



Produced through The Northern Rhode Island Conservation District 's **Providence County Urban Growers Leadership Program**, in partnership with John Kenny from Big Train Farm.

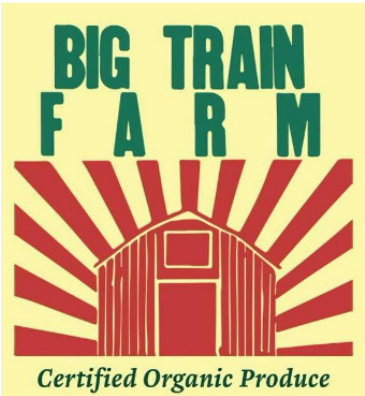


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SOIL IS ALIVE.

Like a human being that has its own tissue, blood cells, blood stream, whose body is full of microorganisms. All of which help us digest our food, control our mental health, help us with our muscles and skeletons, and us as a whole. We rely on microorganisms.

The soil is the same thing. A structure of non-living things that are a mesh of living ecosystems. There is a diverse array of micro organisms that live in the soil.

Plant Root Systems: are a part of that living community. They are a provider and a recipient of carbon that is the energy source from that living system.

Soil and roots are synergistic to reach their full potential.

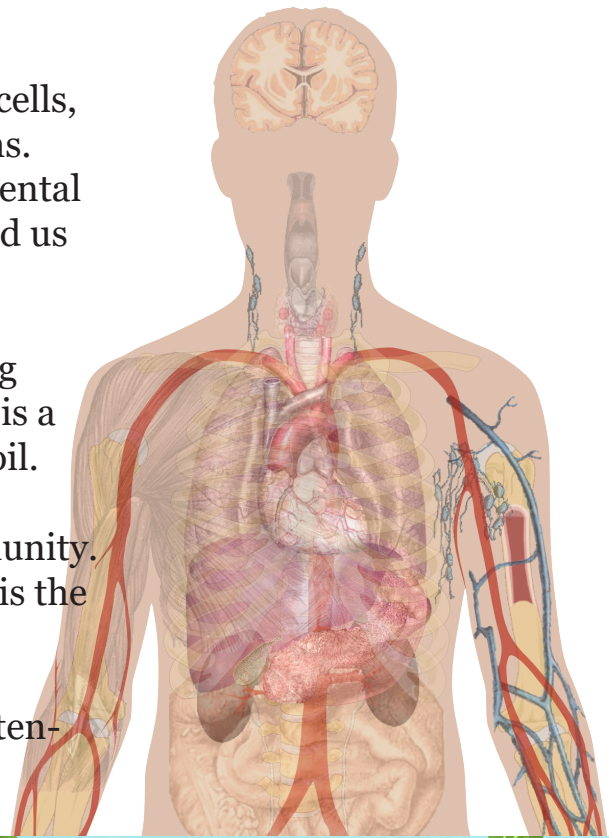


Image by Kelsey Amelia Bates

“I come from the thought that it is not possible to extract roots from the soil and soil from the roots and not have a living thing any longer”

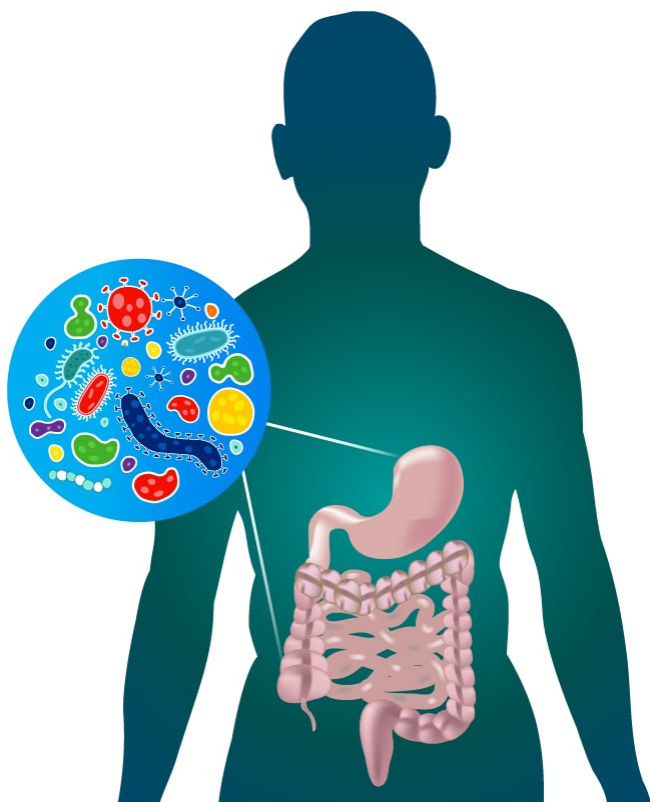
Key Question: How do we interact with the soil in a simple way to help produce/harvest plants that will impact the soil in a positive way?

We are always trying to consider how we impact our soil.

Soil is like the human gut systems. The gut system affects all parts of your body, and is a catalyst for everything. If you impact your gut negatively you will impact the full potential of your body.

A plant's gut is outside its root system of plants in the soil. Most of the microbes that help provide energy and food to the plant through their root system.

Think what we put in our bodies impacts our system, it is the same thing with soil. What you put into the soil impacts the entire soil and plant system on your farm/garden and that system is tied into the entire plant.



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Image courtesy of norgenbiotek.com

Image courtesy of USDA

4 ELEMENTS THAT NEED TO BE BALANCE TO MANAGE THE SOIL:

Air (to breathe)



Water (to sustain)



Minerals (to provide nutrients)



Organic Matter, also known as Carbon
(all of life is built out of carbon structures)



Images courtesy of USDA

How balanced these 4 elements are, depends on how we interact with these elements.

You want to support the diversity in your soil.

When we are interacting with the soil we want to think about:

- Is there air in the soil sufficient enough for the plants and the microbes to breathe?
- Is there water so that the plants and microbes can drink?
- Is there carbon available, so that the microbes can have an energy source?
- What are the mineral strata in the soil? (What is the soil type?)
- How is this going to affect the air in the soil (including the pathways of air within the soil)?
- How is this going to affect the ability to maintain (hold) its water?

1. Air & 2. Water:

Microbes need water and air just like the plant roots do to survive.



3. Minerals:

The physical part of the soil is made up of very fine rock. Depending on how fine the rock is, determines the type of soil it is. New England has very young sandy soil because the soils are new due to the Glaciers receding in the last Ice Age that deposited (left behind) the soil when the Glaciers stopped in New England.

Rock is where we get our minerals for the plant's nutrition. Microbes that interact with the soil (the fine rock material) draw out the minerals and make it accessible to the plants root systems in the soil.

Microbes live among, and within the organic matter, break down the soil organic matter within the soil. At the same time, they are oxidizing (adding oxygen to) the fine rocks within the soil and extracting nutrition out of that. A plant root accepts the nutrition that is being extracted by the microbes in the soil.



4. Soil Organic Matter:

The carbon resources that are provided by the things that die and decompose.

Example: An egg and a banana peel decompose in a compost pile. All their parts that made up those things mix together and become a fused pile, called organic matter.

The lower the percentage of organic matter, the smaller the microbial count is in the soil. When you have more organic matter (material) in the soil, you can have too many microbes that can either slow down or speed up the nutrients available in the soil. Too much nutrients available in the soil at one time can cause the soil to be out of balance. 6-7% organic matter in the soil is a good balance that the soil in New England likes to be naturally based on the typical sand soil.

The carbon from the organic matter is an energy source for the microbes. Plants photosynthesis also releases carbon into the soil.

Four basic elements to balance:
[air, water, minerals, soil organic matter ("life")]

25% air / 25% water

44-43% mineral harvested by diverse food web

- Soil organic matter
- Inoculation (verm)

Maintained by compression strength
(Soil organic matter >6%, raised bed)

- Low Compaction
- Cover Cropping (roots)
- Cash Cropping (roots)

6% -7% soil organic matter

Sand, silt, clay

Bacteria, fungi, nematodes, protozoa, rotifers, insects, arachnids, worms

Nitrogen gas, oxygen gas, carbon dioxide, water vapor, etc.

Main principles to keep/maintain soil close to balance:

- Lack of tillage
- Root systems in place
- Mulch/compost application
- Inoculations (vermicompost)

Beds raised to encourage:

- Lack of compaction (no tires/feet)
- Strong compression strength (3D shape maintains structure)

Raised beds maintained:

- Without aggressive tillage (rakes, narrow shanks/sweeps to facilitate planting, etc.)
- Cover crops, residue, terminated with breathable material
- Tractors have clearance to: mow, dress compost, rake/rip, rake in seed, transplant, etc.
- Overwintered as cover crop, mulch, fabric (30'x150')

Furrows mulched with organic material



When you till the soil you are:

- Adding air to the soil
- Water retained in the soil evaporates
- The diversity of the microbes decrease (some species die, some grow, creating a low diversity of microbes)
- The soil organic matter decreases, while the carbon in the soil gets digested in the soil quickly by the increased number of microbes
- The minerals in the soil gets broken up and becomes soluble (can mix easily in the water) and washes away, causing runoff

Soil tillage is like a hurricane. When you disrupt the soil, you change the diversity of the soil, throwing everything out of balance and into disorder. This causes systems in the soil to become:

- A lot less predictable
- Less reliable
- Become harder to put back together again





If you go out in the farm/garden and you water the soil and plant until there is a puddle, there is no/little air in the soil. The microbial community changes as:

- Some might be able to breath under water and thrive
- Some might not be able to breath under water and will drown
- Some might not be able to breath under water and go dormant

Those microbes that can swim or breathe underwater will change the soil chemistry and cause the soil to be less diverse. This will bring the soil organic matter content down.

Really wet soil will evaporate nutrition in the soil and off-gasses (release of particles or chemicals into the air).





WHAT HAPPENS IF YOU OVER FERTILIZE?

Image courtesy of ohsonline.com

Fertilizers are typically salts.

If you dump a bunch of salts in the soil, it affects the water content and microbes in the soil by:

- Brings down the soil water content (salts absorb water)
- Drying out the soil
- Killing or cause microbes to go dormant in the soil
- Breaking down microbes that create nutrition in the soil and can run off the soil



Image courtesy of UGA Cooperative Extension

GROWING IN RAISED BEDS



Big Train Farm has converted all of their growing land into raised beds on top of the soil (they grow within the ground). These are like small mounds on the soil. Since the creation of these raised beds, they do not use any equipment, or rough equipment, that can disturb the soil.

The goal of keeping raised beds having a balanced soil is to create good soil tilth. **Tilth** is soil that has a nice balance of air and water (you want to be able to stick your fingers in the soil and be soft).

Example: If you were to step on an ant colony you would destroy their tunnels, compact their home, and potentially kill ants in the process. You are doing the same thing when you step on soil. You compact the small air pockets within the soil, compact the soil and reduce water retention, and potentially kill beneficial microbes in the soil.

Microbes move back in and reorganize the pathways and structures back into the soil. Microbes bring together soil organic matter and minerals into what is called **Soil Aggregates**. As this progresses, the more diverse the soil can become. The more diverse the soil is, the more pathways and surface area within the soil for the water and air to reside in, which also supports more microbes in the soil.

Note: Diversity of plants helps provide diversity of microbes in the soil that helps maintain the balance in the soil.

Air is maintained by not compacting the soil using heavy / aggressive equipment (interacting with the raised beds with as little impact as possible). This keeps the raised beds lighter and aerated.

Because of soil structure, good balance of organic matter, and pathways to hold water and air in balance, the beds have a smaller likelihood of drying out (even in a drought).

- Carrots are irrigated twice in July (approximately 1.5hr)
- Transplanted plants like lettuce, fennel, leeks, etc. are irrigated when they are transplanted so they have time to acclimate to the soil without being stressed
- Peppers and tomatoes can still be impacted by a drought but little in comparison if the soil is not balanced



Furrows help the water settle into these divots on the sides of the raised beds and settle down into the soil over time. This helps the soil never get too wet. This helps not accidentally over water.

Image courtesy of USDA

Making Raised Beds:

- Go back to the basics (make sure you are adding organic matter, making sure the soil is aerated, and making sure there is plant roots in the soil as much as possible)
- Big Train Farm made their beds out of heavy equipment (chisel plow) because there is a lot of space to deal with. On a small scale, these same beds can be created with a shovel and digging fork to aerate the soil for a brief amount of time.
- Break the soil up with a hoe (Big Train Farm used a Herrow, which is a large scale hoe) to make the soil workable
- The shape the beds with a shovel (Big Train Farm used a larger scale bed shaper)



Maintaining Raised Beds:

- Compost (added to the beds)
- Cover cropping (grow plants not for harvest but to maintain soil health)
- Fertilizers that are added to the soil are not salts but organic fertilizers (i.e pulverized fish meal, alfalfa meal, soybean meal, blood meal, etc.) Big train Farm typically uses alfalfa meal. Fertilizers are used to stimulate the microbe community (get the microbes proliferating).
- Helping the microbes helps the soil.
- Using a Compost Spreader (machine that spreads compost) in the fall



Preparing the fields for crops:

1. Mower (All the trackers and equipment on the farm wheelbase go in between the beds) chops all of the cover crop material. The cover crop material is still alive.
2. Use large pieces of Perforated Landscape Fabric to cover the beds.
Perforated Landscape Fabric is black plastic material, woven so that air and water can penetrate the fabric, but not light.
3. Over the course of several weeks the cover crop plant material will die under the fabric and then pull the fabric off the beds.



4. Go through the fields with leaf rakes to get rid of any residue left on the beds from the dead cover crops.

5. Use a tractor with a rake attachment (this is not tilling, the rake pushes the soil apart, whereas a tiller inverts the soil) to rake the soil into even beds. While the rake is going over the beds, there are shanks in front of the rake that will rip the soil 2 inches wide and about 2-3 inches deep. These shanks create a space in the soil to transplant the plants. This tractor with this rake and shank on it are helpful in a commercial, larger scale operation. This is some disturbance to the soil, however it is a trade-off when this saves a lot of time in a commercial scale operation. This raking system will help bring any microbes that were dormant in the soil, out of dormancy. The productivity of the plant is not disturbed by this small equipment used.



6. The fields are fertilized with alfalfa meal to get the microbes in the soil moving and getting going for the season.
7. Prep plants for transplanting by inoculating the plants.
Inoculation is through a liquid fertilizer made from worm compost. This liquid extract is high in microbes (this is not compost tea. Compost tea is aerated).
Transplants are put into a tray and the trays are dipped into shallow bins of the inoculation liquid to soak, and then be transplanted in the field.
8. Use a Transplanter Machine (two people sit on the back and the machine creates a small plug space, and the people transplant a plant into the space that the machine creates in the soil) to transplant the plants into the soil



What happens after crops are harvested?

Use light weight tractor to rake the materials into the furrows, and seeded the beds with cover crops (a blend of legume and grasses).

Cut / harvest crops (causing the crops root system to die and micros diversity and jobs to change to decomes those dying roots).

Cover Crops are added in place of the harvested crop to add back in a living root system into the beds to support the microbes in the soil back to making nutrients and minerals available in the soil.

