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Fall burning does not affect nematode density or carbon and nitrogen levels in Iowa oak forest soils

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Abstract

Nematodes have beneficial and detrimental effects in ecosystems, including the cycling of carbon and nitrogen in the soil. Thus it is important to know the impact of disturbances on the nematode population. In an effort to examine nematode density and carbon and nitrogen content in soil, we took soil samples from burned and unburned plots in the oak forest of the Conard Environmental Research Area in central Iowa. We found no significant difference in nematode density or nutrient level between the experimental and control plots. Future research should include measurements of soil moisture and identification of nematode species to better understand the impact of burning on nematode communities.

Introduction

Nematodes are of particular interest because of their positive and negative influences on plants in various ecosystems. They are microscopic worms, averaging 1mm in length (Perry & Zunche 1997) and comprise over 80 percent of the world's animals (Bloemers et al. 1997). Nematodes play a significant role in all ecosystems, ranging from deserts to the North and South Poles (Perry & Zunche 1997). They may feed on bacteria or fungi, or may parasitize a host plant or animal. Plant parasitic nematodes reduce water and nutrient flow into the plant, leading to nutrient deficiencies (Nematode Basics 2002), while other nematodes prey on organisms that negatively affect plants, thereby benefiting the plants.

Controlled burning in prairies and prairie forests replicates the effects of wildfires that are a natural part of the ecosystem. Fire affects plant development, quickly cycles nutrients into the soil, and removes plant litter, allowing more sunlight to reach the soil (Reichman 1987). Burning removes nitrogen from an ecosystem by combusting plant material, sending the nutrients into the atmosphere. However, soil nitrogen may increase through deposition of ash after a fire (Grogan et al. 2000). Carbon, another important element in the production of plant organic compounds, is also affected by burning. Emission of CO_2 during a forest fire reduces carbon content of the vegetation and soil (Amiro 2001). It is important to research the effects of burning to better understand the natural disturbances that took place before human settlement.

In our study, we measured nematode density in the soil of the oak forest burn experiment at the Conard Environmental Research Area (CERA) in central Iowa. Because nematodes affect soil nutrients through decomposition of plant material (Robertson & Freckman 1995), we wanted to measure carbon and nitrogen levels in the soil to see if they correlated with nematode density. We predicted that soil nitrogen content would be higher in the burned plots in the oak forest because of the nutrients from ash. Since carbon is emitted into the atmosphere in burning, we expected to find less carbon in the burned plots. In addition, we hypothesized that nematode density would decrease in burned plots due to lower soil moisture.

Methods

The oak forest at CERA consists of 19 25m X 25m plots, 10 of which were burned annually since 1997 (figure 1). We collected separate soil

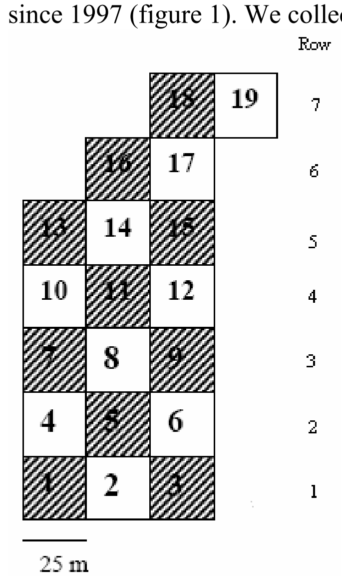

Figure 1. The design of the oak forest plots. Shaded plots were burned.

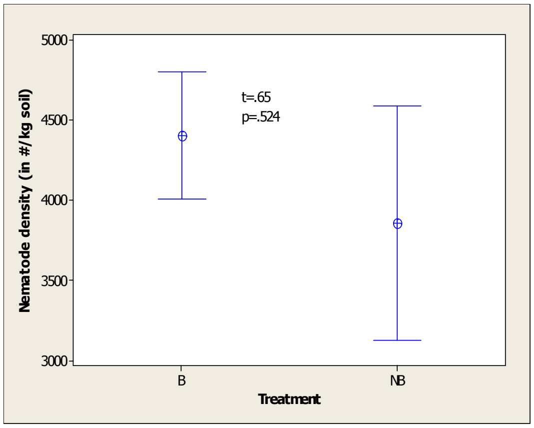

Figure 2. Mean (± SE) abundance of nematodes in burned and unburned plots.

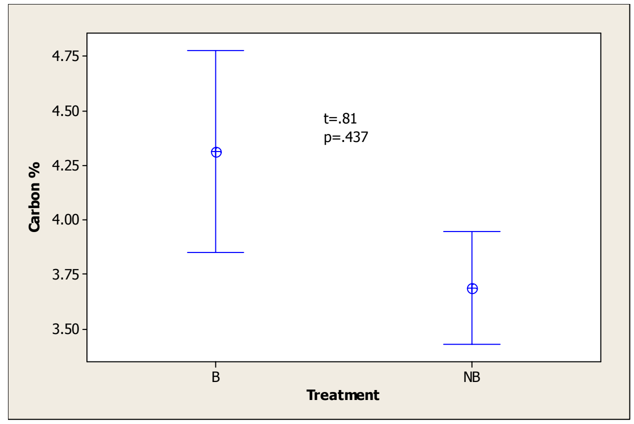

Figure 3. Mean (± SE) carbon content of soil in burned and unburned plots.

carbon/nitrogen analysis (5 cm) at two random points within each plot. The samples were gathered on October 6, 11, and 27, 2004 and stored in a refrigerator until nematode extraction. We used a modified sugar centrifugation technique (Appendix) to extract nematodes from the 38 soil cores. After extraction, nematodes were counted using a microscope at 100X. We counted the number of nematodes in four squares of a 20 square microscope plate grid, and then multiplied the number by 5 for our final nematode count. Nematode abundance was converted to number per kg of soil and averaged for each plot in the data analysis. The soil samples were dried in an oven at 60°C for 5 days. The dry samples were then put through metal screens and crushed with a pestle to remove plant matter and homogenize the soil. The soil was analyzed for carbon and nitrogen content using a Thermo Finnigan C/N analyzer. Again, we used the average of the two values in each plot. Data analysis involved performing t-tests on nematode density, carbon content, and nitrogen content to determine the effect of burning. We also examined the correlation between carbon and nitrogen contents and nematode density.

Results

The analysis of nematode abundance revealed no significant difference between burned and unburned plots in the oak forest (figure 2). Carbon and nitrogen content were generally lower in unburned plots, but the difference was not significant (figures 3 & 4). Nematode density and carbon content were not correlated ($r = -0.275$, $p=.286$) and neither was density and nitrogen content ($r = -0.329$, $p=.197$). However, there was a positive correlation between the row of the plot and nematode density, suggesting a gradient on the forest plots (figure 5). Nitrogen content and row had a nearly significant negative correlation ($r = -0.476$, $p=.053$), while carbon content and row were not correlated ($r = -0.308$, $p=.229$).

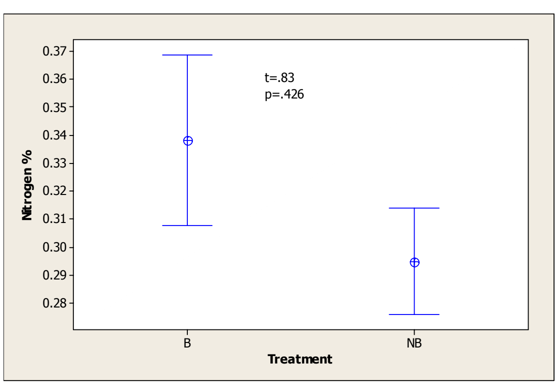

Figure 4. Mean (± SE) nitrogen content of soil in burned and unburned plots.

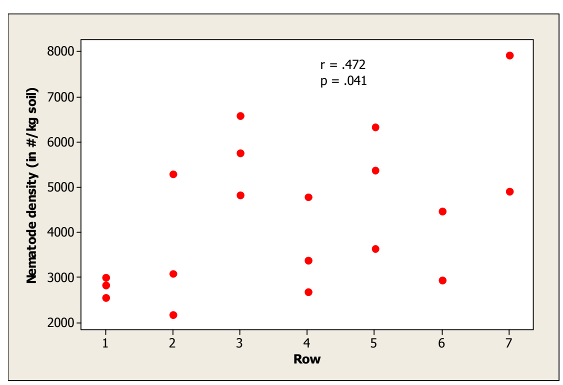

Figure 5. Scatterplot of nematode density and row of plot.

Discussion

Previous studies at CERA have shown that experimental burning in prairies decreases nematode density (Mitros 2004; Kenepp 1999). Burning removes plant litter, allowing more sunlight to reach the soil surface, thus drying the soil. Nematodes are most abundant in moist soils (Smolik & Dodd 1982 in Mitros 2004), because micro-organisms are more abundant and they are an important food source for nematodes (Sohlenius 1982). Our data does not reflect these conclusions, as we found no significant difference in burned and unburned plots in the forest. Since burning does not greatly affect the forest canopy, the amount of sunlight reaching the soil may not be influenced by burning. Therefore, burning would not affect moisture or soil temperature. Isis-Brown et al. (2004) found a positive correlation between row number and canopy cover in the oak forest at CERA. A dense canopy would block more sunlight than a sparse canopy, yielding cooler and moister soils. This finding could explain the increase in nematode abundance on higher rows.

The non-significant increase in soil nitrogen content in the burned plots was also found by Mitros et al. (2002). This increase can be explained by the increase in soil pH after burning, which facilitates nitrogen fixation and nitrification (Fowells & Stephenson 1934 in Mitros et al. 2002). Additionally, fire creates a nutrient-rich ash layer from plant matter, which can raise the nitrogen content of the soil (Reichman 1987).

Further research on soil and nematodes could include measurement of moisture in the soil, as well as the identification of nematode species. Since nematodes are reliant on soil moisture (Smolik & Dodd 1982 in Mitros 2004), it would be interesting to look at any long-term correlation between moisture and nematode abundance. Bloemers et al. (1997) showed that forest disturbance had an effect on nematode species diversity, possibly due to the large change in the nematode food supply. Therefore, it would be worthwhile to see if burning affected the nematode trophic groups (herbivores, fungivores, bacterivores, predators, and omnivores) differently. Finally, Yeates (1982) showed plant production and nematode density to be correlated; a study relating the two may show the impact of fire on the different groups of nematodes and the effect on the nematodes' food source. As the knowledge of nematodes increases, the information can be used in the management of natural and agricultural ecosystems.

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Appendix 1
Nematode extraction procedure
Taken from Mitros 2004.
Materials

1. Table centrifuge
2. Sucrose solution (454 g sucrose/L water)
3. 50 mL centrifuge tubes
4. Sieves (230-mesh, 400-mesh, 40-mesh)
5. 1 liter beaker
6. 150 mL test tubes
7. 5% formalin solution

Procedure

1. Place approximately 50 g of soil in a large beaker
2. Add water to 270 mL
3. Stir with hands for 30 seconds
4. Pour immediately into wet sieves- a 40-mesh on top of a 230-mesh.
5. Rinse gently through the top of the stack, keeping the sieves at an angle as the water filters through.
6. Remove top sieve
7. Rinse from the top of the sieve down, never directly on top of nematodes that are collecting at the bottom angle of the sieve. Let water cascade down and carry the nematodes into the bottom wedge of the angled screen.
8. Tap screen gently to filter water.
9. Rinse from the front and the back, keeping the screen at an angle and not allowing the water in it to overflow the edge of the screen.
10. Backwash nematode into a 50 mL centrifuge tube.
11. Load and balance centrifuge. Run for 6 minutes at 1750 rpm.
12. Decant of all liquid.
13. Fill with cooled sucrose solution.
14. Stir gently until pellet at bottom of centrifuge tube is broken up.
15. Centrifuge at 1750 rpm for 2 minutes.
16. Decant onto wet 400-mesh screen.
17. Rinse well with water and backwash with 20mL of water into a 150 mL beaker.
18. As necessary preserve samples using a hot 5% formalin solution added to an equal volume of nematode-water solution.