"KLIMENTS' DAYS"
Faculty of Biology, Sofia University "St. Kl. Ohhridski", 5th November 2020

Long Term Effects of Soil Fumigation on Nematode Community in a Greenhouse Continuous Cycle of Production

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Figure 1. Experimental area in Sadovo – August 2018

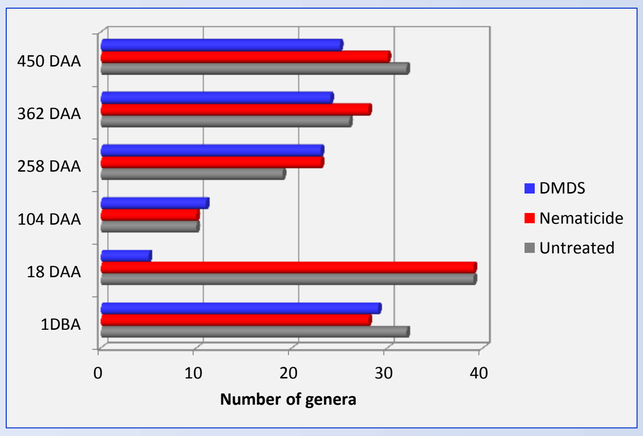

Figure 3. Taxonomical diversity of nematodes in experimental variants (days before and after application of DMDS)

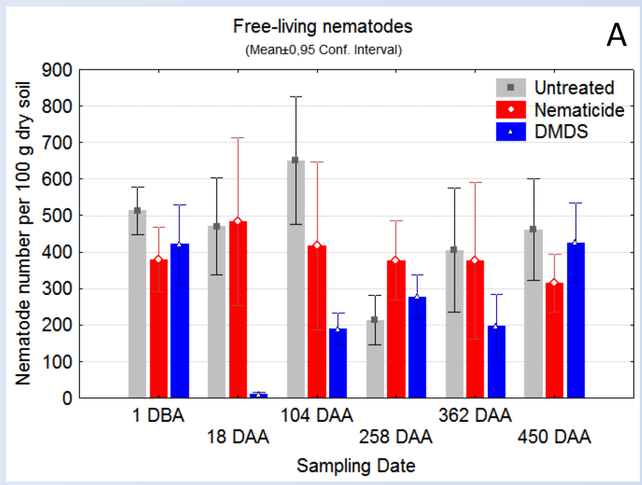

Figure 4. Abundance of free-living (A) and root-knot nematodes in experimental variants (days before and after application of DMDS)

Dimethyl Disulfide (DMDS) is a perspective nematicide with limited persistence in the environment, no long-term toxicological effects on plants and no adverse effect on the ozone layer. According to our knowledge no study followed the long term effects of fumigation with DMDS on target and other organisms. Nematodes are convenient as bioindicators because their representatives are almost in all groups of food webs in soil (Yeates et al., 1993) and several analytical instruments based on nematodes are widely used in assessment of soil stress (Bongers, 1990, 1999; Ferris et al., 2001).

The aim of this study is to evaluate long term effects of DMDS on soil nematode groups in greenhouse cucumber in comparison with the usual farmer practice.

Material and Methods

Effects of DMDS fumigation of soil on nematode communities was followed in 5 successive crops (cucumber-lettuce-lettuce-cucumber- cucumber) in greenhouse experiment. The trial was conducted in 3 variants: 1) DMDS – soil fumigant; 2) Nematicide (Fosthiazade-2018 and Oxamyl -2019) used by farmer and 3) Untreated control. The replicates of each of the variants were randomly placed in 170 m^2 of vegetable greenhouse established in 2007.

Soil nematodes were isolated from four bulk samples per each replicate. After Identification to genus level specimens were separated in trophic groups and functional guilds. Impact of fumigation was estimated on the base of analysis of food web condition in 6 different samplings – one before (BA) and five after the application of DMDS (AA).

Data from the assessments were analysed by variance analysis (ANOVA) with software Statistica 7.0 of StatSoft. If significant effect of the treatment was obtained differences between ranks of variants were checked with a Tukey's test ($p<0.05$). In the case of data showing heterogeneous variances ($P<0.05$) at *Levene Test of Homogeneity of Variances*, prior to the analysis the data were transformed with: Ln(X+1) recommended for *numbers or* Arcsine square root % [Arcsin √(%)] recommended for *percentage values*.

Results

Diversity of nematodes is relatively low - 44 genera were identified. Most of them belong to the group of bacterial feeding (18 genera), followed by omnivorous – 8, animal predators – 7, fungal feeding – 6 and plant parasitic nematodes – 5 genera/species (Fig. 2).

Root knot nematodes and Bacterial feeders dominated in all variants before treatment and in 2th and 3rd variants after fumigation. There was no significant difference between dominant groups between variants with conventional nematicide and control. Total abundance rapidly fell down after fumigation with DMDS in variant 1st and only single bacterial feeders and root knot nematodes were isolated in some of the subsamples. The most abundant genera and frequently occurring were bacterial feeding *Zeldia, Diploscapter* and *Cruznema*. They were the first that appeared in DMDS variant after treatment. All other groups had generally low abundance in all variants and were not represented after DMDS treatment. Their diversity recovered after 258 days after DMDS treatment Abundance of other groups was recovered after the 258 days after fumigation. On the other hand, abundance of gall nematode was significantly lower than other variants till a year after fumigation and four successive crops.

Table 1. Diversity and functional indexes of nematode community in different trial variants during study period

	1 DBA	18 DAA	104 DAA	252 DAA	362 DAA	450 DAA
Maturity Index (MI)						
Untreated	1,7	1,6	1,1	1,8	1,4	1,7
Nematocide	1,8	1,6	1,2	2,0	1,4	1,7
DMDS	2,0	1,8	1,6	1,5	1,6	1,8
Plant Parasitic Index (PPI)						
Untreated	3,0	2,9	3,0	3,0	3,0	3,0
Nematocide	3,0	2,9	3,0	3,0	3,0	3,0
DMDS	2,9	3,0	3,0	3,0	2,9	2,9
Taxonomic Richness (S)						
Untreated	31	37	9	16	25	31
Nematocide	28	37	10	21	26	29
DMDS	30	5	11	23	26	28
Shannon's Diversity Index (H')						
Untreated	2,0	2,3	1,2	1,6	1,9	2,1
Nematocide	1,8	2,4	1,0	1,3	2,0	1,7
DMDS	1,9	1,0	1,2	1,8	1,9	1,9
Evenness Index (Eχ)						
Untreated	0,6	0,6	0,5	0,6	0,6	0,6
Nematocide	0,5	0,7	0,4	0,4	0,6	0,5
DMDS	0,6	0,6	0,5	0,6	0,6	0,6

Figure 2. Experimental area in Sadovo – March 2019

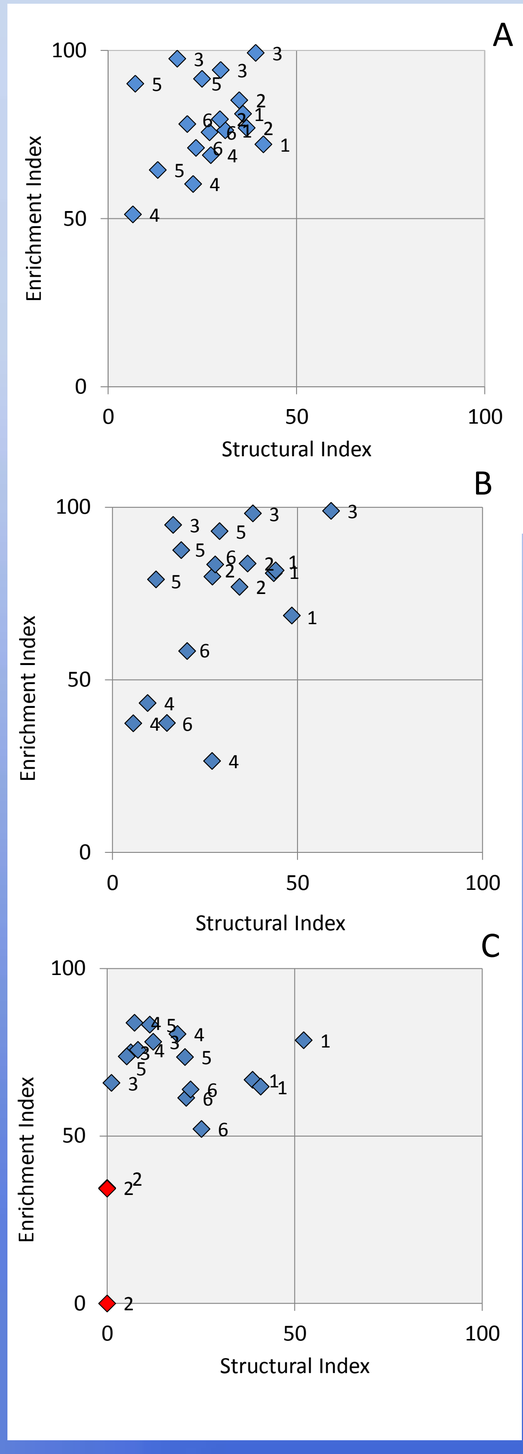

Figure 6. Soil trophic webs in variants (a – Untreated; b – Treated with nematicide; c – treated with DMDS) during whole study period (*Sampling*: **1** – before treatment; **2** – 18 days after treatment; **3** – 104 days after treatment at the end of Crop 1; **4** – after winter period, at the end of crop 3; **5** – a year after treatment at the end of crop 4, **6** – 450 days after treatment at the end of crop 5).

All used diversity and functional indexes as a measure of stress were not very appropriate in the case of our study (Table 1). That was the reason to try to evaluate soil food webs based on weighed nematode faunal analysis after Ferris et al. (2001). Food webs in whole trial area were characterized as N-enriched, with the prevalence of bacterial decomposition channels, low C:N ratio and disturbed. Stress in variant 1 after DMDS application corresponded with a depleted enrichment and degradation of food web conditions (Fig. 5). In all following samplings food web conditions recovered and were similar to those in untreated plots. In plots treated with nematicide usual for farmer practice a winter degradation of food web conditions was observed at sampling 4. Generally a higher variability was recorded there and degradation of food webs were registered even the last sampling – a year and four months after beginning of the experiment.

Final conclusion was that regardless pronounced negative effect of DMDS on the target group of root knot nematodes that fumigant had not long term effect on soil nematode communities in studied greenhouse area.

Acknowledgments. This work was partly supported by the bilateral contract ISSAPP-CERTIS /01.06.2018 (80%) and by BNSF under contract № КП-06-Н-36/12 2019 "GallNem" (20%).