



The role of shoot residues vs. crop species for soil arthropod diversity and abundance of arable systems



Nicole Scheunemann*, Mark Maraun, Stefan Scheu, Olaf Butenschon

J.F. Blumenbach Institute of Zoology and Anthropology, Georg August University Göttingen, Berliner Str. 28, 37073, Göttingen, Germany

ARTICLE INFO

Article history:

Received 29 July 2014

Received in revised form

16 October 2014

Accepted 4 November 2014

Available online 18 November 2014

Keywords:

Agroecosystem

Arthropods

Maize

Residues

Soil food web

Wheat

ABSTRACT

Removal of crop residues has become common practice in arable systems, however, little is known about how soil arthropod communities change in response to reduced resource availability and habitat complexity associated with residue removal. We added maize residues to wheat and maize fields and investigated soil arthropod diversity and abundance over the period of one year. Residue addition did not affect the diversity and little affected the abundance of soil arthropods in wheat and maize fields with the latter being restricted to few taxonomic groups, suggesting that at least in the short-term soil arthropods benefit little from crop residue-mediated increase in food supply and habitat structure. Contrasting the minor effects of residue addition, densities of soil arthropods were much higher in wheat than in maize fields, presumably due to more dense and more continuous coverage by plants, and higher input of root residues. Furthermore, in wheat fields density of arthropods more strongly varied with season, presumably due to more pronounced pulses of root exudates and root residues entering the soil in wheat as compared to maize fields in summer and winter, respectively. Low density and little variation in densities of soil arthropods in maize fields reflect that environmental conditions and resource supply varied little with crop coverage and season. Overall, the results point to low importance of aboveground crop residues for soil arthropod communities and highlight that belowground plant resources, i.e. root exudates and root residues are the major driver of soil arthropod communities of arable systems. Thus, at least in short term removal of crop residues for e.g., biofuel production is likely to be of minor importance for soil arthropod communities. In contrast, changing crop species from wheat to maize markedly reduces the density of soil animals threatening the ecosystem functions they provide.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Currently, 40% of the terrestrial land area is used for agriculture and projections suggest that profound intensification will be needed to meet the demand for food and fibre of a growing human population (Foley et al., 2005; Tilman et al., 2011). Annually 3 Gt of crop residues are produced globally, and typically they are left on the field to reduce soil erosion and to maintain soil organic carbon stocks and soil fertility (Michels et al., 1995; Wilhelm et al., 2004). However, increasing interest to mitigate global climate change has led to the practice of complete crop residue removal for biofuel production with potentially adverse environmental impacts (Bussi ere and Cellier, 1994). Importantly, the removal of crop residues may also impact soil biodiversity and impair key soil functions

(Freibauer et al., 2004). Although there is evidence from previous studies that crop residue removal impact certain taxa including fungi (Karlen et al., 1994) and Lumbricidae (Karlen et al., 1994; Blanco-Canqui and Lal, 2007), understanding consequences for soil food web structure and functioning is limited.

Soils are inhabited by a large number of organisms, from unicellular microorganisms and protists to a variety of arthropods that interact in complex food webs and provide important services including carbon sequestration, recycling of nutrients and plant growth (Bardgett, 2005). Organic material derived from plants serves as basic resource of the soil food web, and carbon and nutrients mobilized by soil organisms during decomposition propagate to higher trophic levels (Moore et al., 2004; Ilieva-Makulec et al., 2006; Schneider et al., 2012). Soil arthropods, such as Lumbricidae, Diplopoda, Isopoda, Oribatida and Collembola, facilitate decomposition by removing litter from the soil surface and increasing leaf litter surface area for microbial attack (Bardgett et al., 2005; Chamberlain et al., 2006). Other soil arthropods, in

* Corresponding author. Tel.: +49(0)551 3933660; fax: +49 (0)551 395448.
E-mail address: nscheun@gwdg.de (N. Scheunemann).

particular soil micro-arthropods, benefit from litter inputs by feeding on saprotrophic microorganisms colonizing the litter materials (Ruess et al., 2007). Apart from serving as resource, plant residues also increase habitat structure, and favour the abundances of decomposers and arthropods of higher trophic levels (Halaj and Wise, 2002). In arable fields, removal of crop residues therefore is likely to detrimentally impact both habitat structure and resource availability of many soil organisms, resulting in simplified food webs of low diversity and abundance thereby impairing their services (Culman et al., 2010; Postma-Blaauw et al., 2010).

Addition of plant residues to the soil has been shown to impact arthropod performance in a number of ecosystems; however, the response of soil arthropods is controversial (Sayer, 2006) and both positive (Axelsen and Kristensen, 2000; Hansen, 2000) and negative effects have been documented (Salamon et al., 2006), suggesting that effects are species and/or context specific. Moreover, recent studies in forest ecosystems suggest that root derived carbon surpasses aboveground plant inputs in driving soil food webs (Pollierer et al., 2007; Eissfeller et al., 2013), whereas in arable soils little is known on the relative importance of above- and belowground plant inputs for soil food web structure and functioning.

Wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) are the two most important crop species and dominate arable fields in central Europe (FAO Stat, 2014). Habitat conditions vary between these crop species. For example, important drivers of soil arthropod communities, such as plant density and growth rate, and soil humidity and plant cover (Lal, 1978; Filser, 1995), differ markedly between maize and wheat fields (Sharratt and McWilliams, 2005). Further, root structure and density also differ between wheat and maize, and this likely adds to differential impacts of wheat and maize on soil arthropod communities.

We added crop residues to wheat and maize fields, and analysed soil arthropod abundance and diversity over a period of one year aiming at investigating the role of aboveground and belowground plant inputs for soil arthropod communities throughout one crop cycle. Wheat and maize fields without crop residue addition served as control. We hypothesised that (1) the addition of crop residues increases abundance and diversity of soil arthropods by increasing habitat structure and food availability, but we expected this effect to vary (2) between wheat and maize fields due to plant specific effects on micro-environmental conditions, and (3) during the growing season due to changes of belowground resource availability.

2. Materials and methods

2.1. Study site

The study site is located in Holtensen in central Germany near Göttingen (51°33'N, 9°53'E) at 160 m a.s.l. The climate is temperate with a mean annual temperature of 8.7 °C and a mean annual precipitation of 645 mm. The soil is characterized as haplic luvisol. After decades of C3 crop cultivation, the crop was changed to maize in 2009 (plot size 24 × 240 m) embedded into a field of winter wheat. In each wheat and maize field 10 plots of 24 × 24 m were established next to each other; half of the maize and wheat plots received crop residues in autumn to establish four treatments: maize plants with (M+) and without (M-) crop residues, and wheat plants with (W+) and without (W-) crop residues. Before and after seeding, maize plots were fertilized with ammonium nitrate and diammonium phosphate, while wheat plots were fertilized once with granular sulphate-nitrate fertilizer before seeding and three times with urea solution after seeding. Further, at the start of the experiment, tillage practice was changed from deep tillage to chisel plough tillage to a depth of 12 cm. In 2010, winter

wheat was changed to summer wheat (sown in April) to improve comparability of growing seasons between wheat and maize (also sown in April). Further information on fertilizer application and management practice is given in Kramer et al. (2012). Wheat was harvested in August 2009 by cutting wheat plants 10 cm above the soil surface and removing them from the plots. After harvest of maize cobs in October 2009, maize plants were cut at a height of 10 cm above soil surface and shoots (without cobs) were hacked to a particle size of ca. 1 cm². Hacked crop residues were added to the respective maize and wheat plots at an amount of 0.8 kg dry weight m⁻² resembling the aboveground biomass of maize. Crop residues remained at the soil surface, and wheat and maize roots remained in the soil during winter and were tilled into the soil in spring 2010 prior to seeding of wheat and maize.

2.2. Sampling and analyses

Soil samples were taken at four dates, July 2009, two month after establishment of the experiment, September 2009, December 2009, six weeks after residue addition to the plots, and July 2010. The samplings in July, September and December referred to the maize growth periods of highest root exudation shortly before flowering, low root exudation before harvest and high input of root residues after harvest, respectively. At each sampling, two soil cores of 20 cm diameter and 10 cm depth were taken at each plot using a stainless steel soil corer. Soil arthropods were extracted by heat with the temperature gradually increasing from 25 to 55 °C during 10 days (Kempson et al., 1963), transferred to saturated NaCl solution and kept at -10 °C until further processing. Abundances of meso- and macrofauna were analysed using a dissecting microscope, which was also used for identification of macrofauna taxa, while mesofauna taxa were identified using a light microscope allowing 1000× magnification. Schaefer (2010) was used as standard key for macrofauna, while Hopkin (2007), Weigmann (2006) and Karg (1993) were used for identification of Collembola, Oribatida and Gamasida, respectively.

2.3. Statistical analyses

Soil arthropod abundances are given as number of individuals m⁻² ± standard error of the mean (SEM). The number of soil arthropod taxa per soil sample was determined and is further referred to as “diversity” and given as species number ± SEM. To improve homogeneity of variances, data on diversity and abundance were log₁₀ (x + 1) transformed prior to statistical analyses. Effects of Sampling date (July 2009, September 2009, December 2009 and July 2010) and Crop species (wheat, maize) on diversity of taxonomic groups, and abundance of taxa and taxonomic groups were analysed by two-factorial analysis of variance (ANOVA), while three-factorial ANOVA was used to inspect effects of Sampling date (December 2009, July 2010), Crop species (wheat, maize) and Residue addition (with, without). In the latter, we focus on effects of Residue addition and its interactions with Sampling date and Crop species. ANOVAs were followed by Tukey's HSD test for comparison of means (significance level at p < 0.05).

Effects of Sampling date and Crop species at each sampling, as well as effects of Sampling date, Crop species and Residue addition on soil arthropod community composition after residue addition were inspected after reduction of the data-set to six dimensions by non-metric multidimensional scaling (NMDS with Bray-Curtis distance). In addition to two- and three-factorial ANOVAs, the NMDS reduced dataset was analysed for effects of Sampling date and Treatment (W-, W+, M-, M+; including only sampling dates of December 2009 and July 2010) using discriminant function analysis (DFA). Canonical scores were presented in two-

Download English Version:

<https://daneshyari.com/en/article/2024416>

Download Persian Version:

<https://daneshyari.com/article/2024416>

[Daneshyari.com](https://daneshyari.com)