Kootenay & Boundary Farm Advisors

Soil Microorganism Brews and ID with Jo Tobias — Nelson, Feb 17 2020

Event Summary

39 people attended an all-day workshop at Taghum Hall, Nelson, to learn about soil microorganisms. The workshop included hands-on work with tea/extract brewers and compound microscopes. Content focused on good composting and basic microscopy skills to identify fungi, protozoans, and nematodes.

Major Discoveries

Soil samples brought by participants revealed some interesting trends:

- **Some composts were superb**, with many and diverse nematodes, lots of fungi, numerous amoeba, flagellates, and some ciliates. One microarthropod was found!
- **Many soils were near-lifeless**, with poorly structured silt-sand samples showing only bacteria, and not much at that.
    - **It is important to sample from the "root zone"** (aka rhizosphere).
    - **Even samples in winter dug from under the snow should exhibit good soil life.**

Compost Theory

Building beneficial soil life begins with good compost:

- Use diverse feedstocks with **5 or more ingredients**:
    - Typically **50-60% brown** (e.g. wood chips, shavings, sawdust), **10-15% hot nitrogens** (e.g. manures), and **25-40% green** (e.g. hay, grass, fresh leaves)
- Mix all materials well into a pile or berm about 1-meter high and across:
    - Make sure it is evenly moist and airy
    - Bigger can lead to anaerobic cores, smaller has difficulty reaching good temperatures.
- Measure the temperature daily with a **long probe thermometer** to know when to turn:
    - **55 to 65°C** (131 to 149 F) => turn after 72 hrs (4th day)
    - **to 70°C** (159 F) => turn after 48 hrs (3rd day)
    - **to 75°C** (167 F) => turn after 24 hrs (2nd day, tomorrow)
    - **to 79°C** (175 F) => turn after 12 hours (Today)
    - **Hotter?? Turn right away!**
        - Be careful: when exposed to oxygen it might catch on fire.
        - Alcohol production has taken place and nutrients are lost.
- Turn the pile (e.g. by front-end loader) with these steps:
    - The "top and sides" surround "the core" (the hottest part) which sits on the "bottom".
    - Cut off the **top and sides** of the pile and reserve for later.
    - Take out the **core** and place it as the **new bottom layer**.
    - Place the **reserved top and sides** in the middle, the **new core**.
    - Finally, the **bottom** material of the old pile goes on **top**.

Compost Teas and Extracts

Teas and Extracts allow us to use a limited amount of compost to "inoculate" a lot more land area than can be covered by directly applying the compost. Applications are only effective if the microorganisms have something to eat, so use mulches, cover-cropping, rotational grazing, and other soil management techniques to provide habitat and food.

- **Extracts** — Soil life in compost is dislodged in water by vigorous agitation from bubbles. The extract is applied without additional feeds to expand the population of microorganisms.
    - Use a 400-micron mesh bag to hold compost in the brew, or filter through this size mesh prior to application, to avoid clogging pumps and sprayers.
    - The proof of a set-up is in the extract it produces, so test it under a microscope.
    - Extracts are great for soil drenches.
- **Teas** — These begin much like an extract, but foods are added to the brew to expand the microorganisms' populations. Too much food and high growth rates can turn the tea anaerobic and favour disease-causing organisms.
    - Teas are great for foliar sprays.
- **Spraying** — Ensure the nozzles are big enough to allow nematodes and fungal strands (mycelia) to pass. Check sprayed samples under the microscope.
- **Clean equipment** thoroughly after use. The easiest way to clean the brewers by using a high-pressure hose while transferring the solution into the sprayer equipment.

Compound Microscope Skills

To look at a soil or compost sample under a compound microscope:

- Dilute the sample approximately 1 part soil and 4 parts distilled water (e.g. 5ml of final dilution contains 1ml of soil). **Shake vigorously and let settle**.
    - If the sample is too gritty (often the case for soils with poor structure) let it settle for **30 seconds** before drawing the sample, and try double the dilution (e.g. 10ml of final dilution contains 1ml of soil).
- Put one drop on a glass slide, avoiding or removing chunks or gritty particles.
- Cover the drop with a coverslip (18x18) starting at one edge of the drop, capturing a very thin film of water with as few bubbles as possible.
    - If the sample dries out, a new slide must be mounted.
- Put the slide on the microscope "stage" and adjust the stage to center the slide.
    1. **Lowest power** objective lens (4x) and **focus**.
        - Magnification = 40x (with a 10x eyepiece)
    2. **Medium power** objective (10x) and **focus**.
        - Magnification = 100x (with a 10x eyepiece)
        - **Scan the entire coverslip first** for large, moving organisms like nematodes and microarthropods ***before*** looking at high power for smaller organisms.
            - Use high power (40x objective) to focus on each **nematodes' mouthparts** to identify the type of nematode.
    3. **High power** objective (40x) and **focus**.
        - Magnification = 400x (with a 10x eyepiece)

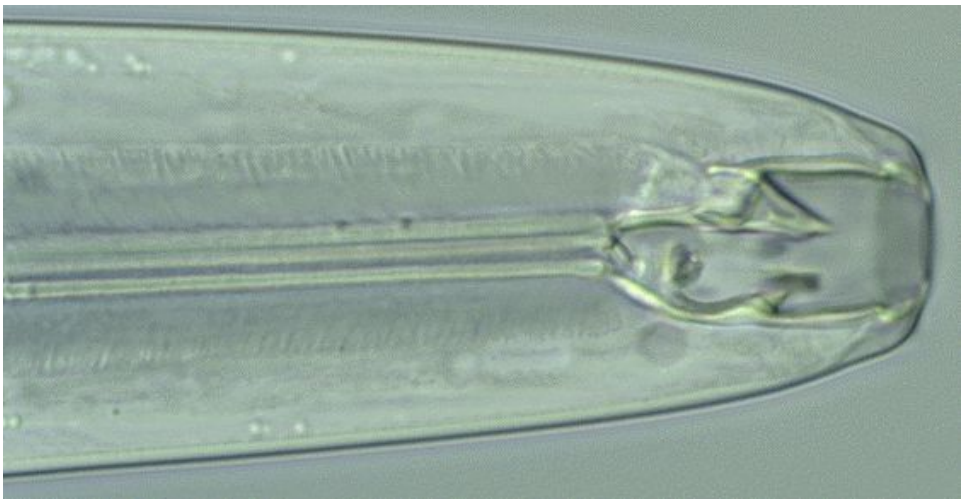
- **Scan the entire coverslip** for ciliates, flagellates, and amoeba.
- Quantitative assessments of numbers of organisms per field-of-view are done with 20 fields-of-view per slide.
    - Bacteria can now be seen (about 1 micron)
    - Smaller flagellates, testate & naked amoeba are clearer at this scale.
    - Fungi septa (dividing walls) can be distinguished.

- Technique:
    - Scan the slide by moving the stage so the field of view traverses long, non-overlapping strips from one edge of the coverslip to the other.
    - Constantly adjust the fine focus to move the field of view from the bottom to the top of the thin film of water sandwiched between the slide and coverslip.
    - At higher powers, the light source will need to be brighter.
    - Adjust the diaphragm of the Abbe Condenser to create "shadows" that can make objects pop out more clearly from the light background.

Keystone Soil Microorganisms

The following organisms are powerful indicators of soil health. Soil animals like nematodes and microarthropods, and protozoans like amoeba, flagellates, and ciliates all require support from a large food web.

- **Nematodes** — Ideally **one per drop** in a soil sample, **more for compost.**
    - **Bacteria-feeding nematodes** have "fancy lips" and are a good indicator.
    - **Root-feeding nematodes** have a distinct, fat and round "bulb" low in their "throat", and could indicate a problem.
    - **Fungi-feeding nematodes** look similar to root-feeders, but have a smaller, thinner, or almost non-existent bulb in their throat. These are a good indicator in the presence of fungi, but some will move on to eat roots if fungi are absent, and so can cause problems.
    - **Predatory (nematode-eating)** nematodes are much larger, have a tooth, and are an excellent indicator.



The "tooth" of a predatory nematode is visible with a compound microscope under high magnification.

- **Microarthropods** — These "detritivores" are rarer than nematodes, **one per drop is excellent**.
    - **Mites** belong to the arachnid (spider) family, these furry six-legged creatures eat a variety of soil organisms and indicate a well-populated food web. They are major players in the decomposition process
    - **Springtails** belong to the Collembola family and are important decomposers.
- **Amoeba** — **One in every other field of view** is a good indicator
    - Protozoans that eat bacteria, fungi, algae, other protozoans
    - **Testate Amoeba** have a shell and don't move much. There are a wide variety of shapes and sizes.
    - **Naked Amoeba** have no shell, just a cell wall, and "bloop" around very slowly with "pseudopods". They can be small (a few microns) to very large, filling the view at 400x.
- **Flagellates** — **One in every other field of view** is a good indicator.
    - Protozoans that eat bacteria and other protozoans.
    - Many shapes and sizes, they all have one or more "flagella", long thin tails that whip around so they can move, often quickly and twitchily.
- **Ciliates** — Best if there are **no more ciliates than there are flagellates and amoeba.**
    - Protozoans that eat bacteria, fungi, and other protozoa.
    - Many shapes and sizes, with many hair-like "cilia" to move and to direct water currents to capture food.
    - They move very fast, much quicker than a flagellate.
    - In great numbers, ciliates can indicate anaerobic (air-less) conditions which they tolerate as well as aerobic conditions.
- **Fungi** — **One in every other field of view** is a good indicator.
    - **Beneficial Fungi** come in many kinds, but general characteristics include some colouration, fatter hyphae with uniform width, and evenly-spaced septa.
    - **Disease Fungi** are more commonly clear, thinner with uneven widths, rougher edges, and randomly-spaced septa.
    - Approximate ideal Fungi-to-Bacteria biomass ratios:
        - F:B = 0.5 to 0.8 for vegetables (besides cole crops)
        - F:B = 1:1 for hay, grass, grains, …
        - F:B = 2+ for shrubs, trees, perennials, …
- **Bacteria**
    - Many shapes and sizes, but most frequently round balls (cocci) or rods (bacillus). They may be connected together in strings or lumps, they may have flagella, and they may move.
    - Long rod bacteria may be lactobacili. High numbers may indicate fermentation.
    - Spiral bacteria may be disease-causing.

Microorganism ID Field Guide?

Nope! For now all we've got is an internet image search (that's what Jo does!)

Let us know if you know of one...