The effect of humate fertilizer on earthworm community structure and crop yield

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Introduction

Humic substances are organic compounds that can improve soil properties by increasing soil fertility, water-holding capacity and provide energy for soil organisms, which is why the use of humate fertilizers can be a promising solution for sustainable agriculture. Earthworms among other soil organisms can be used to assess the sustainability of current and promising management practices due to their role in soil functioning and sensitivity towards changes in their environment.

This study aimed to investigate the impact of humate fertilizer applied at different rates on the earthworm community, microbial activity and the yield of *Brassica nigra* and winter wheat.

Material and methods

A field experiment with a split-plot design was established in 2020 to study the effect of granulated organic humate fertilizer applied at two rates – 100 ml/m^2 (HF100) and 500 ml/m^2 (HF500) in spring 2020. The humate fertilizer was produced from peat, poultry manure and wood ash and had the following properties: P 0.8 %, K 2.4 %, Ca 3.5% and Mg 1.3%. The experimental site was located near Tartu, Estonia (58°22'N, 26°40'E) at the Estonian University of Life Sciences' Eerika experimental field on *Stagnic Luvisol* soil.

Experiment design and field-site

CONTROL TREATMENT	CONTROL TREATMENT	CONTROL TREATMENT
HF100	HF100	HF100
HF500	HF500	HF500

After crop harvest, earthworms were collected from 50 x 50 x 40 cm soil blocks by a combination of hand-sorting (Meyer, 1996) and vermifuge (Gunn, 1992). Subsequently, earthworms were washed, dried and fixed in ethanol. The earthworms were determined using the identification key by Timm (1999). The respiratory activity of soil microorganisms was determined using the WTW OxiTop® system and microbial biomass was assessed by substrate-induced respiration (SIR) (Platen, Wirtz, 1999; Reuschenbach et al., 2003).

Results

The results showed that in the year of humate fertilizer application, the abundance and number of species were lowest for soils treated with HF500 and highest under HF100.

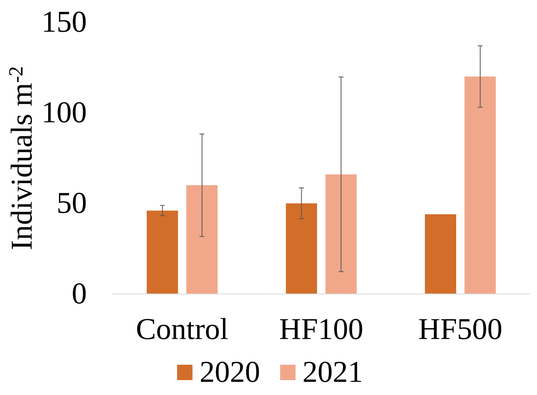

Figure1. Abundance of earthworms at different humate fertilizer rates

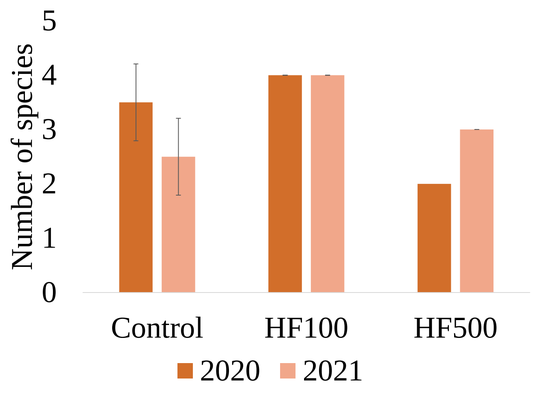

Figure 2. Number of earthworm species at different humate fertilizer rates

HF100 tended to have a more positive effect on species diversity and community structure indicated by the presence of epigeic species relative to HF500 treatment.

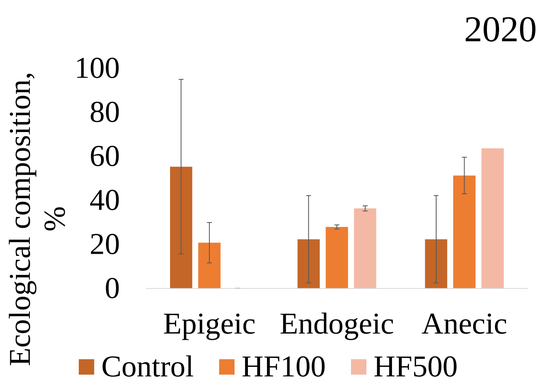

Figure 4. Ecological composition of earthworm community at different humate fertilizer rates in 2020

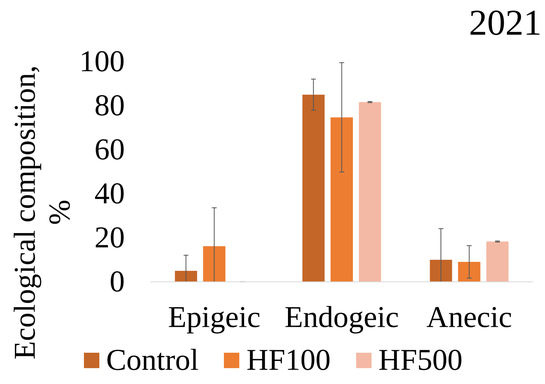

Figure 5. Ecological composition of earthworm community at different humate fertilizer rates in 2021

Photo: Mari Ivask

The number of species and the species present in the experimental field were typical for intensively managed Estonian agricultural soils. The absence of sensitive epigeic specie *Lumbricus rubellus* and the dominance of endogeic species *Aporrectodea caliginosa* and *Aporrectodea rosea* under HF500 treatment suggest limiting ecological conditions.

Table 1. Earthworm species under different treatments and years.

Species	2020			2021		
	Control	HF100	HF500	Control	HF100	HF500
Aporrectodea caliginosa (Savigny, 1826)	8	12	16	50	38	78
Aporrectodea longa (Ude, 1885)	10	24	28	4	4	22
Aporrectodea rosea (Savigny, 1826)	2	2	0	2	18	20
Lumbricus terrestris (Linnaeus 1758)	0	0	2	0	0	0
Lumbricus rubellus (Hoffmeister, 1843)	26	10	0	4	6	0

Soil respiratory activity was in a positive relationship with humate fertilizer rate (ρ=0.95, p=0.0138), which was 57% and 124% higher under HF500 treatment relative to HF100 and control on the year of soil amendment.

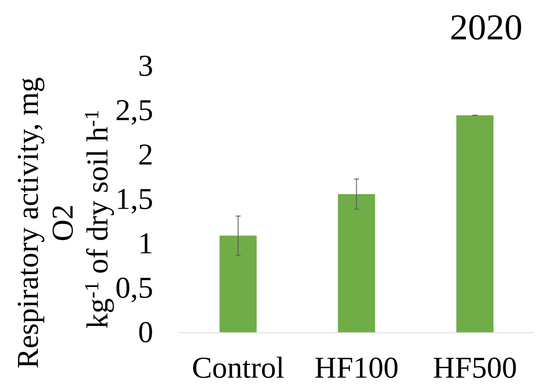

Figure 6. Soil respiratory activity at different humate fertilizer rate in 2020

Aporrectodea longa
Photo: Mari Ivask

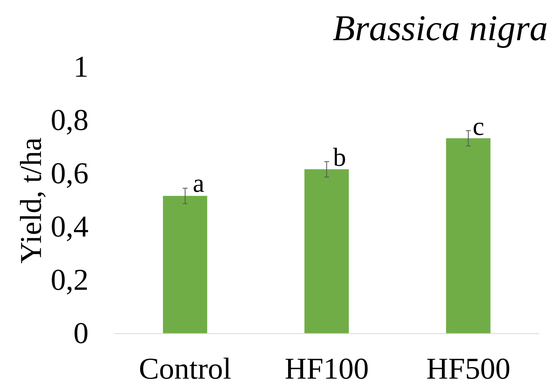

Figure 7. The yield of *Brassica nigra* in 2020. Different letters indicate statistically significant differences according to Tukey post-hoc test.

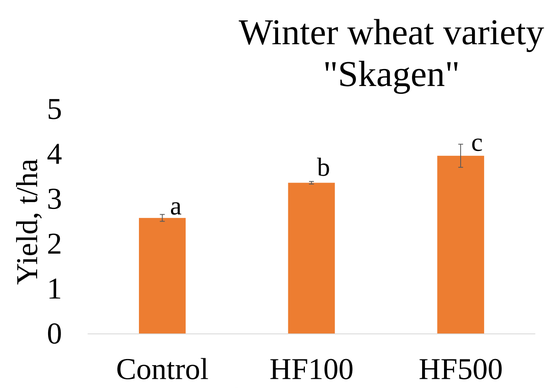

Figure 8. The yield of winter wheat in 2021. Different letters indicate statistically significant differences according to Tukey post-hoc test.

The treatment had a significant impact on the yield of *Brassica nigra* (F=42.3, p=0.0003) and winter wheat (F=59.7, p=0.0001). The yield of *Brassica nigra* was 19% and 42% higher under HF500 relative to HF100 treatment and control, respectively. A year after soil amendment, the yield of winter wheat was 18% and 54% higher for HF500 compared to HF100 and control.

Conclusions

- Higher rate of humate fertilizer had a negative influence on epigeic species. The epigeic live near the soil surface and can be more vulnerable to soil amendments.
- The negative impact of the use of a higher rate reduced in the subsequent year in terms of earthworm abundance and soil respiration stabilised, however, the differences in the earthworm community structure persisted.
- Humate fertilizers show great potential for improving crop yield, however, the long-term influence of applying high rates on soil biological properties and sustainability needs further investigation.

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