Hungarian University of Agriculture and Life Sciences

Effect of organic mulching on potato yield and tuber damage

DOI: 10.54598/005480

Thesis of Doctoral (PhD) dissertation

Anikó Südiné Fehér

Gödöllő
2023

Doctoral School

name: Doctoral School of Plant Sciences

discipline: Plant Production and Horticulture

head of the Doctoral School:

Lajos Helyes PhD DSc
Professor
Hungarian University of Agriculture and Life Sciences,
Buda Campus, Institute of Horticulture

Supervisors: Ferenc Tóth PhD
Horticultural team leader
Hungarian Research Institute of Organic Agriculture

György Turóczi PhD
Professor
Hungarian University of Agriculture and Life Sciences,
Faculty of Agriculture and environmental Science,
Institute of Plant Protection,
Department of Integrated Plant Protection

……………………………..	…………………………….	…………………………
Approval of the School Leader	Approval of the Supervisor	Approval of the Supervisor

Content

1. Introduction

Nowadays, soil is increasingly recognized as an important, slowly renewing natural asset. Its protection and proper management are receiving more and more attention (Ngosong et al., 2019).

Mulching has become increasingly popular in recent years and has become an important alternative to soil protection, primarily in small gardens and kitchen gardens. This is mainly due to the physicochemical and biological improvement in the soil due to mulching (Bharati et al., 2020; Nowroz et al., 2021).

The potato (*Solanum tuberosum* L.) is the most important non-cereal food crop in the world (Zhang et al., 2016). Mulch cultivation can be easily and effectively incorporated into its cultivation technology, resulting in a significant yield increase (Li et al., 2018; Wang et al., 2019).

However, among the researches dealing with potato mulches, there are only a few that examine the effects of different organic mulches on the occurrence of potato soil-dwelling pests and pathogens, or their tuber damage.

The fallen foliage of deciduous trees, which is most similar to the litter of forests and is available in large quantities in gardens, is a less studied mulch material. It is typically not used for mulching, and walnut leaves are not even used for composting, they are only taken away thanks to organized collections.

The use of mulch allows an alternative potato sowing method and the abandonment of soil disturbance, which is also the subject of little research. In this case, the potato tuber is sown not in the soil, but on the soil surface, under the mulch.

Over the years, some elements of the basic experiment have been narrowed down, while others have been expanded with both field and laboratory experiments and tests.

1.1. Objectives

The main aims of my work was to determine whether, in addition to its numerous known benefits, mulching poses a plant protection risk, and whether it mitigates the damage caused by pests and pathogens when properly applied. Special research was needed to investigate which organic mulches and which sowing methods increase the yield of healthy potatoes the most. Furthermore, what the role of useful microorganisms is in this cultivation system, and the large number of decomposers that appear during field surveys, whose plant protection assessment is not uniform. My aim was also to determine whether the use of walnut mulch, which is also controversal, has growth-inhibiting or other harmful effects that would distinguish it from mixed-species leave mulch.
The aim of my work was therefore the different:

• organic mulch materials (straw, walnut leaves, nut-free mixed leaves and residential compost)

• sowing methods (sowing in soil; sowing on soil surface, under mulch)

• antagonist (*Trichoderma asperellum*), entomopathogenic (*Metarhizium anisopliae*), symbiont (*Glomus* spp.), decomposer (Isopoda) organisms

• soil-dwelling pests (*Arionidae, Limacidae, Elateridae, Melolonthidae, Noctuidae, Rodentia*,)

• soil born pathogens (*Streptomyces scabies, Streptomyces* spp., *Rhizoctonia solani, Fusarium solani, F. oxysporum f. sp. tuberosi, F. sambucinum, F. sulphureum*)

investigation of its interactions using the potato (*Solanum tuberosum* L.) test plant.

2. Materials and methods

2.1. Open-field mulching experiments (2013–2018)

The settings of the open field potato plots experiment and their main variables are summarized in Table 1. As the number of experimental sites and the size of the plots decreased over the years, the number of repetitions increased. The number of potato varieties included in the experiment decreased and the range of tested cover materials increased, and two types of sowing methods and microorganism treatments were added. During the experiments, monoculture potato cultivation was carried out, without irrigation or nutrient supply. Weeding was done manually when needed. With our experiments, we modelled the kitchen gardens' and home gardens' potato cultivation.

In the first three years of the experiment, the metal-sealed seed tubers of domestically bred potato varieties were sown in rows 10-15 cm deep, 20-25 cm apart, with a row spacing of 90 or 70 cm, and then we made a ridge. In the following three years, microplots (2×2 m) were created (one bush/m^2). Here, the tubers were traditionally sown 10-15 cm deep into the soil, or placed on the surface of the soil and covered with mulch (15-20 cm thic

Table 1: Location, area size, pre-crop, number of repetitions, potato variety, mulch material, sowing method and microorganism treatment during the years of field potato experiments

Year	**Experiment location**	**Area size (m^2)**	**Pre-crop**	**Number of repititions**	**Potato variety**	**Mulch materials**	**Sowing method**	**Microorganism treatment**
2013	Gödöllő (MATE)	292	potato	2	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	Cut grass	Into the soil	-
	Gödöllő (Blaha)	1032	potato	1	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	Cut grass	Into the soil	-
	Isaszeg	40	potato	1	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	Cut grass	Into the soil	-
	Nagyecsér	65	potato	1	Balatoni Rózsa, Démon, Hópehely, Katica, Sárpo Mira, White Lady	Cut grass	Into the soil	-
2014	Gödöllő (MATE)	432	potato	2	Démon, Hópehely, Sárpo Mira, White Lady	Mixed leaves	Into the soil	-
	Isaszeg	40	potato	1	Démon, Hópehely, Sárpo Mira, White Lady	Cut grass	Into the soil	-
	Nagyecsér	65	potato	1	Démon, Hópehely, Sárpo Mira, White Lady	Straw	Into the soil	-
2015	Gödöllő (MATE)	348	potato maize	4	Démon, Hópehely	Mixed leaves	Into the soil	-
2016	Gödöllő (MATE)	288	potato	8	Démon, Hópehely	Straw, Walnut leaves, Mixed leaves, Compost	Into the soil/On the soil surface	Mikorrhiza, *T. asperellum*
2017	Gödöllő (MATE)	288	potato	8	Démon	Straw, Walnut leaves, Mixed leaves, Compost	Into the soil/On the soil surface	Mikorrhiza, *T. asperellum*
2018	Gödöllő (MATE)	288	potato	8	Démon	Straw, Walnut leaves, Mixed leaves, Compost	Into the soil/On the soil surface	*M. anisopliae*, *T. asperellum*

The organic material required for mulching was collected at each site in the simplest and most practical way possible. The cut grass (Lolium perenne, Poa pratensis, Dactylis glomerata, Elymus repens, Festuca ovina, Agrostis capillaris) was from the areas immediately surrounding the experimental plots, the leaves forming the mixed litter (Platanus x acerifolia, Quercus robur, Acer campestre) were from the park areas of the university, and the walnut leaves were collected in separate bags from private gardens in Gödöllő. The wheat straw also came from a producer in Gödöllő. Compost was a product made from municipal and household green waste.

The continuous covering was carried out before planting with a 15-20 cm layer of mulch. In 2013–2015, half of the rows were mulched, the other half was an untreated control. In 2016–2018, the arrangement of cover materials and sowing methods in the microplots followed a random block arrangement.

The potato tubers were picked by hand. The weight of the tubers was measured and the damaged tubers were examined individually. We used Microsoft Excel to analyze the data. Treatments were compared using one-way analysis of variance and Tukey's post hoc test using SPSS statistical software. For the 2016–2018 analyses, the data were logarithmically transformed (ln(X+1)) in the case of the total yield, and arcsine transformation was used for the proportion of tuber damage.

2.2. In vivo and in vitro microorganism interaction experiments (2016–2018)

During the microorganism on-field experiment, in each of the 72 microplots, one of the four potato tubers was treated with mycorrhiza (Symbivit), the other with *Trichoderma asperellum*, the third with both fungi, and the fourth with neither (control). In a similar arrangement in 2018, we treated the potato tubers with *T. asperellum* and *Metarhizium anisopliae* mushroom suspension before planting.

During the laboratory experiment, examining the joint applicability and dominance of the microorganisms, we provided a time (12, 24, 36, 48, 50 hours) advantage for *M. anisopliae* to develop, before inoculating the more intensively growing *T. asperellum*. During the experiment set up in 5 repetitions, we observed an increase in the colony diameter of the fungi on the nutrient medium of the Petri dishes.

2.3. Consumption of *Fusarium solani* mycelia and potatoes by isopods

To investigate the role of terrestrial isopods appearing in large numbers in the covered plots during the field experiment, we placed a potato tuber artificially infected with *Fusarium solani* and an intact potato tuber in plastic boxes. We placed *Porcellio scaber* individuals in one third of the boxes and *Porcellionides pruinosus* individuals in the other third of the boxes. The other boxes were control treatments without isopods. The experiment took place with two potato varieties, in 10 repetitions, for 10 days.

3. Results

3.1. Open-field mulching experiments (2013–2018)

During the potato mulch experiment, we produced a total of 2,023 kg of potato tubers in four locations over six years and examined them one by one.

Examining the annual total yield of all mulched and unmulched potato plots, we found that in the first two years (2013, 2014) the yield-enhancing effect of mulching was not statistically detectable, but in the other four years, significantly more potatoes were produced in the mulched plots (Figure 1).

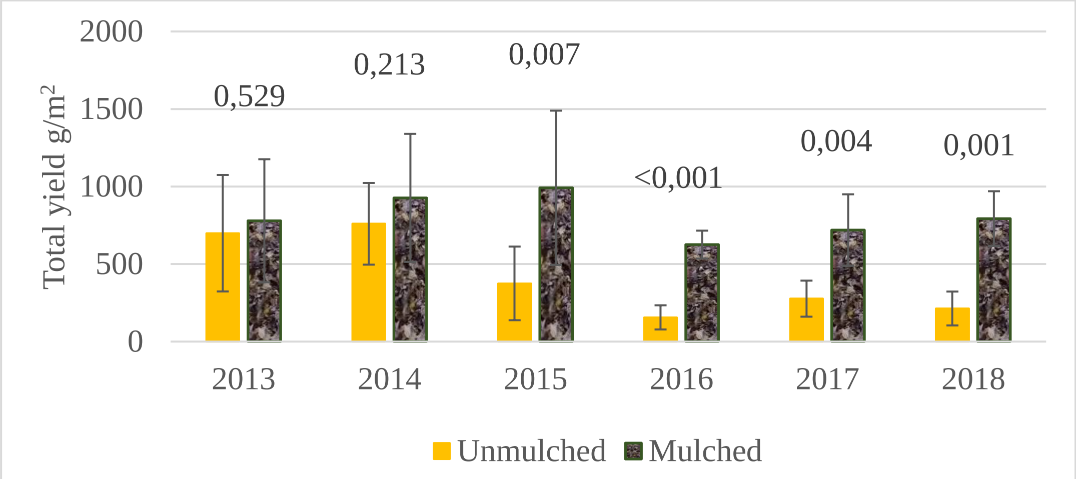

Figure 1: Annual potato total yield (g/m^2) of all experimental sites in the mulched and non-mulched plots (2013–2018).

Similar results were obtained when we compared the annual total yield of intact tubers in mulched and non-mulched plots. In the first two years of the experiment, there was no detectable difference between the covered and uncovered treatments, but in the other four years there was a significantly higher yield of intact tubers in the mulched plots.

Examining the type and extent of damage (Table 2), we found that during the six years, tuber damage by soil-dwelling pests and pathogens (*F. solani* damage, Wireworm damage, Cutworm/ Chafer grub damage, Rodent damage) was not greater in the covered plots than in the uncovered ones. Statistically, no difference could be detected between the damaged tuber mass of the covered and uncovered plots (as a percentage of the total yield per year) in any of the years.

Table 2: The weight of the tubers damaged by different pests and pathogens in the studied locations, as a percentage of the total yield, in the mulched (M) and unmulched (U) plots (The weight values of the tubers damaged in various ways are shown in several columns; The significance groups compare the proportion of the yield in mulched and unmulched plots damaged in the same way in the same years they show)

	2013		**2014**		**2015**		**2016**		**2017**		**2018**	
	U	**M**	**U**	**M**	**U**	**M**	**U**	**M**	**U**	**M**	**U**	**M**
***F. solani* damage**	4,5 % [a]	2,3 % [a]	2,7 % [a]	3,1 % [a]	20,6 % [a]	10,6 % [a]	3,6 % [a]	1,2 % [a]	1,7 % [a]	0,5 % [a]	1,6 % [a]	1,8 % [a]
Wireworm damage	2,8 % [a]	2,3 % [a]	1,5 % [a]	3,0 % [a]	28,1 % [a]	21,5 % [a]	8,6 % [a]	9,7 % [a]	15,3 % [a]	7,4 % [a]	34,6 % [a]	19,9 % [a]
Cutworm/ Chafer grub damage	1,6 % [a]	0,8 % [a]	0,9 % [a]	1,0 % [a]	8,3 % [a]	15,0 % [a]	11,7 % [a]	7,7 % [a]	4,5 % [a]	3,7 % [a]	3,0 % [a]	3,9 % [a]
Rodent damage	0,0 % [a]	0,0 % [a]	6,6 % [a]	4,2 % [a]	0,4 % [a]	0,0 % [a]	1,7 % [a]	0,6 % [a]	0,4 % [a]	0,2 % [a]	2,6 % [a]	1,6 % [a]

During the three experimental years examining cover materials and sowing methods separately (Table 3), in the case of the treatments sown in the soil, the annual total yield of the compost plots exceeded that of the control plots in all three years, as did the yield of walnut leaves and mixed leaves (with the exception of 2017). The yield of plots with straw mulch did not differ from the control in any year. In 2016, the compost yielded more than the two types of leaves mulch. The yield of the two types of leaves mulches did not differ in either year from the other. The yield of straw mulch in 2016 and 2017 did not differ from the two types of leaves mulch, but in 2018 fewer potatoes were produced in the plots with straw. The sowing method (in the soil or on the soil surface under the mulch) did not influence the annual development of the total yield within the cover material treatment.

Examining intact, marketable tubers over 50g in treatments sown in the soil, in 2017 the yield of intact tubers from the compost exceeded that of the control plots. In this year, the marketable yield of the walnut leaves mulch and mixed leaves mulch did not differ from each other, nor the straw or the control, just as the compost did not differ from the two types of leaves mulches. In 2016 and 2018, the plots with walnut leaves, mixed leaves and compost mulch also produced more marketable tubers than the control. There was a difference between the straw mulched and the control plots in 2016, but in the other two years there was no difference in terms of marketable tubers. The yield of intact tubers in the two types of leaves mulch, and compost mulched plots did not differ from each other in any of the years. The sowing method did not statistically affect the marketable tuber yield of potatoes in any year, within any cover material treatment.

Table 3: The effect of different cover materials and sowing methods (I: int he soil; S: surface ont he soil) on the investigated variables in an open-field potato experiment (2016-2018) (There is no significant difference between the data marked with the same letter within the individual years; p-values smaller than 0.05 are in italics).

year	Variable	unit	ANOVA	ANOVA	Control	Straw		Walnut leaves		Mixed leaves		Compost	
			F	p	I	I	S	I	S	I	S	I	S
2016	Total yield	g	14,932	*0,000*	625^{a}	1231^{abc}	1109^{ab}	1995^{bcd}	1961^{bcd}	2072^{bc}	2334^{cde}	4260de	5055^{e}
	Marcetable yield	g	14,011	*0,000*	63^{a}	526^{bc}	406^{b}	835^{bc}	768^{bc}	1193^{bc}	1074^{bc}	2170^{c}	2171^{c}
	Dry rot	%	2,013	0,059	3,6	0,0	0,0	0,0	1,1	0,0	0,7	2,2	1,6
	Chewed	%	1,957	0,067	19,2	15,8	3,9	19,8	7,4	21,1	10,6	22,4	19,8
	Green	%	10,360	*0,000*	0,0^{a}	0,3^{a}	6,7^{ab}	7,7^{ab}	28,7^{c}	2,8^{ab}	15,3^{b}	5,2^{ab}	13,5^{b}
	Cut	%	4,124	*0,001*	22,8^{b}	5,9^{a}	2,0^{a}	12,1^{ab}	4,8^{a}	9,0^{ab}	4,1^{a}	10,2^{ab}	2,4^{a}
	Deformed	%	0,888	0,532	12,4	7,9	12,4	8,3	5,1	10,9	13,2	13,1	10,1
	Cracked	%	1,214	0,305	0,3	0,7	2,3	3,7	0,1	0,6	2,2	2,1	1,9
2017	Total yield	g	7,967	*0,000*	1107^{a}	1287^{a}	1326^{a}	2057^{ab}	2106^{ab}	2611^{abc}	2358^{abc}	5269^{bc}	5998^{c}
	Marcetable yield	g	4,824	*0,000*	478^{a}	887^{a}	849^{a}	1550^{ab}	1363^{ab}	2150^{ab}	1616^{ab}	4287^{b}	3980^{b}
	Dry rot	%	2,067	0,053	1,7	0,0	0,0	0,0	0,0	0,2	0,4	0,4	1,2
	Chewed	%	0,803	0,602	17,6	14,9	13,5	7,2	11,2	10,2	8,1	13,6	11,0
	Green	%	4,024	*0,001*	0,8^{ab}	0,1^{a}	2,1^{abc}	1,8^{abc}	7,5^{bc}	1,3^{ab}	8,7^{c}	2,8^{abc}	6,9^{abc}
	Cut	%	5,758	*0,000*	11,3^{b}	1,9^{ab}	0,0^{a}	11,5^{b}	0,0^{a}	11,7^{b}	1,0^{a}	7,2^{ab}	0,4^{a}
	Deformed	%	4,423	*0,000*	39,9^{b}	32,9^{b}	23,2^{ab}	23,0^{ab}	12,5^{a}	23,6^{ab}	11,5^{a}	29,8^{ab}	26,5^{ab}
	Cracked	%	3,703	*0,001*	0,8^{a}	2,1^{a}	3,3^{a}	4,1^{a}	6,4^{ab}	9,8^{ab}	3,2^{a}	7,4^{ab}	17,1^{b}
2018	Total yield	g	16,924	*0,000*	854^{a}	686^{a}	1024^{a}	3346^{bc}	4197^{bc}	2213^{b}	2924^{bc}	5054^{bc}	5924^{c}
	Marcetable yield	g	8,463	*0,000*	308^{a}	254^{a}	569^{a}	1752^{b}	2764^{b}	1300^{ab}	1851^{b}	2685^{b}	2994^{b}
	Dry rot	%	2,587	*0,016*	1,6^{ab}	0,1^{a}	0,0^{a}	1,2^{ab}	1,3^{ab}	0,0^{a}	0,3^{ab}	2,2^{ab}	4,1^{b}
	Chewed	%	0,729	0,665	39,4	30,9	27,0	21,8	19,0	26,1	20,0	24,5	29,1
	Green	%	3,062	*0,006*	0,0^{a}	1,3^{ab}	0,0^{a}	1,7^{ab}	6,2^{b}	0,1^{a}	3,8^{ab}	1,3^{ab}	3,2^{ab}
	Cut	%	3,959	*0,001*	19,3^{b}	11,3^{ab}	0,0^{a}	20,0^{b}	0,0^{a}	11,2^{ab}	0,0^{a}	7,5^{ab}	0,3^{a}
	Deformed	%	2,461	*0,022*	15,3^{b}	1,5^{a}	9,1^{ab}	9,7^{ab}	10,5^{ab}	3,5^{ab}	6,6^{ab}	3,5^{ab}	3,5^{ab}
	Cracked	%	5,344	*0,000*	7,1^{a}	6,3a	2,2^{a}	20,6^{ab}	17,9^{ab}	15,6^{ab}	15,4^{ab}	33,5^{b}	32,9^{b}

Examining the proportion of tubers infected with fusarium, we did not find any significant differences in any of the experimental years, covering materials or sowing methods, only in the 2018 compost mulch and sowed under mulch treatments, the number of fusarium infected tubers was higher compared to all other combinations of covering materials and sowing methods. No significant differences between the two types of sowing methods could be detected in any of the experimental years when examining the tubers damaged (chewed) by soil-dwelling pests.

There was also no difference in the proportion of green tubers between the cover materials or the control treatments in the case of traditional (soil) sowing within each year. On the other hand, two characteristic differences emerged from the method of sowing on the soil surface under mulch treatment. There were more green tubers in treatments planted under mulch. In 2016, the number of green tubers was statistically higher in the walnut leaves mulch, mixed leaves mulch and compost mulch treatments than in the control. In 2017, there were significantly more green tubers in the plots sowed under walnut and mixed leaves mulch than in the control treatment. In 2018, there were more green tubers in the plots of walnut leaves mulch planted on the soil surface. In 2016 the plots covered with walnut leaves mulch, and in 2017, the plots covered with mixed straw had significantly more green tubers in the treatments sown on the soil surface, under mulch, than in the treatments sown in the soil with these two cover materials.

On the other hand, sowing under mulch had an effect on the number of tubers damaged by a tillage tool during harvesting. In 2016, there was significantly more cut tuber in the untreated control, than in the soil surface sowed treatments in case of all cover materials. In 2017, the cut tuber weight of the control plots, the soil sowed walnut leaf and mixed leaf covered plots also exceeded the cut tuber weight of the under mulch sowed treatments of all cover materials. In 2018, the untreated control and the walnut leaves mulch soil sowed treatment resulted in more cut tubers compared to the under mulch sowed treatments of all cover materials.

In the case of cut tubers, a statistical difference was also observed within the cover material treatments. In 2017, in the case of the two-leaf mulch, the method of sowing in the soil increased the proportion of cut tubers compared to treatments sown on the soil surface under mulch. In 2018, there were more cut tubers in the treatments sown in the ground covered with walnut leaves compared to the treatments sown on the soil surface covered with walnut leaves. There were no statistical differences between the covering materials in the soil sowed treatments, apart from a single occasion when in 2016 there were fewer cut tubers under the straw mulch than in the control.

The amount of distorted tubers within the treatments planted in the soil in 2016 and 2017 did not differ between cover materials. In 2018, there were more distorted tubers in the control plots than in the plots with straw mulch. Sowing on the soil surface under mulch treatment, in 2017 significantly reduced the amount of distorted tubers in the case of walnut and mixed leaves cover.

Examining the cracked tubers in the case of treatments sown in the soil in 2016 and 2017, there was no difference between the cover material treatments compared to the control, but in 2018 there were more cracked tubers in the plots with compost mulch than in the plots with straw mulch and without mulch (control). The sowing method had no detectable effect on cracked tubers within the cover material treatments in any of the years.

3.2. In vivo and in vitro microorganism interaction experiments (2016–2018)

During the harvesting of the experiment, no pest individuals infected by *M. anisopliae* were found, so we measured the microorganism's effectiveness based on the chewing damage on the tubers. In the field experiment, there was no significant effect of any of the microorganism treatments or their combination on any of the mulching materials either on the damage caused by chewing or fusarium disease (*Fusarium* sp.) or on the yield per bush (Table 4).

Table 4: One-factor analysis of variance p-values when examining the effect of microbiological treatment per year and cover type. Treatments in 2016 and 2017: C, T, S, T+S; In 2018: C, T, M, T+M; C: control, T: *T. asperellum*, S: Symbivit (*Glomus* spp.), M: *M. anisopliae*

Year	Mulch materials	Total yield	Biotically intact yield	Fusarium scale average	Chewing scale average
2016	Unmulched	0,784	0,814	0,349	0,561
	Straw	0,503	0,640	n.é.	n.a.
	Walnut leaves	0,385	0,570	0,467	0,514
	Mixed leaves	0,995	0,924	0,531	0,656
	Compost	0,927	0,979	0,697	0,812
2017	Unmulched	0,721	0,891	0,910	0,467
	Straw	0,647	0,666	n.é.	0,399
	Walnut leaves	0,976	0,943	0,399	0,455
	Mixed leaves	0,789	0,590	0,393	0,488
	Compost	0,852	0,724	0,567	0,433
2018	Unmulched	0,613	0,603	0,246	0,633
	Straw	0,199	0,185	0,399	n.a.
	Walnut leaves	0,916	0,445	0,137	0,399
	Mixed leaves	0,457	0,904	0,399	0,399
	Compost	0,791	0,910	0,350	0,053

During the laboratory microorganism interaction study, the *T. asperellum* control without *M. anisopliae* showed the most intensive colony growth (Figure 2). The T. asperellum grew to the greatest extent when it was added to the culture medium at the same time as *M. anisopliae*. The more time advantage was provided for *M. anisopliae* to develop, the colony diameter of *T. asperellum* increased less and less. In the case of *M. anisopliae* added 48 hours earlier, *T. asperellum* showed no colony growth at all.

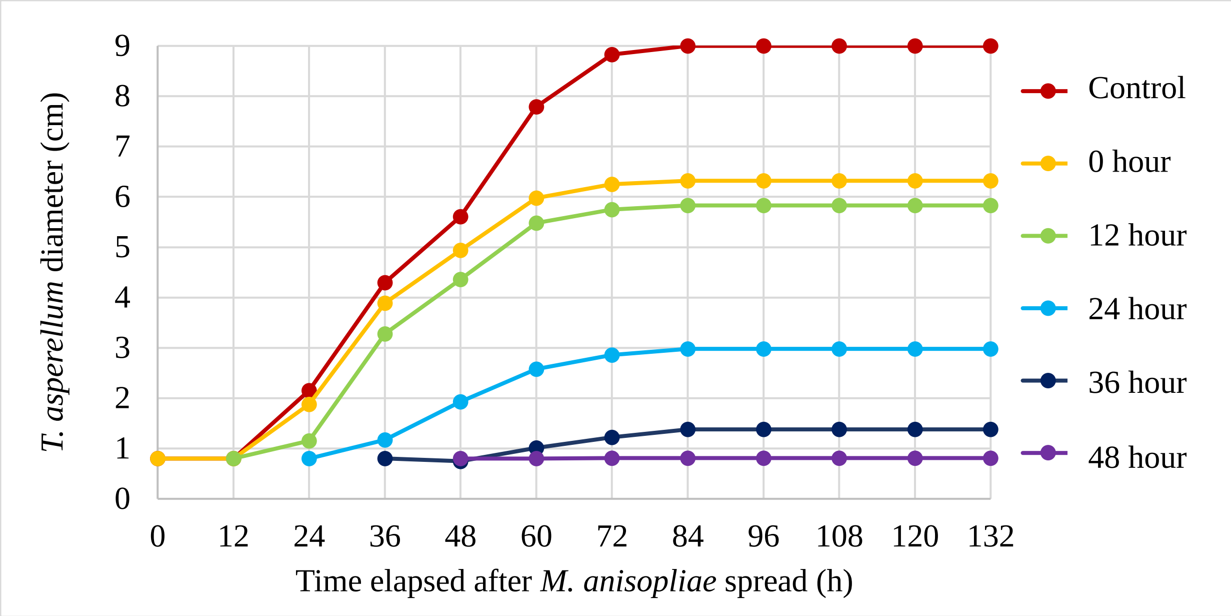

Figure 2: Developmental dynamics of *T. asperellum* on medium spread with spores of *M. anisopliae* as a function of the time elapsed between spreading and inoculation (control: *T. asperellum* alone; possible maximum colony size: 9 cm)

3.3. Consumption of *Fusarium solani* mycelia and potatoes by isopods

In the presence of both isopod species, the F. solani infection was reduced compared to the control, both in intact tubers and artificially infected tubers, but this difference was only significant in the case of P. scaber. The larger P. scaber individuals consumed significantly more potatoes per individual from the artificially infected tubers during the experiment than the P. pruinosus individuals. There was no difference in the consumption of the originally intact tubers between the two isopod species. Potato consumption by isopods was not affected by whether the tuber was artificially infested or not. No statistical difference could be established in the consumption of originally intact and infected tubers. There was no difference between the two potato varieties in Fusarium infection, nor in potato consumption by isopods (P= 0.733).

4. Conclusions and suggestions

During the review of the domestic and international literature, we did not find any similar research that examined the effect of walnut leaves and mixed tree leaves mulch, as well as sowing methods, on potato yield, as well as on soil-dwelling pests and soil-borne pathogens.

4.1. Open-field mulching experiments (2013–2018)

During the 6 years of testing, as the total yield of potatoes increased, so did the yield of intact tubers. However, the proportion of damaged tubers did not change, even in the last four years, when the total yield of the covered plots was significantly higher than the controls'.

Although there was not always a consistent yield difference between the investigated mulch materials, a trend emerged over the years that plots mulched with compost produced the most potatoes, followed by walnut leaves and mixed leaves mulch, which did not differ from each other, and finally straw mulch, which any year was also not different from the control. We have shown that the cover made of walnut leaves is clearly a better cover material for potatoes than straw, and is not inferior to the mulch made of mixed leaves.

There was no statistically detectable difference in the damage caused by pests and pathogens under the different mulch materials. The literature explains this by stating that if the mulch material is not thick enough, the favorable effects cannot be observed either. To this end, it would be worthwhile to increase the amount of mulch materials applied. The two types of sowing are also a special feature of the thesis, they were hardly used in potatoes, and their effect on pests or pathogens were not investigated. Although abandoning sowing in the soil did not change the total yield and the mass of damaged tubers, thanks to the method the number of cut tubers was reduced, which is important not only for aesthetic problems but also for minimizing infections during storage. Sowing under mulch increased the number of green tubers in some treatments, but it can be easily avoided with more careful covering. We can draw the conclusion that sowing on the soil surface reduces the work required for sowing and harvesting, without reducing the quantity of the crop or deteriorating its quality.

4.2. In vivo and in vitro microorganism interaction experiments (2016–2018)

During the experiments, the covering materials had neither a negative nor a positive effect on the tested microorganisms. We know from the literature that as the microbiome of the soil enriches under mulch, its suppressiveness also increases, and the natural microbiological conditions make the effect of microorganisms more uncertain. The explanation for the lack of the expected effect is therefore to be found in the soil. If the assumption regarding the suppressiveness of the soil is true, we recommend the combined use of microorganisms in combination with mulch primarily in areas with an impoverished microbiome, because there it is expected that they would have a greater impact on the growth of the plant and its pests and pathogens

During the laboratory test, we hypothesized that the much more intense growth antagonist does not allow other microorganisms to grow. This antagonistic effect occurred when *T. asperellum* was exposed to *M. anisopliae* spores within 48 hours. Later, however, *M. anisopliae*, more developed than 48 hours, also showed an antagonistic effect against the T. asperellum. The key to the joint applicability of the two useful microorganisms is that if we want to give *M. anisopliae* a time advantage, it should not exceed 48 hours.

4.3. Consumption of *Fusarium solani* mycelia and potatoes by isopods

During the laboratory experiment, we determined isopods role in stopping the spread of *Fusarium solani* infection, and showed that, in the absence of alternative food, they consume both intact and infected potato tubers. We assume that their higher number of individuals in the covered plots was not due to potatoes, but to many other alternative food and hiding places provided by the cover materials. In such an environment, they probably do not cause damage to the potato tubers, but at the same time they may play a role in the consumption of certain formulas of the pathogens, as has already been proven by numerous studies on the subject.

4.4. Suggestions

I recommend the long-term use of organic mulches, especially compost, walnut leaves and mixed leaves, in home garden potato cultivation, because in addition to their many positive effects, they increase the yield of potatoes, but at the same time do not increase the proportion of damaged tubers. In addition to the above benefits, by abandoning soil sowing and using mulch of suitable thickness, we can reduce the work required for sowing and harvesting and increase the yield of intact potatoes without cutting.

5. New scientific results

1) Examining the mulching effect of walnut leaves, walnut-free mixed leaves, and residential compost, I was the first to show that all three mulches have a positive effect on total yield and intact tuber yield compared to straw and the unmulched control.
2) I found that the effect of walnut leaves on potato yield and intact tuber yield is not different from that of mixed leaves, I did not experience any allelopathic effect of walnut leaves on potatoes.
3) I found that the most potatoes were produced under compost mulch, followed by walnut leaves and mixed leaves, and straw did not increase the yield of potatoes. Examining the intact tuber output, I established this order.
4) Examining the combined effects of two types of sowing methods (sowing into the soil or on the soil surface) with mulch, I was the first to show that there was no difference between the two sowing methods in the yield of potatoes or in the yield of intact tubers.
5) By examining the effect of the Symbivit preparation containing *Glomus* species, *Metarhizium anisopliae* and *Trichoderma asperellum* in the open field, on potato, covered with different organic materials, I was the first to show that neither when applied alone nor when applied in combination, they did not increase the yield or reduce the proportion of damaged potato tubers.
6) In a laboratory experiment, I established that if we provide a time advantage (12–24 hours) for *M. anisopliae*, it can compete with *T. asperellum* in colony growth, so there is no obstacle to their common use in the open field.

6. Scientific publications related to the topic of the dissertation

Publications in foreign languages in peer-reviewed, scientific journals:

- Mészárosné Póss A., **Südiné Fehér A.**, Póss A., Turóczi Gy., Tóth F. (2022): The Spread of the Soil-Borne Pathogen *Fusarium solani* in Stored Potato Can Be Controlled by Terrestrial Woodlice (Isopoda: Oniscidea). *Agriculture, 12 (1):* 45.
- **Südiné Fehér A.**, Turóczi Gy., Tóth F. (2023): Potato (*Solanum tuberosum* L.) Soil Covering with Organic Matter: Results and Knowledge gap. *Acta Phytopathologica et Entomologica Hungarica,* befogadva.
- **Südiné Fehér A.**, Zalai M., Turóczi Gy., Tóth F. (2023): Six-year results on the effect of organic mulching on potato yield and tuber damages. *Plant, Soil and Environment*, benyújtva.

Publications in Hungarian in peer-reviewed, scientific journals:

- **Fehér Anikó**, Ambrus G., Turóczi Gy., Tóth F. (2016): Szerves talajtakarás hatásának vizsgálata a burgonyagumót károsító kártevők és kórokozók jelenlétére illetve kártételére. *Növényvédelem, 77 (52) 7*: 339-343.
- **Fehér A.**, Póss A., Turóczi Gy., Tóth F. (2017): Különböző szerves talajtakaró anyagok talajlakó károsítókra gyakorolt hatásának vizsgálata burgonya tesztnövény segítségével. *Növényvédelem, 78 (53) 9:* 399-404.
- **Südiné Fehér A.**, Erdős E., Tóthné Bogdányi F., Turóczi Gy., Tóth F. (2019): *Metarhizium anisopliae* és *Trichoderma asperellum* kölcsönhatásának vizsgálata laboratóriumi és szabadföldi körülmények között. *Növényvédelem, 80 (55) 7:* 295-303.

Other evaluable journal articles:

- **Südiné Fehér A.** (2018): Mikorrhiza: miként lehet hasznos a biológiai növényvédelemben? *Agrofórum Online*
- **Südiné Fehér A.** (2018): Miből lesz a cserebogár és miből a rózsabogár? *Agrofórum Online*
- **Südiné Fehér A.,** Mészárosné Póss A., Turóczi Gy., Tóth F. (2017): Termésnövelés és károsítók elleni védekezés burgonyában szerves talajtakaró anyagokkal. *Biokultúra 28 (5): 14 –15.*
- **Südiné Fehér A.**, Turóczi Gy., Tóth F. (2019): Jó, ha takarjuk a talajt. *Kertészet és Szőlészet,* 2019 (68) 8: 10–11.

- Tóth F., **Südiné Fehér A.** (2022): Szerves talajtakarással az ép bioburgonyáért, avagy átállás forgatás nélküli talajművelésre a biokertészetben. *Agrofórum: a növényvédők és növénytermesztők havilapja,* 2022 (33) 1: 90-92.

Abstracts published in a foreign language conference publication

- **Fehér A.**, Póss A., Turóczi Gy., Tóth F. (2017): The effect of two isopod species (*Porcellionides Pruinosus* and *Porcellio Scaber*) on *Fusarium solani* infection, and their damage to potato in laboratory experiment. *10th International Symposium on the Biology of Terrestrial Isopods*. Abstracts.

Abstracts published in Hungarian conference publication:

- Balázs N., Mészárosné Póss A., **Südiné Fehér A.**, Turóczi Gy., Tóth F. (2018): Szárazföldi ászkarákok (*Porcellionides Pruinosus, Porcellio Scaber*) kórokozó-fogyasztásának vizsgálata laboratóriumi körülmények között. . In: Haltrich A., Varga Á. (szerk.): *64. Növényvédelmi Tudományos Napok,* poszterek, 105.
- **Fehér A.**, Ambrus G., Turóczi Gy., Tóth F. (2016): Szerves talajtakarás hatása a burgonyagumó egyes károsítóira és a termésmennyiségre. In: Horváth J, Haltrich A, Molnár J. (szerk): *62. Növényvédelmi Tudományos Napok*, Előadások összefoglalói, 101, 96.
- **Fehér A.**, Ambrus G., Turóczi Gy., Tóth F. (2016): Szerves talajtakarás hatása a burgonyagumó egyes károsítóira és a termésmennyiségre. *NATURA 2000 területek természetvédelmi vizsgálatai, élőhelykezelései, fenntartási tapasztalatai a „Fenntartható fejlődés a Kárpát-medencében III." című konferenciasorozat keretében*. Absztraktkötet, 40.
- **Fehér A.**, Póss A., Turóczi Gy., Tóth F. (2017): Különböző szerves talajtakaró anyagok talajlakó kártevőkre gyakorolt hatásának vizsgálata burgonya tesztnövény segítségével. In: Horváth J., Haltrich A., Molnár J. (szerk.): *63. Növényvédelmi Tudományos Napok*, Előadások összefoglalói, 110. 45.
- **Fehér A.**, Tóth F. (2017): A szerves talajtakarás növénytermesztési és növényvédelmi előnyei. *Országos fenntarthatósági Szakmai Nap* 2017. *UNI-NKE.*
- Putnoki Csicsó Barna, **Fehér Anikó**, Petrikovszki Renáta, Póss Anett és Tóth Ferenc (2016): Szerves talajtakarás hatása bagolylepkehernyók *(Lepidoptera, Noctuidae)* kártételére paradicsomban és burgonyában. *A Magyar Tudomány Napja Erdélyben, Agrártudományi Szakosztály XII. Konferenciája*, Programfüzet és Kivonatfüzet, 22-23.

- **Südiné Fehér A.** (2018): Szerves talajtakaró anyagok, különböző mikro- és makroorganizmusok, valamint ezek kombinációinak hatása a burgonya ép gumókihozatalára és talajlakó károsítóira. In: Áldorfai György (szerk). (2018): SZIE Kiváló Tehetségei Konferencia Előadásainak Összefoglaló Kiadványa, 157. 103.
- **Südiné Fehér A**., Erdős E., Turóczi Gy. És Tóth F. (2019): *Metarhizium anisopliae* és *Trichoderma asperellum* kölcsönhatásának vizsgálata laboratóriumi és szabadföldi körülmények között. In: Haltrich A., Varga Á. (szerk.): *65. Növényvédelmi Tudományos Napok,* Előadások összefoglalói, 108. 38.
- 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. In: Haltrich A., Varga Á. (szerk.): *64. Növényvédelmi Tudományos Napok,* Előadások összefoglalói, 105.