Bacterial-feeding nematodes as indicator of soil fertility in experimental fields of organically managed apple, cherry and grape trials

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Abstract

Soil fertility is an important pillar in organic agriculture and part of the four principles of organic practices laid down by the IFOAM. However, there are no commonly applied biological parameters, which reflect plant growth relevant soil fertility. In our study, we investigated whether the abundance of bacterial-feeding nematodes (Nbt) might be suited to reflect plant growth relevant soil fertility, as their N-need is less than they feed, and thus release proportionally much plant-available N as e.g. ammonia. At the research centre for organic agriculture (FiBL) in Frick (Switzerland), soil samples from long-term (8-10 years) field trials with grape vines, apple and cherry and with different fertilisation combinations (compost, commercial organic N fertiliser, bacterial preparation (BactoFil®2), compost press water and cover plant mulch) have been sampled in March, June and August 2015. They were analysed for the type (bacterial feeding vs. others) and number of nematodes. Also concentration of mineralized nitrogen (N_{min}) in the soil and SPAD values of the leaves as an indicator for nitrogen uptake, have been measured. As a general trend (occasionally significant) soil amended with compost showed higher numbers of nematodes, in particular Nbt or its proportion on total nematodes. N-mineralization in soil (N_{min}) and SPAD did not closely correlate with the number of Nbt, however its proportion to total nematodes correlated fairly well (R^2=0.47) with plant-uptake (SPAD) over all 3 crop species. The results show that further studies in this direction are promising to use nematodes as biological and plant growth relevant parameter of soil fertility.

Keywords: Bacterial-feeding nematodes, soil fertility, N_{min}, SPAD

Introduction

A healthy and biological active soil is a result of recycling processes and provides essential nutrients for the plants (Lampkin *et al.*, 2000). Microorganisms play an important role in the soil turn over processes (Yeates, 2003). Bacterial-feeding nematodes (Nbt) are the main grazer of bacteria and excrete ammonia besides other nitrogenous compounds. Nitrogen in form of ammonia can be taken up by the plant directly from the soil and is incorporated into the roots, stems and leaves (Bouwman *et al.*, 1994). There are numerous methods available to assess soil fertility. However, they vary in their complexity and applicability for practical farming (Lampkin *et al.*, 2000), and often the direct link for plant growth (e.g. the potential to mineralise N) is not obvious. Our study in long-term fertilisation experiments in apple, cherry and grape investigates whether bacterial-feeding nematodes might be suited as plant growth relevant indicators for soil fertility.

Material and Methods

Soil samples from plots with different fertilisation combinations of compost, commercial organic N fertiliser, a bacterial preparation (BactoFil®2), compost press water and cover plant mulch in experimental fields of organically managed apple, cherry and grape trials were analysed over a time span of five months (March-August). Firstly, soil samples were taken from the top soil (0-25 cm) for each fertilisation treatment. Secondly, the soil was

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homogenised and prepared on the one hand for the analysis of mineralized nitrogen (N_{min}) by a inject analyser, and on the other hand for the isolation of nematodes. With a method similar to the Baermann funnel, the nematodes were extracted by their migration into water (down time 72 h). Caught nematodes were fixed with TAF (Triethanolamin, Formaldehyd, distilled water) at 60 °C for further identification. The total number of nematodes was quantified using a microscope (magnification 200x) and the Nbt counted separately. As proven sensitive indicator for N-uptake by the plants, we measured the SPAD values of the leaves in August. Data were analysed by ANOVA procedures and post-ANOVA Tukey tests (JMP® Pro 11.2.0).

Results and Discussion

The sampling date had a significant effect on Nbt after the fertilisation in spring for cherry (p-value=0.0001), apple (p-value=0.0002) and grape (p-value=<.0001) compared to the values 6 weeks before (March) and 3 months after fertilisation (August). The fertilisation treatments had significant effects on Nbt values with cherry (p-value=0.0002), apple (p-value=0.0294) and grape (p-value=0.0438) as well. In the cherry trial the highest values of Nbt (58 % over control) were found for the combination of compost with organic N fertiliser, in the apple trial for the treatment with compost and BactoFil®2 (55 % over control) and in the grape trial for fertiliser followed by compost (50 % reps. 54 % over control). At some sampling dates and with some crops there was a certain but never high correlation between Nbt or the ratio Nbt to Nb with N_{min}. Mainly with cherries, nematode abundance correlated significantly with the SPAD-values of the leaves (R^2=0.47). Discussing the results, the amount of Nbt increased - most probably temperature driven - through the season. Compared to unfertilized plots, soil treated with compost and/or organic N-fertilizer showed higher abundance of nematodes, and Nbt in particular. Three months after fertilisation an excess of nutrients supply could lead to a decrease of the numbers of Nbt (Venette and Ferris, 1997). For the first time, our study could confirm also for bacteria-feeding nematodes former studies of e.g. Yeates (2003) reporting that fertilisation has an impact on the numbers of nematodes and that organic amendments in general lead to an increase of the amount of nematodes. Further studies to evaluate the use of Nbt as a bio-indicator for the plant growth relevant soil fertility in fruit production seem to be justified.

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