Pesticide interactions with N source and tillage: Effects on soil biota and ecosystem services

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Introduction

Pesticide effects on soil biota must be interpreted in the context of the specific management practice, including rotation, fertilization, tillage, and pest control. For example, tillage has been shown to reduce earthworm populations by up to 80%, depending on timing and specific tillage technique (Krogh et al. 2007). Such disturbances may fully or partly conceal effects of pesticides. The direct effects of pesticides and other management factors and their interactions must, therefore, be quantified before integrated pest management strategies that protect soil biodiversity and maintain soil functions can be identified.

Study design

This study was planned to evaluate interactions between pesticide use and other soil management factors. The study was carried out within a long-term tillage experiment using two tillage practices (no-till (NT) and mouldboard ploughing (MP)), two contrasting N sources (manure and mineral fertilizer), and two pesticides (the fungicide mancozeb and the insecticide alpha-cypermethrin) in a split-plot design (Fig. 1.).

Figure 1. Pesticide application in subplots (basic treatment) and sub-subplots (additional doses of either fungicide or insecticide).

Krogh, P.H., Griffiths, B., Demšar, D., Bohanec, M., Debeljak, M., Andersen, M.N., Sausse, C., Birch, A.N.E., Caul, S., Holmstrup, M., Heckmann, L.-H. & Cortet, J. 2007. Responses by earthworms to reduced tillage in herbicide tolerant maize and Bt maize cropping systems. Pedobiol. 51 (3), 219-227.

Results

The area had a normal level of microarthropods in the order of 100 000 m^{-2} (Fig. 2). About 30 species of Collembola were identified. The microarthropods were generally more abundant in the NT system, except for the collembolan *Cryptopygus thermopilus* and to some extend *Isotoma anglicana* (Fig. 2). Mite numbers were reduced by the insecticide while, in contrast, the hemi-epigeic collembolan *I. palustris* was twice as abundant in the insecticide treated plots.

The earthworm abundance was in the order of 100 m^{-2} and covered four species. The most abundant earthworm was *Aporrectodea longa*, which was also significantly more abundant with manure compared to mineral-N fertilizer. The fungicide affected *A. longa* only in the ploughed system (MP), while no effect was observed under no-till. Pesticide effects were pronounced for *A. rosea* in ploughed plots fertilized with manure, reducing its fresh weight from 5 g m^{-2} in the Control to 1 and 0.5 g m^{-2} in fungicide and insecticide treatments, respectively. *L. terrestris* was favoured by the NT system, with 17 g fresh wt. m^{-2} compared to 7 g fresh wt. m^{-2} in the MP system.

Potential nitrification ranged from ca. 10 to 30 nmol NO_2^- g^{-1} h^{-1} (Fig. 3). Statistical analyses of the main treatments indicated an overall effect of the fertilizer regime with higher rates of potential nitrification in treatments with manure compared to mineral fertilizer. There were no main effects of the pesticide and tillage regime.

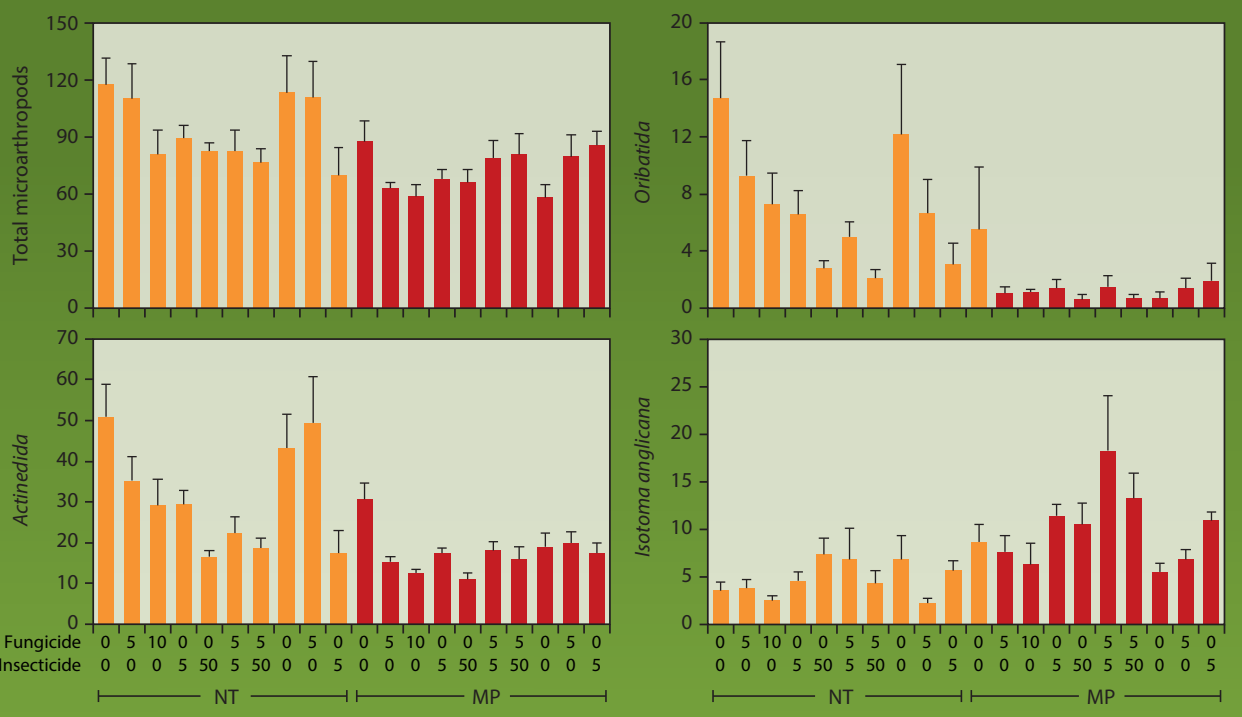

Figure 2. The abundance of microarthropods. NT, no-till; MP, moldboard ploughed. X-axis refer to mark dosages; y-axis to numbers per sample.

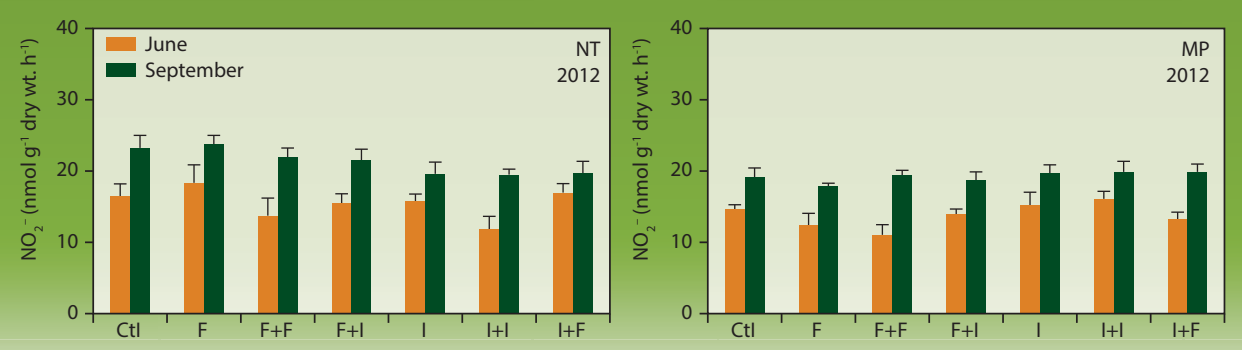

Figure 3. Potential ammonia oxidation. Key to figures: Ctl: control; F: fungicide; I: insecticide, NT: no-till; MP: moldboard ploughed.

Conclusions

The influence of the tillage factor, NT vs. MP, on soil fauna was generally as expected, with NT having higher abundances than the MP system. Similarly, organic manure stimulated earthworm pollution compared to mineral fertilizers. The observed effect of both pesticides on the microarthropod and earthworm populations depended on the tillage, suggesting that plant residues at the soil surface, if omitting tillage, gave some protection against exposure of earthworms. For the microbial community, there was no strong evidence that management introduced major changes in the composition of the soil microbial biomass, although inhibitory effects of pesticides were observed on the potential ammonium oxidation in treatments with ploughing (MP), but not with no-tillage (NT), indicating that enhanced contact between pesticides and nitrifying microorganisms in ploughed soil increased the potential for the ecotoxicological effects.