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THE INFLUENCE OF COVER CROPS AND ANTAGONISTIC FUNGI ON THE HEALTHINESS OF CARROT (*DAUCUS CAROTA* L.)

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Abstract

Cover crops and antagonistic fungi have a very positive effect on the soil environment. Such cover crops as oats, rye, common vetch, tansy phacelia, white mustard, sunflower and fodder radish can be used in the cultivation of different species of vegetables. They increase the biological activity of the soil by stimulating the growth and development of microorganisms antagonistic and can protect cultivated plants from soil-borne phytopathogens. The purpose of the field and laboratory studies was to determine the antagonistic activity of selected fungi species occurring in the soil under carrot cultivated with the use of oats, tansy phacelia and spring vetch as cover crops. The healthiness of the roots of this vegetable was also investigated. Cover crops contributed to the increase of the population of antagonistic fungi (Trichoderma spp., Clonostachys spp., Myrothecium spp. and Penicillium spp.) in the soil. Regardless of the experimental treatment, those antagonistic fungi were most effective in limiting the growth of Sclerotinia sclerotiorum, Alternaria dauci and A. radicina. The effect of those fungi was a little smaller towards Fusarium oxysporum and Rhizoctonia solani. Oats and spring vetch were most effective in limiting the occurrence of soil-borne fungi. Cover crops had a positive effect on the healthiness of carrot roots. Alternaria dauci, A. alternata, A. radicina, Fusarium oxysporum, Globisporangium irregulare, Neocosmospora solani, Phytophthora sp., Rhizoctonia solani and Sclerotinia sclerotiorum proved to be the most harmful towards the studied underground parts of carrot. Oats proved to be the most effective in inhibiting the occurrence of the pathogenic fungi for Daucus carota L.

Key words*: Daucus carota L., cover crops, soil-borne fungi, phytopathogens, healthiness of plants.*

INTRODUCTION

Cover crops and antagonistic fungi have a very positive effect on the soil environment. Such cover crops as oats, rye, common vetch, tansy phacelia, white mustard, sunflower and fodder radish can be used in the cultivation of different species of vegetables. They increase the biological activity of the soil by stimulating the growth and development of microorganisms antagonistic and can protect cultivated plants from soil-borne phytopathogens (Hallama et al., 2019; Schmidt et al., 2018).

Cover crops can increase the number antagonistic microorganisms in the soil and improve the quality of the plants yield (Himmelstein et al., 2016; Oliveira et al., 2016).

MATERIALS AND METHODS

The field experiment was conducted in district of Lublin (22º56'E, 51º23'N, Central Eastern Poland, 200 m a.s.l.), on Haplic Luvisol formed from silty medium loams. The object of the studies was the soil taken from the field where carrot cv. 'Flakkee 2' was cultivated.

The experiment took into consideration cover crops such as oats (*Avena sativa* L.), spring vetch (*Vicia sativa* L.), tansy phacelia (*Phacelia tanacetifolia* Benth.) and one system of soil tillage, i.e.: tillage before winter (ploughing) and spring tillage (a combined cultivator). The conventional cultivation, i.e. without any cover crops, was the control.

Microbiological analysis of the soil was made according to the method described by Patkowska and Błażewicz-Woźniak (2014). All fungi isolates from the genera of *Clonostachys, Myrothecium, Penicillium* and *Trichoderma*, obtained from particular experimental treatments, were used to establish their antagonistic effect towards such fungi as *Altenaria dauci, Alternaria radicina, Fusarium oxysporum, Rhizoctonia solani* and *Sclerotinia sclerotiorum*. Moreover, the healthiness of carrot roots were determined.

The mycological analysis was conducted according to the method described by Patkowska and Krawiec (2016) for pea. This

analysis made it possible to determine the quantitative and qualitative composition of fungi infecting the underground organs of carrot.

RESULTS AND DISCUSSIONS

Cover crops contributed to the increase of the population of antagonistic fungi (*Trichoderma* spp., *Clonostachys* spp., *Myrothecium* spp. and *Penicillium* spp.) in the soil. Regardless of the experimental treatment, those antagonistic fungi were most effective in limiting the growth of *Sclerotinia sclerotiorum* (Figure 1), *Alternaria dauci* and *A. radicina.* The effect of those fungi was a little smaller towards *Fusarium oxysporum* and *Rhizoctonia solani. Trichoderma* spp. and *Clonostachys* spp. can limit the occurrence of soil pathogens and they improve the plants' healthiness (Sarma et al., 2014; Smitha et al., 2014).

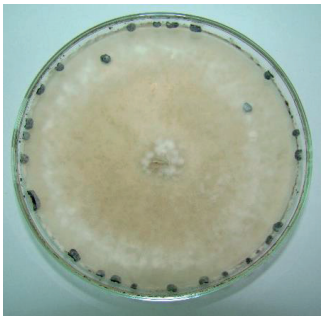

Figure 1. The 10-days colony of *Sclerotinia sclerotiorum* on the malt medium (photo by E. Patkowska)

Oats and spring vetch were most effective in limiting the occurrence of soil-borne fungi. A similar effect of the studied fungi antagonistic towards different species of pathogenic fungi was shown by Patkowska and Konopiński (2014) in the cultivation of scorzonera where cover crops were used. Banaay et al. (2012), Krauss et al. (2013) and Teshome et al. (2013) report that the ability of *Trichoderma* spp., *Clonostachys* spp. and *Penicillium* spp. to inhibit the growth and development of plant pathogens is based on antibiosis, competition and parasitism.

Cover crops had a positive effect on the healthiness of carrot roots. After the harvest of carrot, among fungi considered to be pathogenic, species from the genera of *Alternaria, Fusarium*, *Phytophthora, Rhizoctonia* and *Sclerotinia* were isolated from diseased roots (Table 1). A little more the enumerated fungi were isolated from the infected roots of carrot (Figure 2) cultivated conventionally or after tansy phacelia as a cover crops, while the least after oats.

Figure 2. Sclerotia and mycelium of *Sclerotinia sclerotiorum* on the carrot roots (photo by E. Patkowska)

Table 1. Fungi isolated from diseased roots of carrot after harvest

Fungus species	Experimental treatment/Number of isolates										
	Oats		Spring vetch		Tansy phacelia		Control		Total		Total (%)
	a*	b	a	b	a	b	a	b	a	b	
Acremonium murorum (Corda) W. Gams	-	-	-	-	3	-	4	2	8	2	10 (1.5)
Alternaria alternata (Fr.) Keissl.	1	-	3	-	5	2	16	6	25	8	33 (4.8)
Alternaria chartarum Preuss	-	-	-	-	3	-	9	3	12	3	15 (2.2)
Alternaria dauci (J.G. Kühn) J.W. Groves & Skolko	1	-	1	-	4	2	11	6	17	8	25 (3.6)
Alternaria radicina Meier, Drechsler & E.D. Eddy	1	-	1	-	6	4	17	14	25	18	43 (6.3)
Cladosporium cladosporioides (Fresen.) G.A.de Vries	-	-	-	2	2	3	6	3	8	8	16 (2.3)
Clonostachys rosea (Link)	11	9	9	7	6	3	-	-	26	19	45 (6.6)

Schroers, Samuels, Seifert & W. Gams											
Cylindrocarpon didymum (Harting) Wollenw.	-	-	-	-	3	2	8	4	11	7	18 (2.6)
Epicoccum nigrum Link	-	-	1	-	2	2	7	3	10	5	15 (2.2)
Fusarium avenaceum (Fr.) Sacc.	-	-	-	-	2	2	6	4	8	6	14 (2.0)
Fusarium oxysporum Schltdl.	4	2	6	4	8	4	10	6	28	16	44 (6.4)
Neocosmospora solani (Mart.) L. Lombard Crous	-	-	2	2	3	5	8	3	13	10	23 (3.3)
Penicillium aurantiogriseum Dierckx	2	1	3	1	4	2	8	4	17	8	25 (3.6)
Penicillium chrysogenum Thom	-	-	-	1	2	1	5	3	7	5	12 (1.7)
Penicillium meleagrinum Biourge	-	-	-	-	3	2	9	5	12	7	19 (2.8)
Penicillium simplicissimum (Oudem.) Thom	-	-	-	-	1	-	6	4	7	4	11 (1.6)
Phytophthora sp.	2	-	2	1	4	2	6	5	16	8	24 (3.4)
Rhizoctonia solani J.G. Kühn	5	3	7	4	8	6	12	10	32	23	55 (8.0)
Rhizopus stolonifer (Ehrenb.) Vuill.	2	3	3	2	8	3	16	8	29	16	45 (6.5)
Sclerotinia sclerotiorum (Lib.) de Bary	2	2	5	3	7	5	14	12	28	22	50 (7.3)
Trichoderma harzianum Rifai	7	5	6	4	5	3	2	-	20	12	32 (4.6)
Trichoderma koningii Oudem.	14	12	12	10	10	9	3	3	39	34	73 (10.6)
Trichoderma viride Pers.	10	7	8	5	6	4	2	-	26	16	42 (6.1)
Total	62	44	69	46	105	66	186	108	422	264	686 (100.0)
Total	106		115		171		294		686		

a* - root; b - head of root

Studies by Koike et al. (2017) and Zafar et al. (2017) also pointed to considerable harmfulness of these fungi towards carrot plants. According to Rogers and Stevenson (2010), Tülek and Dolar (2015) and Zafar et al. (2017), fungi, especially *Alternaria dauci*, *A. radicina*, attacked carrots at all stages, causing damping-off, and rotting of roots, crowns, seedlings, petioles, leaves and crowns of maturing carrots.

Studies conducted by Patkowska et al. (2016) and Dawadi et al. (2019) showed that cover plants (rye, oats, white mustard) significantly reduce the population of pathogenic fungi in the soil environment, thus positively affecting the healthiness of the cultivated plants.

CONCLUSIONS

The present studies confirmed the positive effect of cover crops on the growth and healthiness of *Daucus carota.*

Oats, tansy phacelia and spring vetch inhibited the occurrence and development of soil-borne fungi and - consequently - improved the healthiness of the examined plant.

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