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OCCURRENCE OF MITES (*ACARI*) IN THE SOIL OF A BLACKCURRANT PLANTATION AFTER APPLICATIONS OF ORGANIC MULCHES AND MYCORRHIZAL INOCULUM

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Abstract

The study was conducted in the Pomological Orchard of the Research Institute of Horticulture in Skierniewice on a plantation of blackcurrant cultivar 'Tiben'. The following variants of the experiment were applied: control – NPK fertilization only, mulching with a peat substrate, shredded pine bark, sawdust of coniferous trees, bovine manure, plant compost, straw of cereals, and application of mycorrhizal inoculant MYKOFLOR. Mulching was performed each year in the spring in an amount of 25 dm^3 per plot, and the inoculum was applied in an amount of 10 ml per shrub. Samples for acarological examinations were collected at 4 times, in the spring and autumn of successive seasons in 2012-2013. An increase in the overall density of mites, in comparison with the control surface, was observed after mulching the soil with sawdust of coniferous trees and plant compost. On all the plots, the communities of mites were dominated by mites of the order oribatid mites. For these mites, a statistically significant increase density was recorded after mulching the soil with sawdust of coniferous trees, bovine manure and plant compost. Mulching did not increase significantly the species diversity of oribatid mites. The soil of the blackcurrant plantation was found to be inhabited by relatively large numbers of two common oribatid mites species: Punctoribates punctum and

Tectocepheus velatus. An increase in the population density of Punctoribates punctum was observed after mulching with peat, sawdust and compost.

Keywords: organic mulches, mycorrhizal inoculum, bioindication, soil acarofauna, oribatid mites.

INTRODUCTION

The use of organic mulches on horticultural plantations is one way to increase the organic matter content of soils. This treatment has a positive effect on the biological activity of the soil, improves the gaseous exchange between the atmosphere and the soil, and improves its sorption capacity (Derkowska *et al*. 2013). In addition, e.g. in the summer, mulches of straw, sawdust and bark provide good insulation and protect the soil from overheating (Kęsik and Maskalaniec 2005). Mulching of the soil also creates favourable conditions for the development of microorganisms and small soil fauna (Forge *et al*. 2003).

On the other hand, the use of mycorrhizal inocula can contribute to increasing the species diversity of arbuscular mycorrhizal fungi (AMF), and affect, indirectly, the health and growth of cultivated plants (Sumorok *et al*. 2011).

The importance of small soil fauna is most often underestimated, with enzymatic and respiratory activity, and the biomass, composition and numbers of microorganisms being considered the best indicators of the biological activity of soils (Olszowska *et al*. 2005, Brzezińska 2006). Haimi (2000) is of the opinion that soil animals can also be used as indicators of the biological condition of soils. The presence of numerous soil mesofauna, including mites (*Acari*), should have a positive impact on the overall biodiversity of soils and ensure greater stability of the soil system. Moreover, mites, and especially oribatid mites (*Oribatida*), can act as vectors of many beneficial microorganisms, such as mycorrhizal and saprotrophic fungi (Setala 1995, Renker *et al*. 2005, Remén et al. 2010).

The aim of this study was to know the impact of following the use organic mulches and mycorrhizal inoculum on the density and structure of mite communities, and species composition of oribatid mites in the soil of a 'Tiben' blackcurrant plantation.

MATERIAL AND METHODS

Acarological examinations were conducted in 2012-2013 in the Pomological Orchard of the Research Institute of Horticulture in Skierniewice (51°57'36.1"N 20°09'42.6"E). Blackcurrant shrubs of the cultivar 'Tiben' were planted in August 2003. The experiment was set up in 4 replicates (3 shrubs per plot); the spacing between the shrubs was 3.25 m × 0.5 m. The experiment consisted of the following variants: control (C) – without mulching or mycorrhization, mulching with peat substrate (Pe), mulching with shredded pine bark (Ba), mulching with sawdust of coniferous trees (Sa), mulching with bovine manure (Ma), mulching with plant compost (Co), mulching with the straw of cereals, mainly rye (St), application of mycorrhizal inoculum (My) – MYKOFLOR (AMF strains: *Glomus intraradices*, *G. mosseae, G. etunicatum*).

Mulching was carried out every year in the spring in the amount of 25 dm^3 per plot. In the My variant,, the inoculum was applied in the amount of 10 ml per shrub in the spring of each year. All the variants of the experiment were fertilized in a standard way with NPK (60 kg N ha^{-1}, 60 kg P ha^{-1}, 80 kg K ha^{-1}). The plants were irrigated by a computer-controlled system.

Samples for acarological examinations were collected in the spring and autumn, at 4 times on the following dates: 31 May 2012, 23 October 2012, 17 June 2013, 18 October 2013. Soil samples with dimensions of 17 cm^2 × 3 cm deep were taken from each variant in 10 replicates (2 or 3 per plot). In total, 320 soil samples were collected. Mites were extracted in Tullgren funnels for 7 days, and then preserved in 70% ethanol and prepared for examination. Adult and juvenile stages of oribatid mites were identified to the level of species or genus. Other mites were classified into orders. The analysis included 4,448 *Acari*; 3,161 of which were oribatid mites. The average density (*N*) of mites was expressed per 1 m^2 of soil, the dominance ratio (*D*) in %, and the species diversity of oribatid mites was expressed by the number of species (*S*), the average number of species per sample for a series of 40 samples (*s*), and by the Shannon species diversity index (*H'*) (Magurran 1988).

Before the statistical analysis, numerical data were transformed logarithmically – ln(x+1) (Berthet and Gerard 1965). The analysis was performed using Statistica 10.0 software: assessment of the goodness of fit of the distribution of measurable parameters with a normal distribution was performed with the Kolmogorov-Smirnov test; because no distribution fitted the normal distribution, nonparametric analysis of variance (Kruskal-Wallis test) was performed; for statistically significant differences ($p<0.05$), analysis was performed for each pair (Mann-Whitney *U* rank-sum test) to select significantly different means.

RESULTS AND DISCUSSION

Size and structure of mite communities

Mites, and especially oribatid mites, are considered good bioindicators of the biological condition of soils (Behan-Pelletier 1999, 2003, Ruf and Beck 2005, Gulvik 2007). Their numerous presence can therefore provide evidence as to the biological balance of soils being studied. In the present study, the lowest density of mites was recorded on the control plot C – 5,730 individuals m^{-2} (Table 1). On the plots enriched with mulches the density of these arthropods was higher – from 6,680 to 11,810 individuals m^{-2}. However, a statistically significant increase in the density of mites (Mann-Whitney *U* test) was found only in the variants involving mulching with sawdust (Sa) and compost (Co). The application of mycorrhizal preparation did not affect the density of these arthropods. For comparison, the density of soil mites on a blackcurrant plantation near Bydgoszcz was slightly lower than on the plots after mulching – it ranged from 6,460 to 7,600 individuals m^{-2} (Klimek and Rolbiecki 2009).

On all the plots, the mite communities were dominated by mites of the order oribatid mites – *D* ranged from 58.6 to 84.7% of all the mites (Fig. 1). In the experimental variants with the use of organic mulches the percentage share of oribatid mites in mite communities was higher compared with the C variants and application of mycorrhizal inoculum (My). A high, statistically significant, increase in the density of oribatid mites, compared with the control surface, was observed after mulching the soil with sawdust of coniferous trees, bovine manure, and plant compost (Table 1). The ratio of densities of mites of the orders *Oribatida* and *Actinedida* (*Or/Ac*) is considered a good indicator of the quality and stability of the soil environment (Werner and Dindal 1990, Gulvik 2007). The ratio *Or/Ac* below 1.0 is recorded on arable land, and above this value in more stable, less frequently disturbed, ecosystems: e.g. on semi-natural meadows and in forests, where generally one finds a considerable share of organic matter. In this experiment, after the application of organic mulches, an increase in the *Or/Ac* ratio was observed (Table 2). It reached the highest value (20.27) in the variant Ma.

Table 1. Density of mites (*N* in 1000 individuals m^{-2}) in studied variants of the experiment

Taxon	Variant of the experiment								Kruskal-Wallis test	
	C	Pe	Ba	Sa	Ma	Co	St	My	*H*	*p*
Acaridida	0.86	1.26	0.23	0.96	0.36	1.02	0.48	0.48	5.24	0.630
Actinedida	1.20	1.63	1.60	1.29	0.39	1.37	0.69	1.52	14.43	0.043
Mesostigmata	0.23	0.56	0.27	0.38	0.62	0.54	0.29	0.39	12.00	0.100
Oribatida	3.40	6.52	5.51	6.98*	7.93*	8.68*	5.16	3.39	18.30	0.010
Tarsonemida	0.05	0.20	0.03	0.17	0.06	0.20	0.06	0	11.66	0.112
Acari (Total)	5.73	10.16	7.63	9.78*	9.36	11.81*	6.68	5.78	14.26	0.046

Explanations: * – significant differences between the C and other variants – a the Mann-Whitney *U* test at $p < 0.05$
Source: own research data

	C	Pe	Ba	Sa	Ma	Co	St	My
Acaridida	15.0	12.4	3.0	9.8	3.9	8.7	7.2	8.3
Actinedida	21.0	16.0	20.9	13.2	4.2	11.6	10.4	26.3
Gamasida	3.9	5.5	3.6	3.8	6.6	4.6	4.3	6.8
Oribatida	59.3	64.1	72.2	71.4	84.7	73.5	77.3	58.6
Tarsonemida	0.8	1.9	0.4	1.7	0.6	1.7	0.9	0.0

Source: own research data

Figure 1. Dominance of mites communities (D in %) studied variants of the experiment

Less numerous than the already mentioned orders of mites were those represented by *Acaridida*, *Mesostigmata* and *Tarsonemida* (Table 1). The densities of their communities in the individual experimental variants were mostly uniform.

Table 2. The ratio of density *Oribatida* to *Actinedida* (*Or/Ac*), number species (*S*) of oribatid mites, average number of species (*s*), and Shannon *H'* index in studied variants of the experiment

Index	Variant of the experiment								Kruskal-Wallis test	
	C	Pe	Ba	Sa	Ma	Co	St	My	*H*	*p*
Or/Ac	2.83	4.01	3.45	5.40	20.27	6.34	7.46	2.23	-	-
S of *Oribatida*	2	6	8	4	5	6	5	6	-	-
s of *Oribatida*	1.23	1.45	1.60	1.75	1.70	1.53	1.38	1.33	11.49	0.118
H' of *Oribatida*	0.68	0.72	1.02	0.78	0.78	0.67	0.89	0.87	-	-

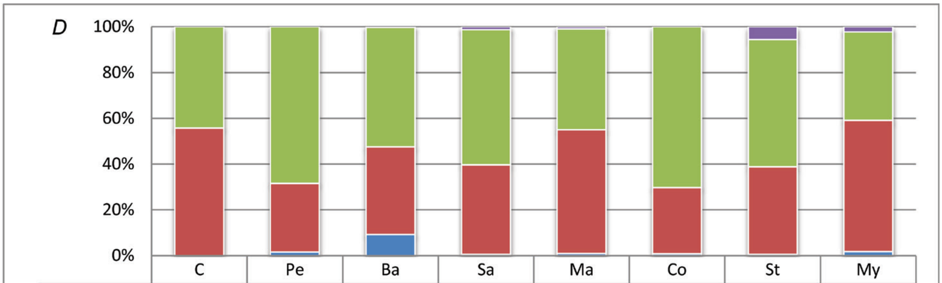
Source: own research data

Species diversity of oribatid mites

In total, 12 species of oribatid mites were recorded on the blackcurrant plantation under study (Table 3). The smallest number of species (2) were found on the control plot. The plots enriched with mulches and the mycorrhizal preparation were inhabited by 4 to 8 species of mites. However, the average number of species per sample *s* was uniform (1.23-1.75), and there were no statistically significant differences between the individual variants of the experiments. Also relatively uniform was the Shannon index of the overall species diversity *H* – 0.68-1.02. The species diversity of oribatid mites determined in this study should be regarded as relatively low. For comparison, in the soil of the blackcurrant plantation near Bydgoszcz – tested using similar methods – from 18 to 21 species of oribatid mites had been reported, *s* was 2.80-3.17 and *H* 1.73-2.14 (Klimek and Rolbiecki 2009).

Analysis of the occurrence of selected oribatid mites species

The communities of oribatid mites in the area under study were dominated by two species: *Punctoribates punctum* (5 times) and *Tectocepheus velatus* (3 times) (Fig. 2). High density of *Punctoribates punctum* (4,120-6,100 individuals m^{-2}) was recorded after mulching with peat (Pe), sawdust (Sa) and compost (Co) (Table 3). The increase in population size on these surfaces, compared with the control plot, was statistically significant. *Punctoribates punctum* is a common oribatid mite in Poland, inhabiting meadows and forests, but preferring grasslands; it can also be found in areas of farmland (Seniczak and Seniczak 2008). It should be mentioned that this species has been found in large numbers in a patch of grass within the orchard complex in Dąbrowice, belonging to the Research Institute of Horticulture in Skierniewice (Klimek *et al*. 2014a, b).



	C	Pe	Ba	Sa	Ma	Co	St	My
O. nova	0	0	0.3	1.3	0.9	0	5.5	2.2
P. punctum	44.2	68.4	52.2	59.1	44.0	70.2	55.7	38.7
T. velatus	55.8	30.0	38.3	39.0	54.1	28.9	38.2	57.3
Others	0	1.6	9.3	0.6	0.9	0.9	0.6	1.8

Source: own research data

Figure 2. Dominance of oribatid mites communities (D in %) in studied variants of the experiment

One of the most common species in Poland is also *Tectocepheus velatus*, which dominated on the control plots and those with applications of mycorrhizal inoculum and mulched with manure (Fig. 2). The population density of this oribatid mite in the different variants of the experiment was, however, quite uniform (1,900-4,290 individuals m^{-2}), and no significant differences were found between the different variants. *T. velatus* is counted among fungivorous soil fauna (Luxton 1972, Ponge 1991, Remén *et al*. 2010). It is a common soil oribatid mite found in different biotopes (Weigmann and Kratz 1981). It is characterized by a high rate of reproduction and a high ability to colonize new environments.

Table 3. Mean species density of oribatid mites (*N* in 1000 individuals m^{-2}) under different variants of the experiment

Species	Variant of the experiment								Kruskal-Wallis test	
	C	Pe	Ba	Sa	Ma	Co	St	My	*H*	*p*
Brachychthonius sp.	0	0.06	0	0	0.06	0.05	0.02	0	11.75	0.109
Eupelops occultus (C.L. Koch)	0	0	0.02	0	0	0	0.02	0	6.01	0.537
Dissorhina ornata (Oudemans)	0	0	0	0	0.02	0.02	0	0	6.01	0.537
Galumna lanceata (Oudemans)	0	0	0.27	0	0	0	0	0.02	22.57	0.002
Oppiella nova (Oudemans)	0	0	0.02	0.09	0.08	0	0.29	0.08	14.95	0.036
Oribatula tibialis (Nicolet)	0	0.02	0.18	0	0	0	0	0	22.57	0.002
Punctoribates punctum (C.L. Koch)	1.51	4.45*	2.87	4.12*	3.49	6.10*	2.87	1.31	23.10	0.001
Ramusella mihelcici (Pérez-Íñigo)	0	0	0	0	0	0.02	0	0	7.00	0.428
Scheloribates laevigatus (C.L. Koch)	0	0	0	0	0	0	0	0.02	7.00	0.428
Suctobelba sp.	0	0	0.02	0	0	0	0	0	7.00	0.428
Tectocepheus velatus (Michael)	1.90	1.96	2.11	2.72	4.29	2.51	1.97	1.94	10.49	0.162
Trichoribates trimaculatus (C.L. Koch)	0	0.02	0.03	0.05	0	0	0	0.03	10.27	0.173

Explanations: see table 3.
Source: own research data

SUMMARY

There was an increase in the overall density of mites, in comparison with the control surface, after mulching the soil with sawdust of coniferous trees and plant compost.

On all the plots, the communities of mites were dominated by mites of the order oribatid mites. A statistically significant increase density of oribatid mites was recorded after mulching the soil with sawdust of coniferous trees, bovine manure and plant compost. Mulching did not contribute significantly to increasing the diversity of oribatid mites species.

In the soil of the blackcurrant plantation under study there were relatively large numbers of two common *Oribatida* species: *Punctoribates punctum* and *Tectocepheus velatus*. Increase in population density of *Punctoribates punctum* was observed after mulching with peat, sawdust and compost.

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