QUANTIFYING THE CONTRIBUTION OF FREE-LIVING NEMATODES TO NITROGEN MINERALIZATION

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Introduction

Soil fauna are estimated to contribute to approximately 30 % of nitrogen mineralization (Verhoef and Brussaard, 1990). Soil nematodes are important contributors to this process through their key trophic positions as microbial grazers. Quantification of this contribution has mostly relied on theoretical food web analyses (Hunt et al., 1987) or laboratory incubations with simplified and artificially constructed ecosystems (Ferris et al., 1998). Incubations are often performed on homogenized soil, though soil biota is known to be responsive to physical disturbance. Furthermore, sterilization typically relies on methods disruptive of soil structure (e.g. autoclaving, freezing). The aim of this experiment was to quantify the contribution of nematodes to nitrogen mineralization during incubation. Intact cores with a representative pore structure and entire nematode populations instead of single species were used. Gamma irradiation was selected as a sterilization method to remove only soil fauna, leaving the microflora and soil structure largely intact (McNamara et al., 2003).

Materials and Methods

Intact cores and bulk soil were collected in October 2008 from an organic agriculture trial field (sandy loam, pH_{KCl}=5.3, org. C=1.0 %, C/N=11). Bulk soil was used to refill cores to the same bulk density as in the field. One third of both type of cores were set aside as control cores, the rest were subjected to gamma-irradiation at a dose of 5 kGy. Half of the irradiated cores were re-inoculated with nematodes extracted from a corresponding amount of bulk soil, after washing extracts over a 5 µm sieve. This produced 6 treatments: CI (intact control), GI+ (inoculated irradiated intact), GI-(as for GI+ but not inoculated), CD (disturbed control), GD+ (inoculated irradiated disturbed), and GD- (as for GD+ but not inoculated). Cores were brought to and maintained at ca. 45% water-filled pore space and incubated at 18˚C for 82 days. Three replicates from each treatment were destructively sampled at days 5, 12, 26, 38, 53 and 82. The following parameters were determined: nematode abundance (zonal centrifuge method), microbial biomass C (fumigation-extraction method), NO_3^- and NH_4^+ (KCl extraction by continuous flow). Two-sample t-tests were used to compare treatments.

Results

Microbial biomass C declined sharply in all treatments (except for a peak at 5 days for CI), reaching a more stable baseline from 38 days onwards (Fig. 1). Overall, microbial biomass C was not affected by the irradiation process (not significant in ANOVA), but was significantly lower in GI- versus CI at days 38 and 82 (p = 0.008 and 0.021 respectively) and in GI+ versus CI at day 82 (p = 0.021). At day 82, microbial C in both GI+ and GI- was also significantly lower than in CD (p = 0.006 and 0.019 respectively). Microbial biomass

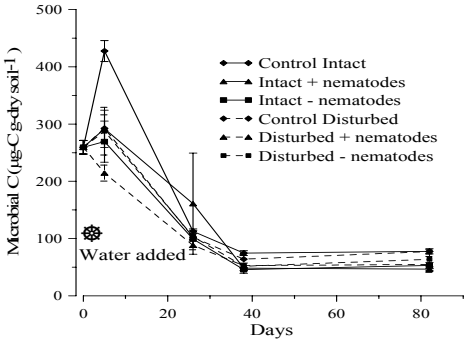

Fig. 1. Evolution of microbial biomass C during the incubation. Error bars represent the standard error.

was not significantly correlated with other parameters at any date. Due to the strong decrease in the first half of the incubation, other parameters were compared at the last 2 dates of the incubation only. Inoculation of nematodes was successful in establishing populations of the same size as in the control samples: after initial fluctuations nematode abundance did not significantly differ between inoculated cores and controls at 53 and 82 days (Fig. 2). Contrary to expectations, nematodes were extracted throughout the incubation period from non-inoculated cores, although their abundance decreased steadily. Subsequent observation confirmed these nematodes were dead. Net mineralization was observed for all treatments throughout the incubation but was consistently more pronounced in irradiated cores in terms of total N (Fig. 3a). This was mainly due to the high levels of NH_4^+-N found in these cores (Fig. 3b). A temporary NH_4^+ flush is a well-documented effect of gamma irradiation (McNamara et al., 2003). At day 53, there is significantly more NH_4^+-N in both GI+ and GI- than in GD+ ($p = 0.035$ and 0.049 respectively) and GD- ($p = 0.035$ and 0.059 respectively), suggesting a strong influence of physical disturbance. By day 82, NH_4^+-N levels appeared to have dropped more strongly in inoculated than in non-inoculated cores, however this effect was only significant for GD+ versus GD- ($p = 0.084$) and GI- ($p = 0.071$). The amount of NO_3^--N tended to be higher in inoculated cores, however owing to strong variability the difference was only significant for GD+ versus GD- at day 82 ($p = 0.039$, data not shown). At day 53, significantly more NO_3^--N had been mineralized in disturbed irradiated cores than in their intact counterparts.

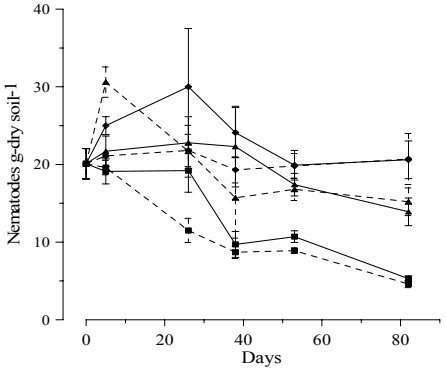

Fig. 2. Evolution of nematode abundance during the incubation. Legend as for Fig. 1.

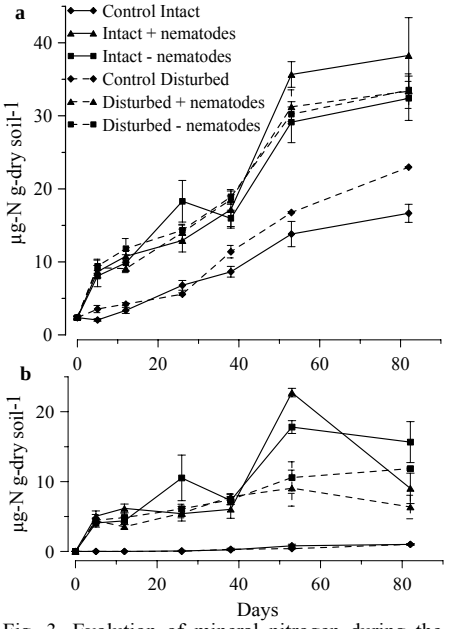

Fig. 3. Evolution of mineral nitrogen during the incubation period: a. total N (NO_3^--N + NH_4^+-N); b. NH_4^+-N (same legend as in a.)

Conclusions

The presence of nematodes appears to increase nitrogen mineralization slightly, although the effect is obscured by the sustained ammonium flush caused by irradiation. Using intact soil cores appears to further increase this flush, although the activity of nematodes may cause it to decline more rapidly. The increased mineralization of nitrate in disturbed cores further highlights the importance of physical disturbance in incubations. The effect of the composition of the microbial biomass and nematode population remains to be investigated.

References

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