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Biomass Power for Rural Development Technical Report:

IMPACT OF WILLOW / POPLAR BIOMASS CROPS ON SOIL MICROARTHROPODS Interim Program Report

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INTRODUCTION

Because of their high density, species richness and ecological significance, soil microarthropods (mites and collembolans, 0.2-1.0 mm long) are well suited as indicator organisms for monitoring sustainability of natural and agricultural systems and the impact of management practices on biodiversity. We are studying changes in the density and community structure of these organisms during Phase 2 research on the production of willow and poplar biomass as alternative fuel. Using field sampling data and the information on the biologies of the specific organisms, available in the literature, inferences can be made about how natural soil processes are impacted by different management practices. Many experimental and theoretical studies show that higher community diversity is associated with higher stability and sustainability of the ecosystem (Bardgett and Cook, 1998; Crossley et al., 1989; McNaughton, 1977). The diverse communities of saprophagous and predaceous soil organisms indicate functionally stable soil environment.

The research will focus on two taxonomic groups of mites that occupy different trophic levels in belowground systems. The oribatid mites (Acari: Oribatida) are saprophages and mycophages. These mites are regulators of the decomposition rate, and through interactions with microflora they affect nutrient cycling, which is an important factor in soil fertility (Coleman and Crossley, 1996; Sulkava et al., 1996). For example, the low abundance and low diversity of these mites may indicate unfavorable soil conditions, correlated to lower plant biomass production potential. The mesostigmatic mites (Acari: Mesostigmata) are important predators that attack other microarthropods and both free-living and plant-parasitic nematodes (Koehler, 1997). The abundance and community structure of these mites reflect the availability of their prey.

Our objectives are to determine the effects of 1) site preparation methods, 2) fertilizer (organic amendments) application and 3) herbicide application on the abundance and species diversity of two representative groups of soil organisms - the decomposer oribatid mites and the predatory mesostigmatic mites.

METHODS

Study sites

Our studies are superimposed on plots that have been established by other SUNY-ESF researchers for determining relevant treatment effects on willow plants and soil (referred to below as 'parent studies'). The site preparation study is at the Lafayette Road site, and both the fertilizer and herbicide studies are located at the Genetics Field Station (Tully). In each case, plots had been established in a randomized block design, and these (or a portion of them) were used by us for sampling soil microarthropods. Both the site preparation study and fertilizer study are in 3 blocks of 8 treatments each. As of our most recent sampling, the herbicide plots had not yet been established, and our sampling has consisted only of random pretreatment sampling over the study area. Exact location of the study sites and the nature of treatments are detailed elsewhere, in descriptions of the respective parent study.

Sampling and sorting

Soil samples are 5 x 5 x 5 cm cubes taken at random within a given plot, using a stainless steel corer. Microarthropods are extracted in the laboratory by drying the soil in small Tullgren funnels constructed from commercial 4-inch (10 cm) diameter plastic greenhouse pots, using 7-Watt light bulbs as a heat source. At a critical low relative humidity, microarthropods develop a positive geotaxis, and move downward through the sample until falling through a screen bottom, into a Nalgene powder funnel and then into a collecting vial filled with 70% ethanol as preservative (Gorny and Grum, 1993). Organisms are then separated from residual soil particles using a stereomicroscope, sorted into major taxonomic groups, and stored for further identification. Identification to species requires mounting specimens on microscope slides (using Hoyer's medium) and subsequent study with phase-contrast or differential-interference contrast microscopy.

Data analysis

The analyses were conducted separately for two groups of soil mites - Oribatida and Mesostigmata. The following strategy was used: first, we conducted overall ANOVA F-test, to check the hypothesis of no effect of treatments on mite density. Second, to identify the effects of treatments on these two taxonomical groups, the data were investigated as the sets of planned comparisons (contrasts) (Kuehl, 1994). All statistical tests were conducted at the level of significance $\alpha = 0.05$.

PRELIMINARY RESULTS

Herbicide Study

Two pretreatment samplings of the study area were made in Fall 1997 and Fall 1998 (Table 1). Plots and treatments are now established, and the first post-treatment sampling will follow in Summer 1999.

Table 1. Herbicide study: Pretreatment samplings. Population density of soil mites, ind./sample.

<i>Fall 1997</i>				
Taxonomic Group	Mean	Std. Dev.	Min	Max
Mesostigmata	0.617	0.739	0	2
Oribatida	4.467	6.746	0	35
<i>Fall 1998</i>				
Taxonomic Group	Mean	Std. Dev.	Min	Max
Mesostigmata	0.655	0.947	0	4
Oribatida	4.397	9.279	0	50

Site preparation techniques (Lafayette)

Random pretreatment sampling of the Lafayette site revealed no significant differences among the mite faunas of the prospective blocks. The experiment was established in Fall 1996. The treatments were:

A1 - Hand planted willows, control;

- A2 - Hand planted with cover crop;
- A3 - Hand planted, no till;
- A4 - Hand planted, strip till;
- A5 - Hand planted, spring site preparation;
- A6 - Hand planted, no weed control;
- A7 - Machine planted, control;
- A8 - Machine planted, no till.

The detailed description of treatments is given elsewhere. Post-treatment sampling was done in summer 1998 and fall 1998. In the summer, 72 samples were taken: three samples in each of 24 treatment plots (3 blocks, 8 treatments per block). In fall (and for subsequent samplings), the number of samples per plot was increased to 4 (96 total)

Processing of samples is ongoing. The population density of individual suborders (Mesostigmata and Oribatida) in summer and fall 1998 is given in Tables 1 and 2. The ANOVA F-tests do not reject a null hypothesis of no differences in mite density among treatments during summer and fall 1998, at least at the considered taxonomic level (Table 4, 5). No treatment effects were discovered in summer 1998. The comparison of treatment means showed that in fall 1998 there was a significant negative effect of tillage on population density of mesostigmatic mites (Table 6). The density of this group was also significantly higher at the plots planted with machines. The highest density of mesostigmatic mites was observed under machine planted no-till treatment. No significant treatment effects were found for oribatid mites (Table 7).

Fertilizer study (Organic Amendments)

The experiment was established in the spring of 1996. The following fertilizer treatments were applied:

- C** - control;
- N1, N2, N3** - 100, 200, 300 kg N/ha respectively of slow-release urea fertilizer;
- M** - plastic mulch;
- CH** - chicken manure compost at 250 m³/ha, or 2.5cm thick;
- B** - lime-stabilized biosolids at 250 m³/ha;
- M+B** - stabilized biosolids covered in plastic mulch.

Post-treatment sampling was done in summer 1998 and fall 1998. In the summer, 72 samples were taken: three samples in each of 24 treatment plots (3 blocks, 8 treatments per block). In the fall (and for subsequent samplings), the number of samples per plot was increased to four (96 total).

The population density of mesostigmatic and oribatid mites is reported in Tables 8-9. The identification of mite species is ongoing. The statistical analysis of data indicated no significant difference between treatments for predatory mesostigmatic mites in summer 1998, but fall 1998 sampling showed significant overall treatment effect on these mites (Table 10). Significant treatment effect on population density of the decomposer oribatid mites was seen in both summer and fall 1998 (Table 11).

Analysis of the treatment effects on mesostigmatic mites indicated significant positive effect of treatment B (stabilized biosolids) on their population density (Tables 12, 13). The results shown in

Tables 14 and 15 suggest that there was a significant negative effect of mulch and biosolids on oribatid mites. The highest density of oribatid mites was observed under treatment CH (chicken manure compost). At this early stage, we have no explanation for these differences. The analysis of data on the species level is necessary to explain observed effects.

Table 2. Population density (ind./sample) of Mesostigmatic mites (Acari: Mesostigmata) under different site preparation treatments.

<i>Summer 1998</i>					<i>Fall 1998</i>				
Treatment	Mean	Std. Dev.	Min	Max	Treatment	Mean	Std. Dev.	Min	Max
A1	1.111	1.692	0	4	A1	1.167	1.946	0	6
A2	0.889	1.054	0	3	A2	0.750	1.215	0	4
A3	2.778	1.481	1	6	A3	1.500	1.567	0	4
A4	1.778	1.856	0	6	A4	1.139	1.010	0	3
A5	2.444	4.035	0	13	A5	2.333	2.708	0	9
A6	1.778	1.986	0	6	A6	1.917	2.065	0	6
A7	1.333	1.500	0	4	A7	1.250	1.422	0	4
A8	1.889	1.900	0	5	A8	6.194	11.813	0	43

Table 3. Population density (ind./sample) of Oribatid mites (Acari: Oribatida) under different site preparation treatments.

<i>Summer 1998</i>					<i>Fall 1998</i>				
Treatment	Mean	Std. Dev.	Min	Max	Treatment	Mean	Std. Dev.	Min	Max
A1	3.333	5.545	0	14	A1	7.9167	7.0641	0	21
A2	4.778	6.160	0	18	A2	7.3608	9.0680	0	33
A3	3.444	4.825	1	16	A3	5.2500	9.0265	0	33
A4	4.000	4.924	0	16	A4	4.5558	4.5403	0	16
A5	1.333	1.937	0	5	A5	8.0833	8.2071	0	24
A6	4.333	2.450	1	9	A6	8.8333	7.5418	1	20
A7	1.444	2.186	0	6	A7	5.8333	4.8586	0	15
A8	3.556	5.271	0	14	A8	16.0000	15.4508	2	49

Table 4. ANOVA F-statistics for the null hypothesis of no site preparation treatment effect on population density of Mesostigmatic mites (Acari: Mesostigmata), Alpha = 0.05.

Summer 1998

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	18.250	9.125	2.12	0.1291
Treatment	7	25.944	3.706	0.86	0.5432

Fall 1998

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	87.438	43.719	2.22	0.1148
Treatment	7	258.141	36.877	1.87	0.0839

Table 5. ANOVA F-statistics for the null hypothesis of no site preparation treatment effect on population density of Oribatid mites (Acari: Oribatida), Alpha = 0.05.

Summer 1998

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	148.361	74.181	4.11	0.0211
Treatment	7	100.222	14.318	0.79	0.5962

Fall 1998

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	368.238	184.119	2.45	0.0922
Treatment	7	1070.792	152.970	2.04	0.0595

Table 6. Comparison of site preparation treatment effects on population density of Mesostigmatic mites (Acari: Mesostigmata) in Fall 1998, Alpha = 0.05.

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Hand planting vs. Machine planting	1	91.485	91.485	4.65	0.0339
Weed control vs. No weed control	1	0.180	0.180	0.01	0.9240
Tillage vs. No tillage	1	105.512	105.512	5.36	0.0230
Strip till vs. Standard till	1	1.185	1.185	0.06	0.8068
Strip till vs. No tillage	1	58.663	58.663	2.98	0.0879
Spring preparation vs. Fall prep.	1	3.466	3.466	0.18	0.6759
Cover crop vs. No cover crop	1	22.513	22.513	1.14	0.2880

Table 7. Comparison of site preparation treatment effects on population density of Oribatid mites (Acari: Oribatida) in Fall 1998, Alpha = 0.05.

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Hand planting vs. Machine planting	1	276.125	276.125	3.68	0.0585
Weed control vs. No weed control	1	10.006	10.006	0.13	0.7160
Tillage vs. No tillage	1	224.014	224.014	2.98	0.0878
Strip till vs. Standard till	1	93.005	93.005	1.24	0.2689
Strip till vs. No tillage	1	294.678	294.678	3.92	0.0508
Spring preparation vs. Fall prep.	1	21.770	21.770	0.29	0.5917
Cover crop vs. No cover crop	1	5.244	5.244	0.07	0.7923

Table 8. Population density (ind./sample) of Mesostigmatic mites (Acari: Mesostigmata) under different organic fertilizer treatments.

Summer 1998

Treatment	Mean	Std. Dev.	Min	Max
B	1.333	1.118	0	4
C	1.222	2.279	0	7
CH	0.556	0.527	0	1
M	0.778	0.833	0	2
M+B	0.889	1.269	0	3
N1	1.444	1.130	0	3
N2	1.333	2.550	0	8
N3	0.333	0.707	0	2

Fall 1998

Treatment	Mean	Std. Dev.	Min	Max
B	4.833	4.629	0	17
C	1.417	1.443	0	5
CH	2.667	1.923	0	6
M	1.333	1.670	0	5
M+B	1.167	1.193	0	3
N1	0.250	0.452	0	1
N2	1.583	1.311	0	4
N3	1.167	1.467	0	4

Table 9. Population density (ind./sample) of Oribatid mites (Acari: Oribatida) under different organic fertilizer treatments.

<i>Summer 1998</i>				
Treatment	Mean	Std. Dev.	Min	Max
B	0	0	0	0
C	1.000	1.225	0	3
CH	6.556	4.035	1	13
M	0.222	0.441	0	1
M+B	0	0	0	0
N1	1.111	1.054	0	3
N2	1.444	2.877	0	9
N3	1.111	1.764	0	5

<i>Fall 1998</i>				
Treatment	Mean	Std. Dev.	Min	Max
B	0.333	0.888	0	3
C	29.000	21.089	3	65
CH	65.917	70.855	3	235
M	9.083	13.069	0	38
M+B	0.917	0.996	0	3
N1	12.917	21.331	0	77
N2	13.500	19.709	1	74
N3	36.667	24.258	0	82

Table 10. ANOVA F-statistics for the null hypothesis of no fertilizer treatment effect on population density of Mesostigmatic mites (Acari: Mesostigmata), Alpha = 0.05.

<i>Summer, 1998</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	4.861	2.431	1.13	0.330
Treatment	7	10.542	1.506	0.70	0.673

<i>Fall, 1998</i>					
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	15.771	7.885	1.81	0.1700
Treatment	7	162.823	23.260	5.34	0.0001

Table 11. ANOVA F-statistics for the null hypothesis of no fertilizer treatment effect on population density of Oribatid mites (Acari: Oribatida), Alpha = 0.05.

Summer, 1998

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	1.861	0.931	0.24	0.7890
Treatment	7	289.875	41.411	10.61	0.0001

Fall, 1998

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Block	2	1833.271	916.635	1.04	0.3590
Treatment	7	41051.833	5864.548	6.64	0.0001

Table 12. Comparison of organic fertilizer treatment effects on population density of Mesostigmatic mites (Acari: Mesostigmata), Alpha = 0.05.

Summer 1998

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Treated vs. Control	1	0.573	0.573	0.27	0.6078
Fertilized vs. Not fertilized	1	0.005	0.005	0.00	0.9632
Mulch vs. No mulch	1	0.560	0.560	0.26	0.6119
Biosolids vs. No biosolids	1	0.375	0.375	0.17	0.6780
Biosolids/CH vs. Urea	1	0.167	0.167	0.08	0.7818
Biosolids vs. Chick manure	1	1.852	1.852	0.86	0.3575
N1 vs. N3	1	5.556	5.556	2.58	0.1134

Fall 1998

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Treated vs. Control	1	2.037	2.037	0.47	0.4959
Fertilized vs. Not fertilized	1	5.837	5.837	1.34	0.2503
Mulch vs. No mulch	1	9.753	9.753	2.24	0.1382
Biosolids vs. No biosolids	1	45.920	45.920	10.54	0.0017
Biosolids/CH vs. Urea	1	64.222	64.222	14.74	0.0002
Biosolids vs. Chick manure	1	0.889	0.889	0.20	0.6526
N1 vs. N3	1	5.042	5.042	1.16	0.2850

Table 13. Dunnett's T tests for the population density of Mesostigmatic mites (Acari: Mesostigmata) under different organic fertilizer treatments in Fall 1998.

This tests controls the type I experimentwise error for comparisons of all treatments against a control. Comparisons significant at the 0.05 level are indicated by '***'.

Alpha= 0.05 Confidence= 0.95 df= 86 MSE= 4.356347
Minimum Significant Difference= 2.2724

Treatment Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
B - C	1.144	3.417	5.689	***
CH - C	-1.022	1.250	3.522	
N2 - C	-2.106	0.167	2.439	
M - C	-2.356	-0.083	2.189	
N3 - C	-2.522	-0.250	2.022	
M+B - C	-2.522	-0.250	2.022	
N1 - C	-3.439	-1.167	1.106	

Table 14. Comparison of organic fertilizer treatment effects on population density of Oribatid mites (Acari: Oribatida), Alpha = 0.05.

Summer 1998

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Treated vs. Control	1	1.907	1.907	0.49	0.4871
Fertilized vs. Not fertilized	1	16.116	16.116	4.13	0.0464
Mulch vs. No mulch	1	41.782	41.782	10.71	0.0017
Biosolids vs. No biosolids	1	49.116	49.116	12.59	0.0007
Biosolids/CH vs. Urea	1	12.518	12.518	3.21	0.0781
Biosolids vs. Chick manure	1	257.852	257.852	66.08	0.0001
N1 vs. N3	1	0.000	0.000	0.00	1.0000

Fall 1998

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Treated vs. Control	1	868.595	868.595	0.98	0.3241
Fertilized vs. Not fertilized	1	128.000	128.000	0.14	0.7043
Mulch vs. No mulch	1	8234.722	8234.722	9.33	0.0030
Biosolids vs. No biosolids	1	13338.889	13338.889	15.11	0.0002
Biosolids/CH vs. Urea	1	33.347	33.347	0.04	0.8464
Biosolids vs. Chick manure	1	34104.014	34104.014	38.63	0.0001
N1 vs. N3	1	3384.375	3384.375	3.83	0.0535

Table 15. Dunnett's T tests for the population density of Oribatid mites (Acari: Oribatida) under different organic fertilizer treatments.

This tests controls the type I experimentwise error for comparisons of all treatments against a control. Comparisons significant at the 0.05 level are indicated by '***'.

Summer 1998

Alpha= 0.05 Confidence= 0.95 df= 62 MSE= 3.901882

Minimum Significant Difference= 2.5031

Treatment Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
CH - C	3.052	5.556	8.059	***
N2 - C	-2.059	0.444	2.948	
N1 - C	-2.392	0.111	2.614	
N3 - C	-2.392	0.111	2.614	
M - C	-3.281	-0.778	1.725	
B - C	-3.503	-1.000	1.503	
MB - C	-3.503	-1.000	1.503	

Fall 1998

Alpha= 0.05 Confidence= 0.95 df= 86 MSE= 882.939

Minimum Significant Difference= 32.351

Treatment Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
CH - C	4.57	36.92	69.27	***
N3 - C	-24.68	7.67	40.02	
N2 - C	-47.85	-15.50	16.85	
N1 - C	-48.43	-16.08	16.27	
M - C	-52.27	-19.92	12.43	
M+B - C	-60.43	-28.08	4.27	
B - C	-61.02	-28.67	3.68	

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