Chapter 5
Working with the Soil Food Web

Lecture 22 – Making BioComplete™ Soil Amendments

Definition of BioComplete™ Soil Amendments

Organic matter containing the organisms required to facilitate the full spectrum of ecological functions which a healthy living soil can perform.

- Requires the minimum biomass of each key group of AEROBIC microorganisms;
- Requires the appropriate ratio of Fungi to Bacteria for the desired stage in succession i.e. that of the plants being grown.
- Fungal and Bacterial predators in sufficient number to facilitate Nutrient Cycling.
- Adequate diversity of all groups of microorganisms in order to ensure nutrient cycling throughout all four seasons of the year.

Microbes needed for different types of plants: Understanding succession

Biology & Succession	Dirt	Bare Soil	Weeds	Early Successional
AEROBIC vs ANAEROBIC	ANAEROBIC	ANAEROBIC	ANAEROBIC	AEROBIC DEV
Fungi:Bacteria Ratio	F:B = 0.01	F:B = 0.05	F:B = 0.1	F:B = 0.3
Vegetation	No vegetation	No Vegetation	"Weeds" selected. Little effort put into building soil. Limited root depth. Towards end of this stage, tap root plants.	Wetlands, brassicas, e.g. cole, kale, mustards. Limited root depth. Strong tap rooted plants provide foods & break compaction.
Soil Structure	No structure. Compacts easily.	Poor soil structure. Compacts easily.	Compaction is common.	Soil structure begins.
Nutrient Status	None, no nutrient cycling. Inorganic fertilizer required for lack of soluble nutrients. Any excess leaches rapidly.	Loss of nutrients through anaerobic conditions. Plants suffer lack of available nutrients. Strictly nitrate, pulses.	Uses strictly nitrate. Low functioning food web. Soluble nutrients pulse high, low, high, low.	Nitrate high but measurable ammonium present at times. Nutrient cycling starts normally.
1st Trophic Biomass: Bacteria & Fungi	Low to no bacteria, low to no fungi, both under 10 µg/g	Bacteria > 1000 µg/g Fungi 1-10 µg/g	Bacteria > 1000 µg/g Fungi 5-50 µg/g	Bacteria 500-2000 µg/g Fungi 70-200 µg/g
1st Trophic Details	None	Low bacterial diversity. Typically mostly disease-causing fungi.	Low bacterial diversity. Typically mostly disease-causing fungi.	Bacterial diversity increases. Actinobacteria very important to protect roots from fungal colonization. Fungi may mostly be disease-causing.
2nd & 3rd Trophic Level: Protozoa	None	Ciliates indicate loss of soluble nutrients.	Ciliates often present. Pulses typical.	Flagellates and Amoebae = 10,000/g
2nd & 3rd Trophic Level: Nematodes	None	Rare	Rare to find bacterial-feeders	Bacterial-feeders present.

Microbes needed for different types of plants: Understanding succession

Biology & Succession	Vegetables and Early Successional Grasses	Mid-Successional	Productive Pasture and Row Crops
AEROBIC vs ANAEROBIC	**AEROBIC**	**AEROBIC**	**AEROBIC**
Fungi:Bacteria Ratio	F:B = 0.5	F:B = 0.75	F:B = 0.75-1
Vegetation	Bromus, bermuda grass, root-crops, lettuce, greens, etc.	Turf such as ryegrass, vegetables, annual crops and flowers.	Lawns with no weeds, corn, wheat, barley, etc. Requiring no fertilizers.
Soil Structure	Compaction not well tolerated.	No compaction. Walking on mattress.	No compaction. Walking on mattress.
Nutrient Status	Need both nitrate and ammonium.	Use predominately nitrate but need ammonium.	Need an equal balance of nitrate and ammonium.
1st Trophic Biomass: Bacteria & Fungi	Bacteria 300-1000 µg/g Fungi 150-500 µg/g	Bacteria 500-3000 µg/g Fungi 150-2000 µg/g	Bacteria 300-3000 µg/g Fungi 300-3000 µg/g
1st Trophic Details	Greater bacterial diversity. For most species, mycorrhizal colonization is required (VAM).	Greater bacterial diversity. Mycorrhizal colonization required (VAM).	Greater bacterial diversity. Mycorrhizal colonization required (VAM). The higher the balanced biomass of both F and B, higher the yields, deeper roots grow, higher retention of nutrients, higher organic matter sequestered.
2nd & 3rd Trophic Level: Protozoa	Constant #'s of flagellates and amoebae 10,000-50,000/g in growing season.	Constant #'s of flagellates and amoebae > 50,000/g in growing season.	Constant #'s of flagellates and amoebae > 50,000/g in growing season.
2nd & 3rd Trophic Level: Nematodes	Bacterial, fungal, and predatory nematodes useful.	Bacterial, fungal, and predatory nematodes useful.	Bacterial, fungal, and predatory nematodes needed.

Microbes needed for different types of plants: Understanding succession

Biology & Succession	Shrubs, Bushes, Vines	Deciduous Trees	Conifer, Evergreen, to Old Growth Forest.
AEROBIC vs ANAEROBIC	AEROBIC	AEROBIC	AEROBIC
Fungi:Bacteria Ratio	F:B = 2-5	F:B = 5-100	F:B = 100-1000
Vegetation	Shrubs, Bushes, Vines	Deciduous Trees	Conifer, Evergreen, Old Growth Forest
Soil Structure	No compaction. Walking on mattress.	No compaction. Walking on mattress.	No compaction. Walking on mattress.
Nutrient Status	Require more ammonium than nitrate.	Require mostly ammonium. Nitrate can be harmful and encourage disease-causing fungi.	Require strictly ammonium. Nitrate will harm trees.
1st Trophic Biomass: Bacteria & Fungi	Bacteria 300-3000 µg/g Fungi 600-6000 µg/g	Bacteria 300-2000 µg/g Fungi 1500-20,000 µg/g	Bacteria 300-1000 µg/g Fungi 3000-100,000 µg/g
1st Trophic Details	Fungal activity must be greater than bacterial. Mycorrhizal colonization required (VAM/Ecto/Ericoid).	Lower bacterial biomass. Mycorrhizal colonization required (VAM).	Mycorrhizal colonization required (Ecto). Fungal biomass seasonally consumed by predators to provide nutrients plants require. Fungal re-growth occurs in dormant season.
2nd & 3rd Trophic Level: Protozoa	Constant #'s of flagellates and amoebae > 50,000/g in growing season.	Constant #'s of flagellates and amoebae > 10,000/g in growing season.	Not as important in fungal dominated systems. Flagellates and amoebae #'s > 10,000/g in growing season.
2nd & 3rd Trophic Level: Nematodes	Fungal and predatory nematodes along with microarthropods should start to rival bacterial-feeding nematodes.	Fungal and predatory nematodes should equal bacterial-feeder numbers, unless their function is replaced by microarthropods.	Fungal and predatory nematodes should exceed bacterial-feeder numbers, unless their function is replaced by microarthropods.

Making BioComplete™ Soil Amendments

<u>Stage 1: The Composting Process</u>

- Thermophilic Phase (rapid growth of bacteria and fungi releasing heat, pathogen kill)
- Maturation (Fungal Phase)
- Stabilization (Diversity increases, activity slows down)

Making BioComplete™ Soil Amendments

Key Considerations

- Sourcing the appropriate materials
- Recipe
- Storing materials carefully
- Mixing materials thoroughly
- Assessing and adjusting moisture when mixing
- Monitoring temperature & moisture throughout
- Turning at the appropriate times
- Number of turns
- Environmental Factors: Wind, Rain, Snow
- Testing the Results (Color, Smell, Structure, Biology)

Making BioComplete™ Soil Amendments

BioComplete™ Vermicomposting

- Foods - directly affect F:B
- Moisture is very important
- Various models e.g. Flow-through or stackable bins etc..
- Seeds are not destroyed

Making BioComplete™ Extracts

The Extraction Process

- A small amount of BioComplete™ Compost is taken from a pile after the maturation phase has occurred.
- This is placed in a special bag made of a mesh material which allows microorganisms to pass through it.
- The bag is placed in the brewer and movement of water extracts organisms from the BioComplete™ Compost into the water. An air pump is used to maintain adequate aeration.
- The extract is periodically assessed using a microscope. If desired organisms are not yet present at high enough density, fresh BioComplete™ Compost replaces the extracted BioComplete™ Compost, and the process of extraction is continued until adequate levels of microorganisms have been extracted from the BioComplete™ Compost into the water.

Making BioComplete™ Tea

The Brewing Process

- Add foods to increase microbial biomass during brewing.
- Preservatives are present in foods to prevent microbial growth and must be diluted using water.
- Hang extraction bag with BioComplete™ Compost into the aeration stream in the brewer.
- Organisms will multiply using added foods. Bacteria must grow rapidly to provide a food resource for protozoa to grow.
- Nematodes do not multiply within a 24 to 48 hour brew. If numbers are low, a *nematode extract* can be added.
- It is imperative that the correct amounts of foods are added and that aeration is maintained throughout the process in order to achieve good results.
- BioComplete™ Teas are made to produce active, growing bacteria and fungi which instantly adhere to surfaces of the foliage, thus protecting the plant from diseases and pests.

Sampling BioComplete™ Liquids

<u>Taking Samples from BioComplete™ Liquids</u>

- Wash your hands with special care before taking samples from the brewer to avoid contamination.
- Use CLEAN containers or pipettes/eyedroppers to remove the brew or extract.
- Take samples while the brewer is still aerating.
- Mix 3 to 5 small samples together and observe using a microscope.

Transporting BioComplete™ Liquids

1. Rinse a plastic water bottle
2. Fill bottle ¼ full with your liquid sample
3. Seal with lid and wrap the lid with duct tape
4. Include a completed submission form with your sample
5. Send via overnight mail to the laboratory