Effects of Cover Crop Residue Management on the Soil Surface Invertebrate Community

M. J. Tremelling[1], R. McSorley[1], R. N. Gallaher[2], and R. S. Tubbs[2]

[1]Dept. of Entomology and Nematology, University of Florida, Gainesville, FL 32611-0620. USA.

[2]Agronomy Dept., University of Florida, Gainesville, FL 32611-0730. USA.

Corresponding author's email: rmcs@gnv.ifas.ufl.edu

ABSTRACT

Effects of different methods for managing residues from a rye (*Secale cereale* L.) cover crop on insects and other arthropods active on the soil surface were determined in a field experiment in north central Florida. Treatments consisted of five methods for managing the cover crop: 1) rye combined and remaining residues left on the untilled soil surface; 2) rye mowed, residues removed, plots not tilled; 3) rye mowed, residue left on surface, plots not tilled; 4) rye mowed, residues removed, plots conventionally tilled; 5) rye mowed, residues left on surface, plots conventionally tilled. Arthropod populations were monitored using pitfall traps in a subsequent peanut (*Arachis hypogaea* L.) crop. Most arthropods showed distinct seasonal population trends, becoming more abundant as the growing season progressed. An exception occurred with the *Hypogastrurid Collembola*, which reached unusually high levels (>10,000 per sample) shortly after planting. Most arthropod groups were not consistently affected by the cover crop residue management treatments, although at the end of the peanut crop, total numbers of arthropods were most abundant in the untilled plots in which mowed residues had been left on the plots. Possibly the surface residues offered cover and a habitat favorable to the soil surface invertebrate community.

KEYWORDS

Arthropods, conservation tillage, insects, peanut, rye

INTRODUCTION

Interest in agronomic systems conserving N and soil fertility has been increasing steadily, and the use of cover crops has become more prevalent in such systems (Powers and McSorley, 2000). It is of interest that until inexpensive synthetic N fertilizers became available, cover crops were often used (Bugg and Dutcher, 1989). The use of cover crops is an appealing option since they can both improve the soil fertility and contribute to insect pest management (Bugg and Dutcher, 1989; Bugg *et al*., 1990).

Many insects inhabit the soil surface and the litter layer, using debris for cover (Coleman and Crossley, 1996), and the cover crop used will affect the quality and amount of litter present. The influence that the tillage system and the cover crop will have on pest problems related to future cash crops is contingent on the cover crop, the insect, and the tillage environment (All and Musick, 1986). Both indirect and direct impacts have been noted on habitat suitability for soil invertebrates as a result of different tillage operations in which the intensity of mechanical disturbance varies (Neave and Fox, 1998). Due to the variable nature of these many factors affecting the soil and litter environment, predicting the sorts of changes that may occur or how they might influence existing invertebrate communities is often uncertain.

Effects on the invertebrate community at the soil surface depend on the available cover crops and management practices at our disposal. Research has been completed in parts of California (Altieri and Schmidt, 1985), Massachusetts (Bugg and Ellis, 1990), and Georgia (Bugg and Dutcher, 1989; Bugg *et al*., 1990) illustrating the differences in soil surface invertebrate populations due to choices of various cover crops or to usage of conventional versus conservation tillage practices.

The management of residues from cover crops may also effect soil invertebrate populations in conservation tillage systems. Nematodes in soil were not affected whether cover crop residues were removed as forage or retained on plots as green manure (McSorley and Gallaher, 1994). However, the presence of crop residues on the surface may be more critical for insects and other arthropods that typically reside on the soil surface in debris or litter. The objective of our study was to determine the effect of tillage and cover crop residue management on the "soil" surface invertebrate community (i.e., those invertebrates active at the soil surface and litter layers).

IN E. van Santen (ed.) 2002. Making Conservation Tillage Conventional: Building a Future on 25 Years of Research. Proc. of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Auburn, AL 24-26 June 2002. Special Report no. 1. Alabama Agric. Expt. Stn. and Auburn University, AL 36849. USA.

MATERIALS AND METHODS

The study was located at the former University of Florida Green Acres agronomy farm in Alachua County (29E40'N, 92E30'W), about 5 mi northwest of Gainesville, Florida. The soil type was Arredondo fine sand, a loamy, siliceous, hyperthermic, Grossarenic Paleudults, with 90-92% sand, 4-5% silt, and 4-6% clay, with <2.0% organic matter and pH 5.6-5.9. The study site was planted with a cover crop of 'Wrens Abruzzi' rye at 90 lbs acre^{-1} 20 Nov. 1999. On 8 May 2000, the rye cover crop was terminated, and the following five treatments were applied: 1) rye was combined and residues remaining after combining were left on the untilled soil surface; 2) rye was mowed (stubble <2-3 in tall), residues removed, and plots not tilled; 3) rye was mowed, residues left on the soil surface, and plots not tilled; 4) rye was mowed, residues removed, and plot was conventionally tilled; 5) rye was mowed, residues left on the surface, and plot was conventionally tilled. Conventional tillage consisted of three passes of a rototiller tilling to a depth of 6 to 8 in. The five residue management treatments were arranged in a randomized complete block design with five replications. Individual plots were 25 ft x 20 ft in size. Plots were planted with''Georgia Green' peanut on 11 May 2000 at a density of 380 seeds per 25-ft-long row. At planting, 50 lbs acre^{-1} of muriate of potash was applied as fertilizer. Plots were irrigated as needed using overhead sprinkler irrigation. Plots were sprayed 28 days after planting for weed control using a mixture of Starfire at 11 oz acre^{-1} + Storm at 1.5 pt acre^{-1} + Activate Plus (25%).

Samples of insects were collected on 28 May, 20 July, and 26 Sept. 2000. A plastic sandwich container (5.5 in x 5.5 in x 1.5 in) was used as a pitfall trap (Borror *et al*., 1989). Pitfall traps typically recover a wide range of soil-surface-dwelling insects, including pest and beneficial species (Duelli *et al*., 1999). Each pitfall trap was centrally placed in a plot between two rows of Georgia Green peanuts, buried so that the upper edge was flush with the soil surface. The traps were filled three quarters of the way with water

Table 1. Arthropod numbers in pitfall traps from cover crop residue management experiment conducted in 2000. Data are means of 25 traps, pooled across crop management treatments and replicates.

Residue treatment	28-May	20-Jul	26 Sept.
	------------------- count per trap ------------------		
Acari (mites	0.4 b†	0.8 b	4.4 a
Araneae (spiders)	0.3 b	0.7 b	5.9 a
Coleoptera:Carabidae (ground beetles)	0.4 b	0.2 b	2.8 a
Coleoptera:Cicindelidae (tiger beetles)	0.1 b	1.9 a	0.2 b
Coleoptera:Elateridae (wireworms)	1.0 a	0.6 a	0.2 a
Total Coleoptera (beetles)	3.6 a	4.0 a	3.8 a
Collembola:Entomobryidae	0.1 a	7.4 b	16.9 a
Collembola:Hypogastruridae	11447.7 a	30.2 b	4.6 b
Total Collembola (springtails)	11447.8 a	37.8 b	21.6 b
Dermaptera (earwigs)	0.1 b	0.5 ab	1.0 a
Diptera (flies)	0.1 b	8.0 a	7.8 a
Hemiptera (true bugs)	0 c	2.6 b	5.1 a
Homoptera (leafhoppers)	0 b	3.0 b	9.3 a
Hymenoptera:Formicidae (ants)	1.7 b	23.2 ab	41.2 a
Hymenoptera (wasps)	0 b	2.2 a	3.1 a
Total Hymenoptera	1.7 b	25.4 ab	44.3 a
Orthoptera (crickets)	0.1 b	0.1 b	4.0 a
Orthoptera (grasshoppers)	0 b	0.4 ab	0.9 a
Total Orthoptera	0.2 b	0.9 b	5.8 a
Thysanoptera (thrips)	0 a	0.6 a	0.2 a
Total Arthropoda	11453.9 a	76.8 b	87.2 b

†Means within rows followed by the same letter are not significantly different ($P = 0.01$), according to Duncan's multiple-range test.

Table 2. The effect of rye cover crop residue management on the number of mites, spiders, and beetles in pitfall traps during the 2000 season. Data are means of five replicates.

Residue treatment	28-May	20-Jul	26 Sept.
	---------- count per trap	---------------	
Acari (mites)			
Combined, residue left on plot	0.2 a†	2 a†	2.4 a‡
Mowed, residue removed	1.4 a	0.6 a	0.6 a
Mowed, residue left on plot	0.2 a	0 a	0.6 a
Mowed, residue removed, cultivated	0 a	1.2 a	2.6 a
Mowed, residue left, cultivated	0.2 a	0 a	15.8 b
Araneae (spiders)			
Combined, residue left on plot	0 a†	0.6 a†	3.6 a†
Mowed, residue removed	0.2 b	0.6 a	6.6 a
Mowed, residue left on plot	0.4 ab	0.6 a	6.8 a
Mowed, residue removed, cultivated	0.8 a	1.0 a	3.6 a
Mowed, residue left, cultivated	0.2 b	0.8 a	7.8 a
Carabidae (ground beetles)			
Combined, residue left on plot	0 a†	0.8 a†	2.2 a†
Mowed, residue removed	1.00 a	0.2 a	3.0 a
Mowed, residue left on plot	0.80 a	0.2 a	3.4 a
Mowed, residue removed, cultivated	0 a	0 a	1.6 a
Mowed, residue left, cultivated	0 a	0 a	3.6 a
Total Coleoptera (beetles)			
Combined, residue left on plot	1.4 a†	4.8 a†	3.2 b‡
Mowed, residue removed	6.0 a	3.6 a	3.2 b
Mowed, residue left on plot	3.0 a	3.8 a	6.0 a
Mowed, residue removed, cultivated	5.6 a	5.2 a	2.0 b
Mowed, residue left, cultivated	2.8 a	2.6 a	4.4 ab

†For each arthropod group, means within columns followed by the same letter are not different ($P = 0.10$), according to Duncan's multiple-range test.

‡Means within these groups were separated at $P = 0.05$ according to Duncan's multiple-range test

along with 3 to 4 drops of dish detergent (Ultra Joy®, Procter & Gamble, Cincinnati, OH), which was added to break the surface tension, ensuring the insects would remain in the trap. Pitfall traps were set out in the morning before noon (Eastern Daylight Savings Time) and collected the next day (recorded as sampling date) before noon. The traps were transported to the lab, placed in a cold room at 50°F, and then contents were transferred to vials and stored in 70% alcohol. Sample counts were completed using a dissecting microscope and specimens were identified to order or family where possible. All data were subjected to analysis of variance using MSTAT-C software (Freed *et al*., 1991). Where significant ($P = 0.10$) F-tests occurred, differences among means were determined using Duncan's multiple-range test (Freed *et al*., 1991).

RESULTS AND DISCUSSION

A variety of different arthropod groups (mostly insects but some mites and spiders) were collected at this site. The abundance of most arthropods was greatly affected ($P = 0.01$) by sampling date. Significant effects (even at $P = 0.10$) from crop residue management treatment and interactions (date x crop residue treatment) were observed much less frequently. The seasonal effects are summarized for the most common arthropod groups (Table 1). Most arthropods became more abundant later in the season, as the growth of the peanut plants progressed. An important exception occurred with the *Hypogastrurid* springtails, which reached unusually high numbers in all plots on 28 May but declined rapidly thereafter (Table 1). These minute fungivorous insects are abundant in litter, and their ability to rapidly increase

Table 3. The effect of rye cover crop residue management on the number entomobryid springtails, flies, and total arthropods in pitfall traps during the 2000 season. Data are means of five replicates.

Residue treatment	28-May	20-Jul	26 Sept.
	----------------- count per trap -----------------		
Entomobryidae (springtails)			
Combined, residue left on plot	0 a†	20 a‡	10.8 b†
Mowed, residue removed	0 a	6.8 b	12.4 b
Mowed, residue left on plot	0 a	2.8 b	26.6 a
Mowed, residue removed, cultivated	0.2 a	4.8 b	15.2 b
Mowed, residue left, cultivated	0.2 a	2.8 b	19.6 ab
Diptera (flies)			
Combined, residue left on plot	0 b†	4.6 b†	7 a†
Mowed, residue removed	0 b	9.4 ab	5.4 a
Mowed, residue left on plot	0 b	5.2 b	9 a
Mowed, residue removed, cultivated	0 b	14.8 a	6.6 a
Mowed, residue left, cultivated	0.4 b	6.2 b	10.8 a
Total Arthropods			
Combined, residue left on plot	10,141.8 a†	73.8 a†	65.8 b†
Mowed, residue removed	9,578.4 a	130.2 a	83 b
Mowed, residue left on plot	10,616.8 a	57.2 a	133.8 a
Mowed, residue removed, cultivated	14,539.0 a	57.8 a	59.4 b
Mowed, residue left, cultivated	12,393.4 a	64.8 a	93.8 ab

†For each arthropod group, means within columns followed by the same letter are not different ($P = 0.10$), according to Duncan's multiple-range test.

‡Means within these groups were separated at $P = 0.05$ according to Duncan's multiple-range test

population size and form large aggregations is well known (Coleman and Crossley, 1996). The reason for the large population peak in this experiment is not known. Numbers of these springtails were unaffected ($P = 0.10$) by the cover crop management treatments that resulted in very different amounts of residue on the plots.

Arthropod groups for which significant ($P = 0.10$) residue treatment effects or interactions were observed are summarized (Tables 2, 3). Interactions (date x treatment) resulted from the fact that treatment effects were significant ($P = 0.10$) on some sampling dates but not on others (Tables 2, 3). At the end of the season, total arthropods were most abundant ($P = 0.10$) in uncultivated, mowed plots in which residues were left on the plots (Table 3). This trend was also observed on the same date with *Entomobryid* springtails and total numbers of beetles (Tables 2, 3). Presumably, the greater amount of residue remaining on these plots offered cover and habitat for these surface-dwelling insects. Other effects from the residue management treatments were less consistent.

Typically, conventional tillage is disruptive to soil invertebrates, especially larger organisms such as earthworms, spiders, and ground beetles (Coleman and Crossley, 1996; Wilson-Rummenie *et al*., 1999). In a recent study, population levels of several soil invertebrate groups were inversely proportional to the amount of tillage that had occurred (Wilson-Rummenie *et al*., 1999). Perhaps the differences observed in the current study were not as great as those expected based on previous work. For example, ground beetles, which comprised the largest group of beetles collected on the final sampling date, were unaffected by treatment at that time (Table 2). It is possible, however, that the plot size used (500 ft^2) was too small to effectively assess these wide-ranging, active predators that could run easily from plot to plot. Use of larger plots may address this problem, and in a subsequent study in spring 2001, much larger plots (3600 ft^2) were used (Tremelling *et al*., unpublished).

Much remains to be learned about the influence of tillage and residue cover on specific groups of soil arthropods. These practices can affect both predators and pests (Wilson-Rummenie *et al*., 1999), and so data from each location must be carefully evaluated to determine potential benefits or risks that may result.

CONCLUSIONS

Population levels of most groups of arthropods inhabiting the soil surface increased over time during the course of a peanut crop. At the end of the peanut crop, greatest total numbers of arthropods occurred in untilled plots on which the residues of the previous cover crop were retained. The effects of cover crop residue management on specific groups of arthropods were generally inconsistent and inconclusive. Such effects likely vary with specific locations and crops, and in some cases, relatively large plot sizes may be needed to assay active, wide-ranging insects.

LITERATURE CITED

All, J.N., and G.J. Musick. 1986. Management of vertebrate and invertebrate pests. p. 347-388. *IN* M.A. Sprague and G.B. Triplett (eds.). No Tillage and Surface-Tillage Agriculture. John Wiley & Sons, Inc., New York.

Altieri, M.A. and L.L. Schmidt. 1985. Cover crop manipulation in Northern California orchards and vineyards: effects on arthropod communities. Biol. Agric. Hort. 3:1-24.

Borror, D.J., C.A. Triplehorn, and N.F. Johnson. 1989. An introduction to the study of insects, 6th Ed., Sanders College Publishing, Chicago, IL.

Bugg, R.L., S.C. Phatak, and J.D. Dutcher. 1990. Insects associated with cool-season cover crops in Southern Georgia: implications for pest control in truck-farm and pecan agroecosystems. Biol. Agric. Hort. 7:17-45.

Bugg, R.L. and R.T. Ellis. 1990. Insects associated with cover crops in Massachusetts. Biol. Agric. Hort. 7:47-68.

Bugg, R.L. and J.D. Dutcher. 1989. Warm-season cover crops for pecan orchards: horticultural and entomological implications. Biol. Agric. Hort. 6:123-148.

Coleman, D. C. and D. A. Crossley, Jr. 1996. Fundamentals of soil ecology. Academic Press, San Diego, CA.

Duelli, P., M.K. Obrist, D.R. Schmatz. 1999. Biodiversity evaluation in agricultural andscapes: above-ground insects. Agric., Ecosystems and Environ. 74:33-64.

Freed, R., S.P. Eisensmith, S. Goetz, D. Reicosky, V.W. Smail, and P. Wolberg. 1987. User's Guide to MSTAT (version 4.0). Michigan State Univ., East Lansing, MI.

McSorley, R. and R. N. Gallaher. 1994. Effect of tillage and crop residue management on nematode densities in corn. Suppl. J. Nematol. 26:669-674.

McSorley, R. and L. E. Powers. 2000. Ecological principles of agriculture. Delmar Thomson Learning, Albany, NY.

Neave, P. and C.A. Fox. 1998. Response of soil invertebrates to reduced tillage systems established on a clay loam soil. Appl. Soil Ecol. 9:423-428.

Wilson-Rummenie, A. C., B. J. Radford, L. N. Robertson, G. B. Simpson, and K. L. Bell. 1999. Reduced tillage increases population density of soil macrofauna in a semiarid environment in central Queensland. Environ. Entomol. 28:163-172