RUSSELL RANCH
SAFS PROJECT
Volume 8, Number 3
Summer 2008
UC Davis Agricultural Sustainability Institute

Effects of Agricultural Management on Nematode – Mite Assemblages
Studies suggest they provide information on soil health, fertility

by Sara Sánchez-Moreno, Nicole Nicola, Howard Ferris, and Frank Zalom

Soil nematodes are highly diverse in their habitats and feeding habits. Several million of these multicellular but microscopic organisms may inhabit a square meter of soil, living in water films surrounding soil particles and aggregates of soil particles, as well as in roots and decomposing plant material.

The food sources for different groups of soil nematodes include bacteria, fungi, other nematodes, arthropods, and plant roots. Their numbers tend to be related to the abundance of their food and with those of other soil animals that may be their predators or that may be feeding on the same food sources and adapted to the same environmental conditions. Given their diversity, soil nematodes are useful indicators of the whole soil food web, that assemblage of organisms supported by plants and the herbivorous organisms that feed on them. Accordingly, they provide indication of the functions and services provided by the soil ecosystem.

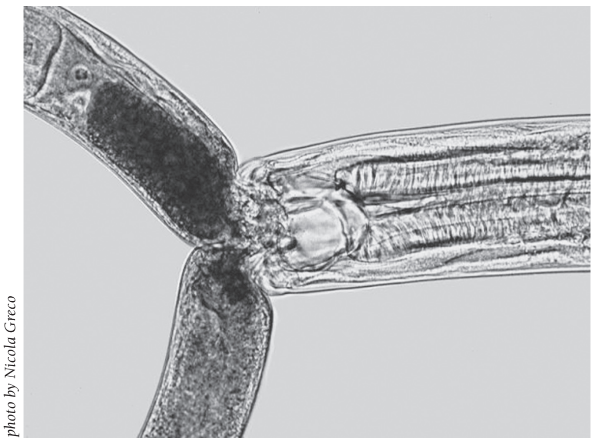

photo by Nicola Greco

▲ *A predator nematode devouring its prey.*

photo by Roy Norton

Soil mite dines on a springtail (or Collembola). ▶

Similarly, the high diversity of microarthropod communities, and their intricate relationships within the soil ecosystem qualify them as bioindicators of the soil food web and functioning of the soil ecosystem. Mites are some of the most abundant soil arthropods and they play important roles in the interactions of soil biota; some are effective predators capable of regulating and suppressing populations of their prey while others indicate levels of ecological disturbance and anthropogenic impact.

The objectives of our study were (i) to determine the effects of organic and conventional management systems, and differing intensity of tillage, on the soil biota through analysis of nematode and mite assemblages, and (ii) to determine the quantitative relationships between nematodes and arthropods in the soil.

Methods

Soil samples were collected from the 0.4 ha plots of the organic (Org) and conventional (Conv) management systems of the Long Term Research in Agricultural Systems (LTRAS) project. Each plot is divided into two subplots; standard tillage and conservation tillage. No-till

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June 17 Russell Ranch/SAFS field day

Welcome to the *Russell Ranch/SAFS Project, Summer 2008, Vol. 8/No. 3* newsletter, which presents research results from the UC Davis Russell Ranch Sustainable Agriculture Facility. The articles here continue our efforts to provide useful information on economically and ecologically sustainable research and management practices for California growers. The research described is based on experiments with the Sustainable Agriculture Farming Systems (SAFS) project, which is funded through 2009 by CalFed. **Note:** Please join us for our annual field day **Tuesday, June 17, 2008** at the Russell Ranch facility in Davis. The editor of *California Farmer Magazine*, **Len Richardson**, will be the keynote speaker. Stay tuned.

—Will Horwath, project leader

treatments were included in the Org plots by hand-weeding two 3-m2 microplots. Thus, five treatments were sampled: Conv-Standard Tillage (CST), Conv-Conservation Tillage (CCT), Org-Standard Tillage (OST), Org-Conservation Tillage (OCT), and Org-No Tillage (ONT). All the treatments were planted with tomato (2005) and corn (2006). There were three replicates of each treatment and three samples were taken in each treatment plot. Thus, 45 samples were collected in March, June, August, and November 2005, and April, May/June, August/September, and November 2006.

Arthropods were extracted, identified and classified into four trophic groups: fungivores and/or saprophages (FS), predators, omnivores, and algivores. Nematodes were extracted, identified and classified into five main trophic groups: predators, omnivores, plant-feeders, fungal-feeders and bacterial-feeders. Soil food web indices (Enrichment Index, Structure Index, Channel Index and Basal Index), were calculated based on the nematode data.

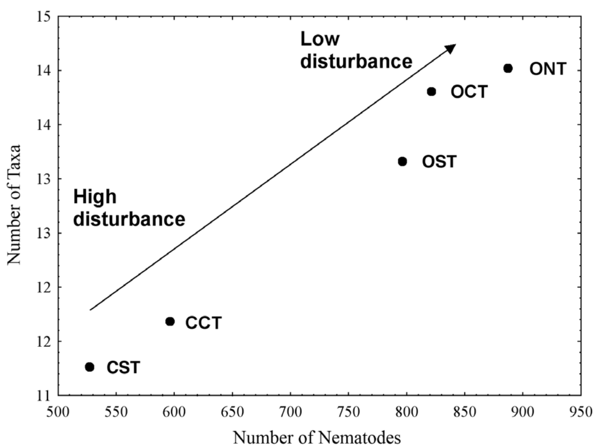

Figure 1. Number of nematodes and nematode taxa in conventional plots with standard (CST) and conservation (CCT) tillage and organic plots with standard (OST), conservation (OCT) and no (ONT) tillage.

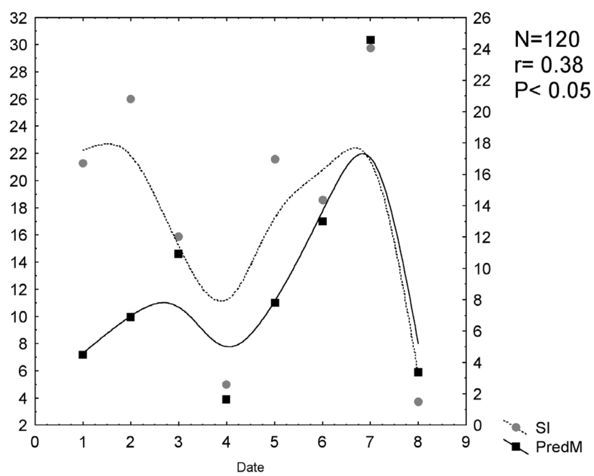

Figure 2. Temporal patterns of the Structure Index (SI) and abundance of predatory mites (PredM). Sampling time (1-8) correspond to March, June, August, and November 2005, and April, May/June, August/September, and November 2006

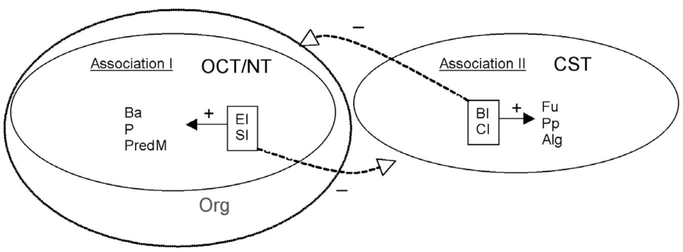

Figure 3. Two biological associations detected in different agricultural management systems.

Results

The effects of different agricultural practices were reflected in both the nematode and the mite community. Of the 37 nematode taxa found in soil samples, some nematodes, such as the genera *Panagrolaimus, Prismatolaimus, Mesorhabditis, Plectus, Tylenchorhynchus* and *Helicotylenchus* were more abundant in the organic treatments, some of them responding rapidly to the organic matter provided by incorporation of cover crops in the Org management. On average, both number of nematodes and number of taxa were greater in Org than in Conv treatments, in a sequence from low (ONT) to high (CST) disturbance (Fig. 1). Organic or conventional management was the most important factor determining the taxa composition of the nematode community.

The Enrichment Index (EI) was higher in Org that in Conv plots (P< 0.01), indicating more abundant microbial populations, more rapid organic matter decomposition and higher soil fertility.

Abundance of predatory nematodes was higher in the Org plots than in CST. As expected, the Structure Index (SI), indicator of soil food web length and connectance, was higher in the ONT treatment than in Conv plots (P< 0.05), since the application of fertilizers and pesticides is often correlated with the reduction of the higher links of the soil food web. Further, the Structure Index, based mainly on generalist and specialist predator nematode groups, was a good indicator of the abundance of predatory mites (Fig. 2). Agricultural disturbance also affected predatory mites, which were in greatest abundance in ONT and OCT and in lowest abundance in CST.

The Channel Index (CI), indicator of slower organic matter decomposition mediated by fungi, and the Basal Index, indicator of stressed and depleted soil food webs, were both significantly greater in Conv than in Org organic plots (P< 0.01), indicating lower availability of organic matter and perturbed soil food webs. Organic matter in Conv is primarily derived from leaf litter and crop residues with high C/N ratios; as the decomposing organic matter becomes more recalcitrant, it is more conducive to fungal decomposition, and the ratio of fungal/bacterial feeding nematodes increases. Thus, abundance of fungal-feeding nematodes was higher in Conv treatments. Fungivore and saprophage mites, on the contrary, were affected separately by management and tillage, with greatest abundances in Org and CT/NT (P< 0.05). Algivore mites were only affected by management system and were at greatest abundance in Conv plots.

We constructed a model describing two different soil assemblages based on the associations among experimental treatments, soil food web indices and trophic groups of nematodes and mites (Fig. 3). Each association is composed of nematode and mite trophic groups that are most abundant in the same treatments.

Association I is composed of bacterial-feeding (Ba) and predatory nematodes (P) and arthropods (PredM), and is typically present in the OCT/ONT plots. High values of the Structure Index (SI) and the Enrichment Index (EI) are positive predictors of this

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association. This association, together with omnivore nematodes (O) and arthropods (OmnM), and fungivore and saprophage mites (FS), comprised the biological assemblage in the Org management system, irrespective of tillage treatment (Fig.3). Absence of physical perturbation and chemical inputs in organic-no till plots led to a nematode-mite assemblage characteristic of high soil food web structure, including abundant predators and a large bacterial-feeding community, probably supported by large microbial populations, which provides a consistent food source for the higher trophic levels of the soil food web. In contrast, Association II is composed of fungal (Fu) and plant-feeding (Pp) nematodes and fungal and algivorous arthropods (Alg); it is indicated by high values of the Basal Index (BI) and the Channel Index (CI). It reflects the presence of short and depleted soil food webs with low diversity in Conv plots. Thus, descriptive indices of the soil food web, based on the structure of the nematode assemblage, also provided a useful indicator of the structure and functions of the soil mite populations.

Organic management and low tillage in crop rotation systems in California's Central Valley greatly increased the abundance and diversity of soil organisms. Overall, Org/NT supported soil food webs that provide higher levels of beneficial food web services. The services include greater suppression of plant-feeding organisms and more rapid organic matter decompositions. Although further steps are needed to relate crop productivity to organism diversity and food web services, our studies suggest that bioindicators such as nematodes and mites may provide valuable information on soil health and fertility.

Resource use reduction from conservation tillage

by Karen Klonsky and Pete Livingston

There are two tillage regimes in the UC Davis Sustainable Agriculture Farming Systems (SAFS) project: Standard Tillage (ST) and Conservation Tillage (CT). The ST plots are farmed in a manner typical for the lower Sacramento Valley for a two-crop rotation of processing tomatoes and field corn. CT reduces the number of field operations as much as possible with the economic objective of reducing costs without compromising yields.

Both tillage regimes have two crops, processing tomatoes and field corn, grown using three farming methods: 1) Conventional (Conv) following standard practices in the Sacramento Valley, 2) Winter Legume Cover Crop (WLCC) using a winter cover crop and judicious use of herbicides, and 3) Organic (Org) using a winter cover crop for both crops and additional compost preceding tomato. The organic system follows the legal requirements of an organic system which precludes the use of synthetic pesticides, herbicides or fertilizer. All three production methods are carried out under both ST and CT regimes resulting in six systems for each crop.

The systems using CT differed from the ST system with respect to ground preparation operations and residue management. The Org and WLCC methods include operations for planting and incorporating cover crops. In addition, Org includes one operation for spreading compost. Conv includes additional herbicide operations, the exact number varying from year to year. In some years the CT WLCC and CT Conv used additional herbicide applications and cultivations. CT Org also used additional cultivations in some years. In other years the hand hoeing for tomato was higher in CT than ST.

Several sustainability indicators utilize resource use as the basis of comparison. In our experiments, resource use differs across farming methods (Conv, Org, and WLCC) and between tillage regimes (ST and CT). In all years for both crops and all farming methods, CT systems used significantly fewer farming operations than ST. The decrease in trips across the field from reduced preplant and postharvest operations was always greater than any increase in weed control operations. This decrease in operations translated into reduced fuel use and tractor labor hours. The differences between tillage systems will be discussed in terms of the number of operations, labor use, equipment hours, and fuel use.

Tomatoes: Using 2006 as an example, the CT Conv tomatoes had 12 trips across the field and 10 for Org and WLCC compared to 21 for the ST systems. Specifically, preplant tillage operations

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Table 1. Labor and Fuel Usage for Tomatoes and Corn

	Standard Tillage			Conservation Tillage		
Resource	**Conventional**	**Organic**	**WLCC**	**Conventional**	**Organic**	**WLCC**
Tomatoes						
Machine labor (Hrs)	7.5	6.9	7.2	5.4	4.8	5.0
Non-machine labor (Hrs)	6.3	6.2	6.3	6.3	6.2	6.3
Gallons of fuel (Gals)	62.2	56.2	58.5	43.1	38.7	39.2
Corn						
Machine labor (Hrs)	4.5	4.5	4.7	2.1	2.9	2.0
Non-machine labor (Hrs)	1.2	1.1	1.2	1.2	1.1	1.2
Gallons of fuel (Gals)	36.1	35.4	36.7	12.3	16.8	11.6

included in ST but not CT were bed-disked three times and ring-rolled once. In contrast, the CT systems only used one strip till pass for a net savings of three trips across the field for preplant operations. Additional postharvest residue management included finish disk (2x), stubble disk, landplane (2X), and list beds for ST. None of these operations are included in the CT systems. Org and WLCC have additional operations related to cover crops while Conv has additional herbicide operations; the result is about half the number of times across the field for CT compared to ST tillage systems.

These differences translates into a reduction in tractor operator labor of 2.1 – 2.2 hours per acre and a reduction in fuel use of 19.1 – 19.3 gallons per acre from using conservation tillage (Table 1). For a 2,000 acre farm with 1,000 acres in tomatoes, this translates into a reduction of 2,100 hours of labor and 19,100 gallons of fuel. Following the convention that tractor labor hours are 10 percent higher than tractor hours to allow for down time and setup time, this is a reduction in tractor use of 1,909 hours between ST Conv and CT Conv.

At first blush, it seems that a reduction in operations of roughly 50 percent should translate into a 50 percent reduction in costs. However, this is far from the case. For processing tomato, most of the costs are in materials, transplants, fertilizer, water, and herbicides. A reduction in tillage operations only decreases fuel, labor, and equipment use and has little direct impact on materials inputs (with the notable exception of some additional herbicide treatments). Further, cutting the number of ground operations in half does not even cut the fuel use in half due to the disproportionate fuel use for the planting and harvest operations, which are very time consuming compared to tillage operations.

Corn: Again using 2006 as an example, ST corn used 21 trips over the field for Conv and 22 trips for Org and WLCC compared to CT corn used, which averaged 11 passes. This represents over a 50 reduction in the number of operations used to grow corn between the ST and CT systems. Unlike tomato, all of the reduction in operations comes from the difference in residue management. Preplant operations do not vary between tillage regimes, only across farming methods. The operations included in ST but not CT are finish disk (2X), stubble disk (4X), landplane (2X), and list beds. The result is a reduction in tractor operator labor of between 2.4 and 2.7 hours per acre and between 23.8 (Conv) and 25.1 (WLCC) gallons of fuel per acre. For 1,000 acres of conventionally grown corn, this means a reduction of 23,800 gallons of fuel, 2,400 tractor labor hours, and 2,181 tractor hours.

More information on UC Davis sustainable agriculture farming systems projects is available online at
safs.ucdavis.edu,
including expanded newsletter articles, updates and resources.

RUSSELL RANCH/SAFS PROJECT

Department of Land Air & Water Resources
University of California, Davis
One Shields Avenue
Davis, CA 95616
7629