Applied Soil Ecology 117–118 (2017) 21–31

Contents lists available at ScienceDirect

Applied Soil Ecology

journal homepage: www.elsevier.com/locate/apsoil

# Influence of cover crops on arthropods, free-living nematodes, and yield in a succeeding no-till soybean crop

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ARTICLE INFO

*Keywords:*
Soil food web
Nutrient cycling
Legume
Cereal grain
Conservation tillage
Trophic groups

ABSTRACT

Production practices that incorporate fall-planted cover crops into no-till agronomic crop rotations have become increasingly popular across the Northeastern United States for weed suppression and enhancing environmental stewardship. Field experiments were conducted in 2011 and 2012 to investigate effects of rotating cereal (barley, *Hordeum vulgare*), legume (Austrian winter pea, *Pisum sativum* subsp. *arvense*), cereal/legume cover crop mixture, and a fallow (bare-ground) control on above- and belowground fauna in a succeeding soybean crop. Free-living nematodes and soybean foliar arthropods were sampled through time to determine effects of cover crops on soil food web structure and complexity and herbivorous and beneficial arthropods, respectively. Our hypotheses were that organic matter from cover crop biomass would provide energy and nutrients to the soil food web and that increased habitat complexity from cover crop residue would provide habitat for more predatory arthropods aboveground. In general, cover crops in this no-till system had a stronger influence on the below- than aboveground fauna. There was no consistent, positive effect of cover crops on beneficial foliar arthropods or on soybean yield. Cover crops increased the soil food web structure and complexity as determined by nematode community indices. Specific effects of different cover crop types on the free-living nematode community varied within the growing season and between study years. Probable causes for differences encountered among cover crop treatments and years are discussed.

## 1. Introduction

Cover cropping has long been used as a practice for reducing soil erosion, increasing soil quality, and suppressing weeds (Colla et al., 2000; Sainju and Singh, 1997; Teasdale, 1996; Yenish et al., 1996). Cover crops have a history of also being used as green manures and providing animal feed during periods of drought (Lu et al., 2000). With concerns over environmental stewardship and sustainability issues, cover crops have become of greater interest for their potential to provide additional agroecosystem services. Cover crops can impact several factors within a cropping habitat contemporaneously such as influencing soil quality, health and fertility, water quality, above- and belowground organisms, and crop yield. For example, cover crops have been shown to increase soil organic matter, reduce carbon loss, improve soil structure and tilth, conserve nitrogen resources, and suppress weeds in a wide range of cropping systems (Hartwig and Ammon, 2002). In addition, integration of cover crops into vegetable crops can increase natural enemies and reduce pest insect abundances (Hinds and Hooks, 2013; Hooks et al., 2013) and influence the health of neighboring ecosystems (Snapp et al., 2005). However, different cover crops can enhance, decrease, or have no effect on yield, arthropods, and other organisms associated with cropping systems according to how they are managed. As such, predicting their influence on a cropping system can be challenging.

Over the years, the adoption of conservation practices in the form of cover crops has increased sharply in the Northeastern US. Cover crops are currently being grown on hundreds of thousands of hectares of arable land throughout this area as part of soil conservation plans. In 2015, cover crops were planted on a total of 199,204 ha in Maryland alone as part of the Maryland Department of Agriculture's Cover Crop Program (MDA, 2016). Producers can receive from 62 to 235 USD per ha to grow winter cover crops in the state of Maryland, which is enough to cover most or all expenses required to grow most cover crops (Pelton, 2010). In the Northeastern US, winter cover crops are planted in early

*Abbreviations:* AWP, Austrian winter pea; BG, bare ground; MI, Maturity index; EI, Enrichment index; SI, Structure index; CI, Channel index; F/B, Fungivore to bacterivore ratio

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http://dx.doi.org/10.1016/j.apsoil.2017.04.003
Received 28 November 2016; Accepted 10 April 2017
Available online 22 May 2017
0929-1393/ 

fall and generally allowed to grow until mid-spring, at which time they are incorporated by tillage or killed and left as a surface mulch into which a crop is planted. In Maryland, soybean (*Glycine max*) producers typically follow a corn (*Zea mays*)-soybean rotation scheme and plant cover crops in the fall after corn is harvested, then terminate the cover crop with a post-emergent herbicide prior to planting a soybean crop.

Though soybean producers grow cover crops mainly for soil conservation benefits, cover cropping can modify the fauna of arthropods within field crop systems and these changes may differ according to the amount of cover crop residue (Smith et al., 1988) and species of cover crop grown. For example, herbivorous arthropod pests and associated plant damage were reduced in soybean plots which contained rye (*Secale cereale*) cover crops prior to planting (Koch et al., 2015). Conversely, rye cover crops can increase pest abundance within the following corn (*Zea mays*) crop, if they serve as a host for polyphagous pest insects (Dunbar et al., 2016). Fall-planted grass cover crops have been shown also to increase natural enemy abundances in corn and soybeans (Hooks et al., 2011; Lundgren and Fergen, 2010).

In addition to influencing organisms above the soil surface, residues from killed cover crops cover the soil surface and release organic carbon and nutrients that provide subsidies to the soil food web, which can alter soil biodiversity (Hooks et al., 2011; Lundquist et al., 1999; Norris et al., 2016; Quintanilla-Tornel et al., 2016). Free living nematodes have often been used as indicators of how land management practices (e.g., tillage, cover cropping, solarization, etc.) in agroecosystems impact biodiversity below the soil. This is because nematodes are ubiquitous, well classified into functional groups, and functionally diverse (Bongers and Bongers, 1998). Further, they are easy to sample and play an important role in soil nutrient cycling. Free-living nematodes directly influence soil processes and reflect the structure and function of many other taxa within the soil food web (Ferris et al., 2001). Their food chain ranges from fast-growing, fast-breeding, bacteria-feeding nematodes at the bottom (colonizers) to slow-growing, slow-reproducing predatory nematodes (persisters) at the top of the food web. Further, nematode communities respond readily to changes in soil physical and chemical conditions and have a direct linkage to ecological processes (Neher, 2010). Some nematodes can survive disturbed environments better than others and some have short life cycles and respond rapidly to environmental changes (e.g., colonizers). Thus, they can provide an early sign of how crop husbandry practices are affecting soil organisms (Hinds et al., 2013; Wang and McSorley, 2005).

Specific effects of cover crops on above- and belowground communities can vary depending on what types of species are used and how they are managed (Gill et al., 2011; House and Alzugaray, 1989). For example, functional groups of plants (i.e., legumes, forbs, grasses) have dissimilar rooting patterns that create habitats more congenial to some species of nematodes than others (Neher, 2010). Djigal et al. (2012) found that grass and legume cover crops increased populations of beneficial nematodes in a banana plantation compared to bare ground, but grass cover crops supported lower populations of plant-feeding nematodes while legume cover crops supported greater numbers of predacious nematodes. In addition to physical features, biochemical compositions of cover crops such as carbon to nitrogen ratio (C:N) will influence the pattern and timing of mineral decomposition and N release of cover crop residues (Kuo and Sainju, 1998). This will in turn mediate the activity of decomposers including the free-living nematode fauna. Barley, *Hordeum vulgare*, and Austrian winter pea, *Pisum sativum* subsp. *arvense* are popular grass (Poaceae) and legume (Fabaceae) winter cover crop species, respectively, in the US. Barley has a relative high C:N ratio and can produce a tremendous amount of biomass in a short time compared to several other grass cover crops and has a thick root system, which can improve soil structure and water infiltration (Creamer et al., 1996; Overland, 1966). Austrian winter pea (AWP) is shallow-rooted and slower to establish than barley, but is capable of rapid biomass accumulation (Norsworthy et al., 2010) and because of high N content, it can readily provide N to subsequent crops (Mahler and Auld, 1989). Barley has been found to inhibit weed emergence through allelopathic chemicals and by providing a physical barrier to weed establishment (Creamer et al., 1996; Overland, 1966). Though AWP is capable of producing a large amount of biomass, it is prone to rapid decay, and as such is not known for providing prolonged surface mulch and weed suppression benefits (Norsworthy et al., 2010).

Limited research has been conducted to investigate impacts of winter cover crops jointly on above- and belowground communities of organisms (Hooks et al., 2011). However, the fact that cover crops can influence these organisms concurrently warrants concerted investigations on these disparate communities. Barley and AWP are often grown as winter cover crops, especially in the northeastern US, and agricultural producers in Maryland can receive incentive payment to plant barley and barley/AWP mixes. As such, if it is determined that these cover crops can have a positive influence on beneficial organisms within the crop field, this will provide an ecological incentive for producers to plant these cover crops as a standard land management practice. Thus, the objective of this study was to compare effects of cereal (barley), legume (AWP), and cereal/legume mixture (barley + AWP) fall planted cover crop and no cover crop (fallow) treatment on the above- and belowground fauna within a subsequent soybean crop. The specific focus was on communities of herbivorous pests and beneficial arthropods within the soybean canopy and free-living nematodes below the soil surface. Our hypotheses were that the additional organic inputs from cover crops and their resulting residue would lead to an increase in the complexity of the soil food web belowground, and the added habitat structure provided by the cover crop would lead to a larger population of predacious arthropods aboveground.

## 2. Materials and methods

### 2.1. Experimental site, treatment, and plot layout

Field trials were conducted in 2011 and 2012 in separate fields (2011: 39.0252°, −76.8412°; 2012: 39.0121°, −76.8314°) at the University of Maryland Beltsville Research and Education Center in Beltsville, MD. Different fields were used in each year of the experiment to follow standard farming practices for the area; farmers rarely plant soybeans in the same field two years in a row. Soils for this study were mesic Aquic Hapludults, and were mapped within the Russett-Christiana complex (Soil Survey Staff, 2016). The soil texture ranged from fine sand to loamy sand with mineral fractions ranging from 81.1 to 88.7% sand, 7.1 to 14.1% silt, and 3.5 to 4.8% clay. Prior to initiation of the experiment, the field site for the 2011 trial was rye (*Secale cereale*) followed by soybean that was mowed prior to reaching maturity, whereas the field for the 2012 trial was planted with wheat (*Triticum aestivum*). Both field sites had been under no-till practices for several years. No-till cropping is defined as planting directly into the residue of the previous crop without performing any tillage operations that disturb the soil prior to planting (Stubbs et al., 2004). The entire experimental area was 0.45 ha with four treatments, arranged in a randomized complete block design, with four replications. Each treatment plot measured 11 m × 12 m, and was separated by 7 m of bare-ground between plots. The four treatments were soybeans planted into (1) AWP, (2) barley, (3) AWP + barley mixture, or (4) bare-ground (BG). Cover crops were planted on 9 October 2010 and 19 September 2011 for the 2011 and 2012 field trials, respectively. Barley and AWP were planted at 112 kg seeds/ha, whereas AWP + barley mixture was planted at 44.8 and 67.2 kg seeds/ha of AWP and barley, respectively. Plant biomass was collected from four 0.1 $m^2$ quadrats randomly placed in each plot just prior to cover crop termination. Samples were dried at 65 °C and weighed. Subsets of biomass samples were ground into powder (< 1 mm) and analyzed for total C and N (A & L Laboratories, Memphis, TN). Soil total C and N were also measured from each plot at