.
- Chilopod assemblages display a larger number of individuals on plots covered with hay than on plots left uncovered.
- Soil cover has a positive effect on the number of individuals in the case of the chilopod species *Lithobius mutabilis* and *L. erythrocephalus.*
- Neither hay nor leaf litter mulch has any effect on the number of click beetle adults.
- EDAPHOLOG® soil monitoring system and soil sampling proved that when compared to non-mulched plots, the number of individuals in case of microarthropods was higher on plots covered with hay mulch. EDAPHOLOG® soil monitoring system showed that when compared to non-mulched plots, hay mulch increased the number of individuals for dipteran larvae and members of the collembolan taxa Entomobriomorpha and Poduromorpha; while soil sampling proved that hay mulch increased the number of individuals in the case of the collembolan taxa Entomobriomorpha and Pauropoda.
- The use of organic mulch results in higher tuber yield.
- When compared to hay mulch cover, plots covered with leaf litter mulch yield a higher proportion of healthier tubers, and the proportion of holes within tubers is lower. At the same time, none of the treatments has any effect on the proportion of wireworm-bored tubers.
- I found that both EDAPHOLOG® soil monitoring system and soil sampling are suitable to evaluate the influence of mulching on the presence of microarthropods. These two methods are not interchangeable, but they complement one another in a complex study.

4 Conclusions and suggestions

- The results of pitfall traps revealed that while the use of organic mulch increases the number of individuals of certain carabid beetles and chilopods, no similar effect was observed in the case of elaterid beetles.

- Hay mulch increased the number of individuals of the studied microarthropod taxa.

- Potato yield was significantly higher on mulched plots than on non-mulched ones.

- Where leaf litter mulch is used, the proportion of hole damage in the tubers is expected to be lower than in plots covered with hay mulch or in plots left without mulch.

- I suggest our mulching studies be expanded from the level of micro-plots to small and large-scale and even to field level.

- I suggest microarthropods be monitored at species level on mulched and non-mulched plots.

5 Publications of Péter Dudás

5.1 Publications within the scope of the doctoral thesis

Research papers:

- DOMBOS, M., KOSZTOLÁNYI, A., SZLÁVECZ, K., GEDEON, CS., FLÓRIÁN, N., GROÓ, Z., DUDÁS, P., & BÁNSZEGI, O. (2017): EDAPHOLOG monitoring system: automatic, real-time detection of soil microarthropods. *Methods in Ecology and Evolution*, 8 (3) 313–321. p.
- DUDÁS, P., AMBRUS, G., PILTZ, M. & TÓTH, F. (2013): Avartakarással kezelt és kezeletlen burgonyatáblák százlábúegyütteseinek (Chilopoda) felmérése talajcsapdázással. *Állattani Közlemények*, 98 (1–2): 47–56. p.
- DUDÁS, P., GEDEON, CS., MENYHÁRT, L., AMBRUS, G. & TÓTH, F. (2016): The effect of mulching on the abundance and diversity of ground beetle assemblages in two Hungarian potato fields. *Columella – Journal of Agricultural and Environmental Sciences*, 3 (1) 45–53. p.
- DUDÁS, P., MENYHÁRT, L., GEDEON, CS., AMBRUS, G. & TÓTH, F. (2016): The effect of hay mulching on soil temperature and the abundance and diversity of soil-dwelling arthropods in potato fields. *European Journal of Entomology*, 113: 456–461. p.

Conference abstracts:

- DUDÁS, P., AMBRUS, G., PILTZ, M. & TÓTH, F. (2013): Mulcsozott es mulcsozatlan burgonyatáblák százlábú (Chilopoda) együtteseinek az összehasonlítása. *59. Növényvédelmi Tudományos Napok* 33.
- DUDÁS, P., AMBRUS, G., PILTZ, M. & TÓTH, F. (2013): Mulcsozott és mulcsozatlan burgonyaparcellák ragadozó ízeltlábú együtteseinek az összehasonlítása. *XXIII. Keszthelyi Növényvédelmi Fórum* 137–142.
- DUDÁS, P., PILTZ, M. & TÓTH, F. (2012): Mulcsozott burgonyatáblák leggyakoribb futóbogár-fajai. *VI. Európai Kihívások Nemzetközi Konferencia* CD

- DUDÁS, P., PILTZ, M. & TÓTH, F. (2012): Mulcsozott és mulcsozatlan burgonyatáblák futóbogár-együtteseinek az összehasonlítása. *Tavaszi Szél 2012* 12–20.
- DUDÁS, P., PILTZ, M., AMBRUS, G. & TÓTH, F. (2012): The effect of mulching on the species composition of Carabid and Arachnid poulations of potato. *PhD hallgatók VIII. Nemzetközi konferenciája* CD
- TÓTH, F., AMBRUS, G., BALOG, A, BOZINÉ PULLAI, K., DUDÁS, P, LAKINÉ SASVÁRI, Z., MÉSZÁROSNÉ PÓSS, A., NAGY, P., PETRIKOVSZKI, R., PUTNOKY CSICSÓ, B., SIMON, B., SÜDINÉ FEHÉR, A., TURÓCZI, GY. & ZALAI, M. (2018): A talajtakarás egyes növényvédelmi vonatkozásainak vizsgálata. *64. Növényvédelmi Tudományos Napok* 42.

5.2 Other publications

- AMBRUS, G., DUDÁS, P. & TÓTH, F. (2013): Adatok a burgonyabogár (*Leptinotarsa decemlineata*, SAY, 1824) hazai ragadozóihoz. *59. Növényvédelmi Tudományos Napok* 83.
- AMBRUS, G., DUDÁS, P. & TÓTH, F. (2013): Mono-diet of agrobiont spiders (*Xysticus* sp., *Tibellus* sp.) on larvae of the Colorado potato beetle (*Leptinotarsa decemlineata*). *19th International Congress of Arachnology* 173.
- AMBRUS, G., DUDÁS, P. & TÓTH, F. (2013): The effect of mulching on spiders of potato fields. *19th International Congress of Arachnology* 172.
- AMBRUS, G., DUDÁS, P., SZALAI, M. & TÓTH, F. (2018): Habitat manipulation: the effect of mulching on dominant and non-dominant spider species. *31st European Congress of Arachnology* 32.
- AMBRUS, G., FEJES, A., DUDÁS, P. & TÓTH, F. (2014): Adatok a burgonyabogár (*Leptinotarsa decemlineata*) hazai ragadozóihoz II. *60. Növényvédelmi Tudományos Napok* 40.
- AMBRUS, G., FEJES, A., DUDÁS, P. és TÓTH, F. (2014): Antipredátor mozgásformák a burgonyabogár lárvák (*Leptinotarsa decemlineata*) esetében. *60. Növényvédelmi Tudományos Napok* 87.
- FLÓRIÁN, N., DUDÁS, P., DÁNYI, L. & DOMBOS, M. (2015): Extrém aszály hatása Collembola populációk dinamikájára egy kiskunsági homokpusztagyepen. *10. Magyar Ökológus Kongresszus* 54.