Impact of *Fallopia* spp. on ecosystem functioning: Nitrogen and organic matter cycling and implicated soil biota

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Introduction

Fallopia japonica is one of the most invasive alien plant species in NW Europe. Its impact on indigenous vegetation is high and well documented, whereas its impact on ecosystem processes has been less studied. It considerably increases primary productivity in invaded ecosystems (Dassonville et al., 2008). It has also been shown to increase cations and P availability in the topsoil by a nutrient uplift mechanism thanks to its very deep rooting system (Dassonville et al., 2007). In the ALIEN IMPACT project, we evaluated the impact of the species on different steps of nitrogen and organic matter cycling and on implicated soil biota. Considering the thick permanent litter layer often observed under clones of *Fallopia*, it was hypothesized that *Fallopia* slows down litter decomposition and nitrogen cycling rate.

Results and Discussion

The litter decomposition dynamic of *Fallopia* has been assessed using the litterbag technique (Dassonville et al., 2009). We measured the decomposition of *Fallopia* litter (stems and leaves) and of native vegetation of the study site (50-50 mixture of *Eupatorium cannabinum* and *Calamagrostis epigejos*). The litter of *Fallopia* decomposes much more slowly than that of native vegetation (Figure1), probably due to its very high C:N ratio (151 and 72 for *Fallopia* stems and leaves, respectively, against 33 for native litter). On the other hand, the decomposition of each litter type was slightly faster in invaded compared to uninvaded plots. This could be an effect of the moister microclimate under the dense canopy of *Fallopia* than on the soil surface of the uninvaded grassland.

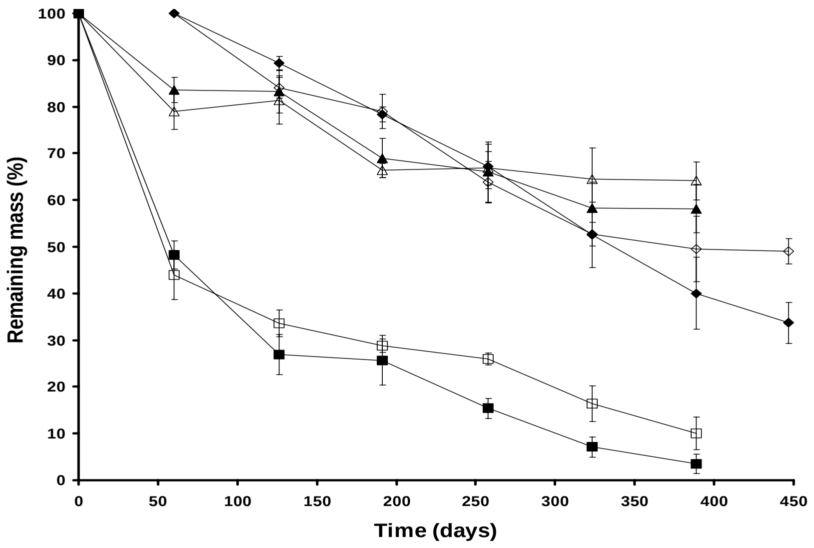

Figure 1: Decomposition kinetics of Fallopia *leaves (triangles) and stems (diamonds) and native litter (squares) during one year. All litter types were incubated in invaded (black) and uninvaded (white) environment; Decomposition is expressed as the percentage of initial mass lost. Values are means ± standard deviation.*

The evolution of the nitrogen stock in the litterbags was followed (Figure2). The N stock decreases rapidly in litterbags with native litter. This means that this litter easily releases N to the soil. On the other hand, N tends to accumulate over time in the litterbags containing *Fallopia*. This suggests that microorganisms living on the decomposing litter have to use mineral N from the soil to compensate for the low N concentration of their substrate. This leads to fixation of mineral nitrogen into organic matter.

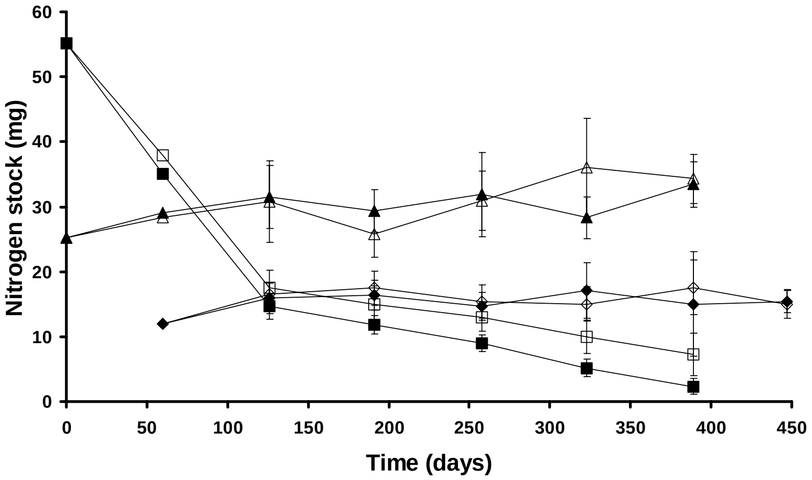

Figure 2: Evolution of the N stock (=remaining mass x N concentration) in Fallopia *leaves (triangles) and stems (diamonds) and indigenous litter (squares) decomposition in invaded (black) and uninvaded (white) environment. Values are means ± standard deviation.*

From N fluxes measurements in the invaded ecosystem, it has been found that the internal cycling of N in *Fallopia* is exceptionally efficient. Indeed, 80 % of the N present in aboveground biomass during summer is translocated to the rhizomes before the abscission of the leaves (This phenomenon explains the high C:N ratio of the litter). This process allows the plant to grow rapidly in spring, independently of soil N mineralization. This contributes to the high productivity of the species and to its competitive superiority.

Fallopia has also been found to decrease the intensity of nitrification and denitrification in sites with high nitrification potential. Molecular analyses show that these differences in activity were partially explained by a decreased number of nitrifying/denitrifying bacteria (assessed by quantitative PCR targeting nitrification/denitrification genes). On the other hand, the structure of the soil microbial communities does not seem to be altered (PCR-DGGE analyses). Our results suggest a potential allelopathic effect of *Fallopia* on soil microbes. The reduction of nitrification and denitrification intensity result in the reduction of N loss from the ecosystem by nitrate leaching and NOx emissions.

From the results mentioned above, it appears that *Fallopia* has a very economic N management, which tends to conserve N in the ecosystem (mineral N fixation on decomposing litter, efficient N retranslocation and reduced nitrification and denitrification intensity). This could be a key trait explaining the invasive success of the plant.

Finally, *Fallopia* also impacts soil fauna. The invertebrate density is 50% lower under *Fallopia* compared to uninvaded grassland. The major groups of the mesofauna (0.2 to 4 mm) are similar (springtails, gamasid and oribatid mites) when comparing invaded and uninvaded plots. On the other hand, some groups of macrofauna (4 to 80 mm) differed between invaded and uninvaded plots. Typical forest taxa like diplopods and isopods or the earthworm *Lumbricus terrestris* are more frequent under *Fallopia* than under the uninvaded grassland vegetation. These taxa are important for litter fragmentation and incorporation to the soil. This could explain the higher decomposition rate under *Fallopia*. On the other hand, ants, aphids and the earthworm *L. castaneus* were totally absent under *Fallopia*. These taxa are thermophilous grassland species. Based on these differences, the invaded and uninvaded plots are very well separated in the PCA analyses (Figure 3). The first axis of the PCA could represent a light and moisture gradient. The changes in soil fauna are thus mainly explained by a reduction of food diversity and a change in soil microclimate.

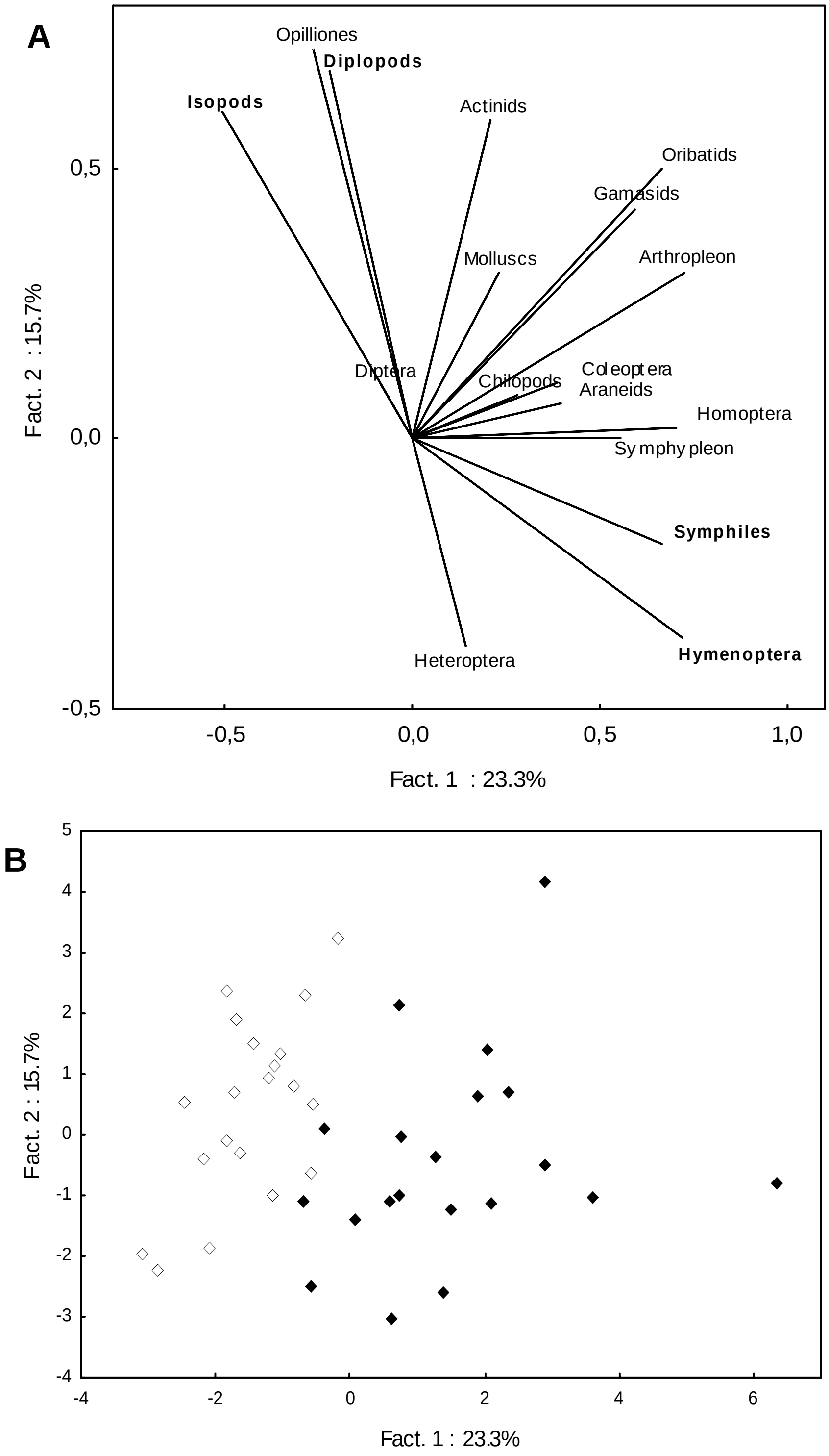

Figure 3: Principal Component Analysis (PCA). A: Projection of variables (taxonomic groups) on PC1 and PC2 for soil fauna but the earthworms. B: Projection of the sampling points from the invaded (white) and the uninvaded (black) plots.

References

Dassonville N., Vanderhoeven S., Domken S., Meerts P., Chapuis-Lardy L., 2009. Impacts of Alien Invasive Plants on Soil and Ecosystem Processes in Belgium: Lessons from a Multispecies Approach. In Wilcox C.P. and Turpin R.D. (eds). Invasive Species: Detection, Impact and Control. Nova publishers. In press.

Dassonville N., Vanderhoeven S., Vanparys V., Hayez M., Gruber W., Meerts P., 2008. Impacts of alien invasive plants on soil nutrients are correlated with initial site conditions in NW Europe. Oecologia 157:131-140.

Dassonville N., Vanderhoeven S., Gruber W., Meerts P., 2007. Invasion by *Fallopia japonica* increases topsoil mineral nutrient concentrations. Ecoscience 14: 230-240.