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INCREASING THE SERVICES OF SOIL INVERTEBRATES IN AGROECOSYSTEMS

NON-TECHNICAL SUMMARY: Vegetable growers look for ways to manage their soils for both crop fertility and to promote naturally occurring biological control of soil insects and other pests. Our research will examine how beneficial soil organisms, in our case microscopic nematodes (round worms) that attack insects in soils, could be managed to suppress insect pests. We will explore three questions in this research: 1.) How can we manage agricultural soils for both fertility and also improved survival of these beneficial organisms Conventional and alternative soil management systems will be established in field plots and survival and establishment of the beneficial nematodes will be measured over time. 2.) How can we enhance the beneficial organisms with non-pest insects Cover crop and compost mixtures will be established to build diverse soil-dwelling but benign insect communities that may increase production of the beneficial organisms. 3.) How do these beneficial soil organisms move within and between fields, and can we move them towards areas with pests that need to be controlled They are known to move within the soil but also to ?ohitchhike? on walking and flying insects, so both forms of movement will be examined. Survival, reproduction and dispersal of the beneficial nematodes will be examined individually and in combination to determine how they interact to influence where we can find beneficial nematodes and how they change the soil food web over time. The results of this research will provide needed ecological understanding of how beneficial soil microorganisms can be managed to increase their valuable ecosystem services while maintaining crop productivity. Results will improve the environmental quality of agricultural ecosystems by reducing reliance on pesticides and synthetic fertilizers, enhancing farm productivity through naturally occurring biological processes.

OBJECTIVES: Management effort is needed to modify the patchy distribution and low dispersal rates of many soil-dwelling beneficial organisms. We hypothesize that altered soil fertility management in cultivated soils will increase both survival and movement of entomopathogenic nematodes (EPNs) from grassy borders where they are relatively common to adjacent vegetable fields where they provide the ecosystem service of regulating soil insect pest populations. Our specific objectives are to test the relative importance of and interactions among three representative means of manipulating a soil organism's distribution: 1.) Enhancing survival in the soil environment - improving cultivated soils with organic matter amendments that maintain or enhance soil quality, fertility and crop yield while establishing the food web structure and enrichment levels associated with EPNs. Amendments will be established in small plots and survival and flows of EPNs from borders into the plots will be measured over time along with soil food web structure and soil nutrient pools. 2.) Enhancing reproduction in non-pest alternative host populations - the alternative soil management system will be compared with the conventional to determine the associated soil-dwelling arthropod communities and their potential as alternative, non-pest hosts for EPNs. 3.) Enhancing dispersal via arthropod phoresy - increasing non-pest arthropod flow across the landscape to increase the frequency and distance of dispersal by EPNs. Association of EPNs with dispersing insects will be measured directly, by sampling dispersing insects, and indirectly, by relating numbers of dispersing insects to distribution of nematodes. The outcome of this research will be an improved ability to manage beneficial soil organisms and capture their services, particularly pest suppression, in agroecosystems.

APPROACH: Our experimental system for this research, vegetable production on high organic matter muck soils in the Great Lakes region, has naturally occurring entomopathogenic nematode populations, landscape diversity but relatively uniform soil characteristics (e.g. soil type and geological history) and multiple soil dwelling insect pests that could eventually be targets for biological control. Each of our experiments requires a means of sampling for EPNs in soil to characterize their abundance, spatial distribution and follow their dispersal patterns over time. Nematode population density will be estimated by baiting the soil with susceptible insects to extract EPNs. To measure dispersal through soil, we plan to release EPNs at known quantities in grass borders neighboring field plots and then follow their movement by sampling on a grid from the border to the neighboring plot over time. To examine the impact of soil management practices on EPN survival within cultivated fields, we will release EPNs and recapture them over time in plots with standard and alternative soil management practices. The alternative soil management system includes organic amendments (compost) to enhance soil food web enrichment and reduce C:N ratio, legume/grass mixtures to enhance food web structure, reduced tillage to leave plant residue covering the soil surface for both weed suppression and moderating soil temperature and moisture, and adjusted P and K application to achieve necessary plant nutrition simultaneously with improved conditions for EPNs. To examine how non-pest insect hosts affect reproduction of EPNs, we will sample the soil arthropod community and measure reproduction of EPNs in these potential alternate hosts in the laboratory, recovery of infected hosts in the field, and the impact of EPNs on insect populations. To examine how insects aid in dispersing EPNs, we will study the dispersal of EPNs from sites with varying populations of arthropods that could aid nematode dispersal. Variation in arthropod populations will be manipulated by several treatments individually and in combination including: the soil management system (conventional and alternative, in particular the ground cover and organic amendments that could influence arthropod detritivores), proximity to grass borders that could serve as corridors for insect movement (adjacent and isolated from borders), and insecticide applications (sprayed with broad-spectrum pyrethroid and unsprayed) to eliminate and repel arthropods. EPN colonization and distribution under these treatments and the resulting variation in arthropod population density and dispersal will be examined by sampling over time on a grid. Finally, we will examine in controlled field plot experiments how survival, dispersal and reproduction interact to influence the spatial distribution of EPNs over time, the ecosystem services in terms of crop yields and soil insect pests, and changes in the soil food web.

PROGRESS: 2010/09 TO 2011/08
OUTPUTS: This project is centered on a designed set of field experiments in which vegetable production soils are being managed in ways that are hypothesized to influence the survival, reproduction and movement of entomopathogenic nematodes, biological controls for soil insect pests. We conducted a second year of field experimentation in 20 plots along grassy borders and 20 plots more distant from field borders in a muck crops (very high organic matter peat soils) production area. Half the plots were treated with conventional tillage and herbicides, the other half with a modified soil management system in which we used compost and legume/grass cover crops to enrich and enhance food web structure, and reduced tillage to leave plant residue covering the soil surface for both weed suppression and moderating soil temperature and moisture. In the border plots, entomopathogenic nematodes (EPN) were released in the grass borders and half of the plots were sprayed with pemethrin to suppress arthropod populations. The soil was sampled for EPN by inserting screen cylinders filled with soil and 5 wax worm larvae. Free-living nematodes were sampled by extraction from Tulgren funnels and were identified under a microscope to genus. Soil dwelling insects were sampled by pitfall traps (macroarthropods) and Berlese funnels (microarthropds) and were identified to family. Soil cores were taken and sent to a soils lab to examine physical and chemical characteristics of the soil in each plot. In the plots that were distant from the border, EPN were released in half the plots and soil sampling was conducted to compare their survival among treatments. EPN, free-living nematodes, insect populations and soils were also sampled in these plots as described above. Carrots were grown in all plots and samples were taken at harvest to compare carrot weevil damage among treatments.

PARTICIPANTS: Casey Hoy - PD, organized and supervised all phases of project Parwinder Grewal - CoPD, assisted with all phases of project, particularly nematology work Zhiquang Cheng - Postdoctoral Researcher, soil sampling, free living nematode extractions and identification, analysis Nuris Acosta - Research Assistant, supervised field experiments, overall data management, insect identification and analysis Harit Bal - Graduate research assistant, assisted with field experiments, nematode movement studies, entomopathogenic nematode sampling. Marcelo Goyzueta - Visiting scholar and field research assistant TARGET AUDIENCES: Farmers, particularly vegetable producers Scientific colleagues PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT: 2010/09 TO 2011/08
Data analysis is in progress. Key results so far are that: Collembola (soil decomposer) populations increased in the alternative soil management plots compared with the conventional, consistent with the project hypothesis. In addtition, the alternative soil management practices have resulted in more abundant free-living nematodes, greater nematode food web maturity index, greater combined maturity index, and greater structure index, compared with conventional soil management. Although we have not yet seen reduction of soil insect pests with the treatments, an ultimate objective, the new soil management practices are improving soil biodiversity and food webs in ways that have been shown to increase system productivity. Therefore, new soil management techniques are improving the health of the soil in ways that will increase crop yields without chemical fertilizers or pesticides.

PUBLICATIONS (not previously reported): 2010/09 TO 2011/08
No publications reported this period

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