21st Century Grower's Guide to Sustainable Farming

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SymSoil Inc. is an evidence-based, soil health company with products and services for regenerative agriculture. Our flagship products are Robust Compost, Fungal Infused Biochar and Grow Cubes for the cannabis and hemp cultivators.

Our science team has 35 years of experience developing solutions to growers' problems based upon a deep understanding of the complete soil microbe biome. Inspired by Dr Elaine Ingham, who first described the complete soil microbe biome (*Soil Food Web*) in the academic literature, SymSoil has developed a number of proprietary techniques to find, cultivate and restore regionally indigenous soil microbes to improve grower profitability. Our patents and processes are based on insights from Korean Natural Farming (KNF) and other composting traditions, academic researchers and microbial cultivation techniques from other industries. A core belief is regional soil microbes can be restored to regenerate the soil, which will significantly increase plant health, crop yields, flavor profile and nutrient density as the plants access nutrients the way nature intended.

The 21st Century Farmer's Guide to Sustainable Farming

The 21st Century Grower's Guide to Sustainable Farming

Introduction

For the past 75 years, most growers have been limited to using expensive chemical fertilizers and pesticides. Unfortunately, this has destroyed soil fertility, and reduced the flavor and nutrient density of crops.

It has been well documented that these chemical fertilizers are harming the environment and are likely contributors to rising cancer rates and other health hazards. Public awareness is driving demand for organic foods and textiles. Not only are agrichemicals toxic to human health and microorganisms in the soil, they also harm pollinators and wildlife, running off into water bodies, polluting rivers, land and wetlands.

Most of the public is less aware of the damage that these products have brought to farmers. Crop yields are declining, while more money is spent each year on chemicals that are needed each year to grow comparable amounts, even as the "comparable amounts" drift downward in most years.

Farmers, the stewards of the land, want fertility of the soil to remain for future generations. Their search for soil health has created a movement called ***biological farming*** based on a relatively new, scientific understanding of the biology with which nature feeds plants. A century ago, our insights into how plants are fed in nature was rudimentary and focused on the chemistry.

Today, scientist know the chemistry was an outgrowth of the soil biology, a complex ecosystem involving thousands of species which, together, cycle nutrients – making them available to plants.

Chemical fertilizers disrupt this ecosystem. Using chemical fertilizers exclusively is akin to feeding children only sugar – initially, they have a burst of energy. But when children eat only sugar, they become hyperactive. Longer-term, without proteins, fats, vitamins and complex carbohydrates, children have poor health.

Plants also need complexity in their nutrition. Chemical fertilizers give plants a quick boost, while starving the microbes which provide the full pallet of nutrients vegetation needs. Most fertilizers are salt-based, so they leave behind residues (or it runs off into waterways). Additionally, other agrichemicals (pesticides) are designed to kill parts of the ecosystem.

Nutrient Cycling - How Nature Feeds Plants

Healthy soil has a complete ecosystem, which includes thousands of species across 7 types of life. The below ground biology in one acre of healthy soil weighs in excess of 10,000 pounds, or about the same as 2 full-grown elephants.

All of human life depends upon what happens in the top six inches of soil.

- Plants use photosynthesis to create sugars and carbohydrates, which are used to grow. In addition to leaves, branches and roots, some of the sugars and carbohydrates are extruded through the roots to encourage the growth of bacteria and fungi.

- As the bacteria and fungi live and reproduce, they process and bind minerals which are essential for plant growth.
- Bacteria and fungi are consumed by the next level of the food web. As the bacteria and fungi are consumed by the higher trophic levels, the minerals are released as enzymes and other chemicals in a plant available form. This is known as nutrient cycling.
- The full spectrum of species that comprise the soil microbe biome produce complex chemistry (many enzymes, amino acids, and other nutrients) that the plants absorb, which creates crop flavor, nutrient density and compound intensity. Feeding the plants, the way nature intended, results in plant health.
- All components of the Soil Food Web are in turn consumed by the insects and other arthropods. These insects crawl through the soil creating pockets of air and increasing water retention in the soil.

Like any ecosystem, an outside observer will see *good guys (*beneficial microbes*) and bad guys* (pathogens) among the soil microbes, but even the *bad guys* have a role in the complex community interactions. The *bad guys* come to dominate and do damage to a farmer's crop when the entire system is out of balance.

There is a continuum from conventional farming to using organic products and methods to sustainable cultivation to regenerative farming.

SymSoil's products can be used to improve growers' profitability at any of these stages, as they are based on deep knowledge of soil biology and an understanding of how different components influence the entire system. As a Benefit Corporation (B-Corp), SymSoil has products which reseed the complete soil microbe biome, provide additional foods for soil microbes, consulting and laboratory testing to assess the soil biology. The components of the soil ecosystem are levers which we use, on behalf of clients, to reduce pathogens, increase plant nutrient cycling, and condition soil.

All farmers have the same goal: To have financially sustainable farming. SymSoil believes this is based upon healthy soil, that improves over time resulting in more valuable crops.

Benefits

Farming, in the 21st century, is the return to the harmonious and mindful application of natural systems to farming. This approach has proven its ability to dramatically increase the nutritional value of crops, increasing yields, while reducing inputs and associated costs of highly intrusive techniques, healing the damage done by conventional approaches to farming.

The benefits of biological farming include:

- **Healthier Plants**: Greater biological diversity of the soil microbe biome means less pathogens and healthier plants. Most plants will develop a larger and healthier root system, which results in a more vitality in the parts of the plant we see above the soil.

- **Better Flavors**: More diverse soil biology, means more complexity in soil chemistry and more complex flavors, terpenes, compound intensity and nutrient density in food. The plants do more of what they naturally want to do.

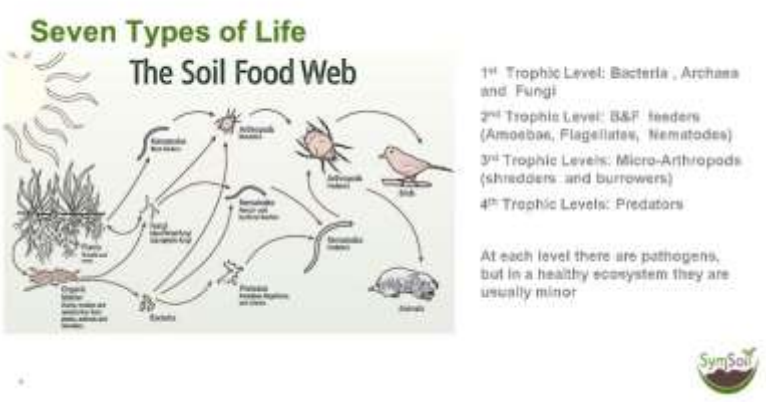
- **Greater Drought Tolerance**: Most farmers find more resilience and lower irrigation needs in their crops. This is a function of greater water holding capacity from the biology and the elimination of salt-based agrichemicals.

- **Carbon Sequestration:** Studies by the Rodale Institute found land reseeded with a biological active robust compost was able to sequester 2.5 tons of carbon per acre. Other studies, involving fungal infused biochar (like SymSoil® FIB, a soil conditioner), demonstrated an even higher amounts of sequestered carbon, about 10 tons per acre, per year.

It cannot be overstated: The key to these benefits is the amount and biodiversity of the soil microbe biome.

Soil Microbe Biome

Plants have their own microbiome, just like people. Humans have microbes on their skin and inside their body. Probiotics are designed to add microbes that humans want to encourage within their digestive track. Plants have a similar system where microorganisms, including bacteria and fungi, live on and in plant roots. Rather than pro-biotics in the gut, the soil microbes could be called pre-biotics in the rhizosphere.



Originally described in the 1980's by Elaine Ingham PhD, the academic literature describes the soil microbe biome as a Soil Food Web, the complex community which feeds and consumes each other.

It starts with the plants *farming* the microbes near their roots, the rhizosphere. The roots extrude sugars, proteins and carbohydrates which attract and feed bacteria, archaea and fungi.

This diagram is the classic representation of Dr. Ingham's Soil Food Web from the USDA Website.

The extrudates from the plant's roots feed bacteria, archaea and fungi that live nearby. These may help the plant directly, with growth stimulants, bringing water from the periphery into the rhizosphere (area near the roots) or fixing nitrogen. Each of these life forms creates enzymes which include elements the plant needs, but the important elements (N-P-K and the minor ones) are bound in the enzymes and unavailable to plants.

A handful of healthy soil has more individual life forms than there are humans living today.

These bacteria and fungi, are in turn, eaten by protozoa and beneficial nematodes. As these "wee critters" higher on the food chain consume the bacteria and fungi, their "waste" releases the nutrients that have been used by the bacteria and fungi, in plant available forms.

Since the 1800's, humanity understood this in terms of chemistry. Now, in the 21st century, humanity has a greater understanding of and appreciation for the biological processes that created the enzymes, proteins, acids, carbohydrates, sugars and other natural chemicals found in healthy soil.

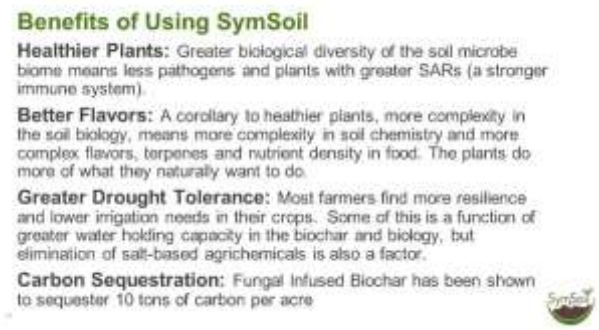
In addition to the microbes described above, there are other components to healthy soil. Worms, insect larvae, larger nematodes and insects (some of which are too small to see unaided) that travel through the soil, consuming

smaller lifeforms, as well as each other, creating pockets for air and water, which allows all of the aerobic microbes to live.

In all, a healthy soil has over 10,000 species and at least 7 types of life: **bacteria** and **archaea**, the smallest single cellular lifeforms, **fungi**, protozoa of various types (**amoebae**, **flagellates**), **nematodes** (most of which are beneficial), and **micro-arthropods**. There are other life forms, but these seven are the keystone, or most critical ones, for soil health.

Benefits of a Healthy Soil Microbe Biome

We farm plants for food, but plants farm soil microbes because of the benefits to themselves. Nutrients already present in the air and soil become available - at a level and a rate compatible with the plant's needs. Biologically active, healthy soil, from the grower's perspective, causes these minerals and elements stay in the soil system instead of leaching away, so very modest additions are needed to the soil in the form of powdered minerals.



This is in contrast with most agrichemicals which, if not monitored correctly, can render the soil completely devoid of biology, and leave behind toxic waste.

Biological farming, with a focus in improving the quantity and biodiversity in the soil, translates directly into less pathogens and healthier plants. The beneficial soil microbes outcompete the harmful ones and many directly strengthen the plant's resilience.

A corollary to heathier plants, due to more complexity in the soil biology, is more complexity in soil chemistry. This results in more complex flavors, terpenes and nutrient density in food. Plants do more of what they naturally want to do – usually larger crops.

In the case of cannabis growers, *Plants doing more of what they naturally want to do,* means higher THC or CBD levels and noticeably higher terpene levels and compound intensity.

For the hydroponic grower, SymSoil has a solution which provides the plants with the same biology – **Grow Cubes infused with the complete Soil Microbe Biome,** as well as specific biology to reduce powdery mildew, fusarium, fungal gnats, root aphids and thrips.

Another benefit of biological diversity in the soil microbe biome the ability to adapt to new situations, something that could be important for agricultural systems in the context of weather volatility.

Most farmers find more resilience to drought and heat, and lower irrigation needs in their crops. Some of this is a function of greater water holding capacity in the biology and biochar, but also the elimination of salt-based fertilizers.

A plant, “rooted to the spot” during its lifespan, heavily relies on its bacterial and fungal allies and adjusts which ones it attracts by changing its extrudates. Robust Compost is a generic term for the biologically active compost which can be used to introduce or reseed the complex microbial community to the plants. Growers need to add biodiversity to the soil, but it is the plant extrudates that determine which species thrive and dominate.

What is Robust Compost (SymSoil RC)?

For plants to farm the microbes and create useful partnerships in the rhizosphere, they need a diverse microbial community, that includes the right microorganisms, to be present in the soil.

Healthy soil usually contains 20,000 to 30,000 species of life. It can take a farmer moving from conventional, agrichemical-based methods a decade, using organic methods alone, to bring biodiversity in the soil microbe biome back into their land. The alternative is Robust **Compost is any product with broad biodiversity across 7 types of life and in excess of 1,000 species.**

These products are in the marketplace under a variety of names, including Living Soil, Soil Food Web compost or Bicomplete compost. Because of their value, they are often in short-supply and often appear expensive to those who do not understand their contribution to grower’s profitability.

***Robust Compost* is a generic term for compost that contains the full spectrum soil ecosystem includes bacteria, fungi, archaea, beneficial nematodes, amoeba, flagellates and micro-arthropods.** Often it has other types of life, including animals (earthworms) and it may contain diatoms and other algae, phages and other types of protozoa.

When the microbiological component of soils is considered, direct and indirect benefits for agricultural production can follow. These include economic and environmental benefits. More efficient nutrient cycling processes and water storage translates into reduced input costs. Yield and crop quality may improve, especially through controlling pests and diseases and enhancing plant growth.

This is where SymSoil’s product line comes in. SymSoil is a leader in creating products for growers, based on a depth of knowledge about all the major components of heathy soil. The company farms soil microbes and creates solutions for a host of farming challenges. The flagship product, **SymSoil RC**, has more than 2,000 species and can be used to reseed the soil microbe biome. **SymSoil Grow Cubes** have the same biodiversity, but additional biology has been added to reduce powdery mildew and fusarium, root aphids, fungus gnats and thrips.

Healthy Soil has 7 Types of Life

The Soil Food Web is a complex microbial community, with tens of thousands of species that cross 7 types of life. Described as a food web rather than a food chain, they pass nutrients, including elements like nitrogen (N),

phosphorus (P) and potassium (K), back and forth between the plant and all the lifeforms in the soil microbe biome.

A food chain is a succession of organisms that eat other organisms and may, in turn, be eaten themselves. They are often thought as linear: Seeds are eaten by a mouse, who is eaten by a bobcat, who is eaten by a coyote. The mouse it the first trophic level, the bobcat is the second and the coyote is the third trophic level.

The **Soil Food Web is more of a complex network** than a food chain, and was first described in the academic literature Dr. Elaine Ingham. Her papers are still among the most cited in the field of soil science. The web has many layers, including omnivores who eat opportunistically, as well as many that live off debris. The population of the debris eaters grow during the decomposition process. In nature, there are diversity of species involved, unlike in commercial composting in which one or two bacterial species dominate and remain at the end of the process.

> *"Dirt" is a dirty 4-letter word, you want "Soil"*
>
> Dr. Elaine Ingham

The Soil Food Web starts with plants *farming* the microbes near their roots. After capturing carbon dioxide in the atmosphere through photosynthesis, at least 10% or more of that carbon goes to the roots and some is shared with the soil microbes. The roots extrude sugars, proteins and carbohydrates which attract and feed bacteria, archaea and fungi.

Soil bacteria (and archaea which are similar in size but genetically distinct) represent some of the smallest single-celled organisms on Earth. Scientists have classified well over ten million unique bacterial species, and it is estimated the cumulative soil bacterial biomass is greater than the biomass of all the plant and animal the world combined! Bacteria can live in a wide range of environmental conditions.

Katharine Hinson, SymSoil's President for Science is convinced that somewhere there exists a bacterium that can eat anything with a carbon chain. There are bacteria that can filter and breakdown most toxins. They have even found bacteria that consume iron. For plants, the most useful bacteria fix nitrogen – some in or near roots, some inside the plant, and some in the soil, separate from the rhizosphere.

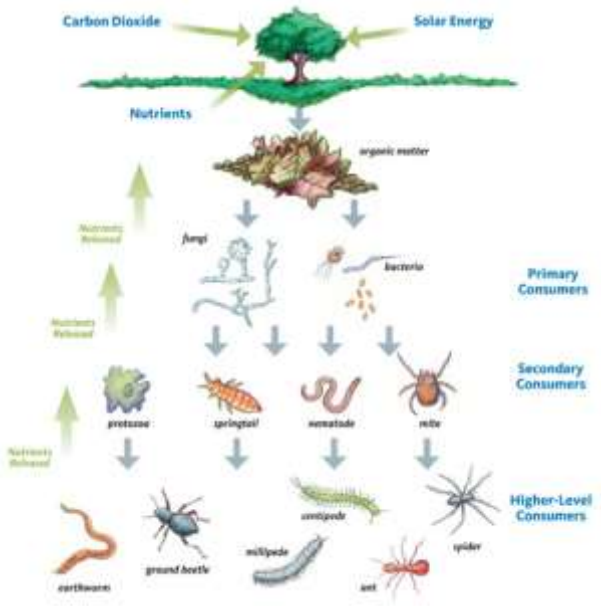
In hydroponic cultivation, beneficial bacteria can be used as growth promoting inoculates, whose enzymes are helpful in soilless media. Soil bacteria can still produce many different functional groups of enzymes to cycle nutrients for plant uptake, even in soilless growth media.

In addition to bacteria, the extrudates stimulate fungal growth. There are an estimated 70,000 unique fungal species. Soil fungi have hair-like structures called hyphae or mycelium that grow throughout the soil. Some species of fungi can grow hyphae great distances, and these can bring water from the periphery to the plant roots. Fungi genetics are closer to animals than plants, but are neither. Molds, yeasts and mushrooms are the most common fungi. In nature, bacteria and fungi play key roles in decomposing organic matter.

Some bacteria and fungi, known as endophytes, enter the plant and spend much of their life inside the plant – enhancing the plant's ability to fight pathogens or fixing nitrogen.

The plant root extrudates signal for specific bacteria and fungi which then tend to dominate, which harms the biodiversity of the community. Crop rotation increases biodiversity, improving resilience and strengthening the community. Farmers that only grow one crop on the land need to actively reseed the soil microbe biome to increase the biodiversity of their land.

At different stages of the plant's life, the extrudates change, changing the species of bacteria and fungi come to dominate the area around the roots. Each of these life forms create their own set of chemicals, which include the macro and micro elements the plant needs. Some of these chemicals protect plants from stresses that would otherwise inhibit their growth. Stress can be caused by drought, heat or cold, pathogens or accumulation of salts. Studies have shown how some of these soil microbes can even alter the gene expression of plants to help them navigate sudden environmental changes.



With all of this chemical activity, it is easy to see why the early, primitive understanding of plants and their nutrient needs focused on chemistry.

Still, at the first trophic level (the bacteria and fungi), most of the important elements (N-P-K and the minor ones) are bound in the enzymes and unavailable to plants.

Complexity abounds! The prior paragraphs describe the first trophic level, out of four described by Dr. Ingham as the Soil Food Web. A trophic level, describes where an organism sits in a food chain. A food chain is a succession of organisms that eat other organisms and may, in turn, be eaten themselves. The trophic level of an organism is the number of steps it is from the start of the chain.

In the second trophic level, protozoa (amoebae, flagellates and ciliates) and beneficial nematodes consume the bacteria and fungi. In their digestion process, the "waste" releases the nutrients that have been "bound" in the first trophic level, in ionic forms that are plant available.

While amoebae, flagellates or beneficial nematodes all consume the bacteria and fungi, the most fun to observe are the group of amoebae known as pseudopods (fake foot). These amoebae grow out and around the food source, and then consume it.

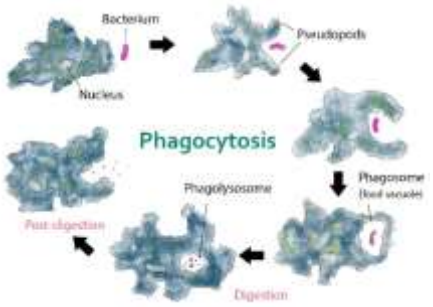
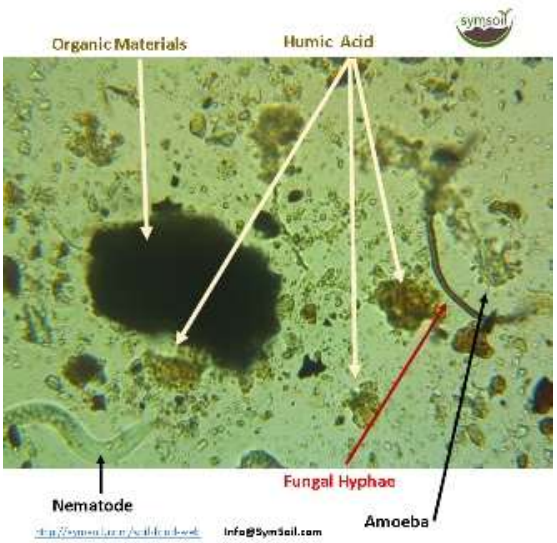


Diagram of amoeba engulfing a particle of food by phagocytosis, by Kate Taylor from Wikipedia

For two centuries, humanity has understood this in terms of chemistry. At the molecular level, ionic chemicals are the result of biological process is known as phagocytosis, which is Ancient Greek for "to eat". At the biological level, or the second trophic level, protozoa eat the bacteria and fungi and release waste in the form of amino acids and enzymes in an ionic form. That is, each molecule carries a mild electrical charge, with either an extra electron or missing an electron. The electron exchange is a critical component in nutrient cycling – making the key elements available to the plant roots.

Salts are a combination of two ions, which have the ability to separate in water – with both carrying a slight charge. This is why chemical fertilizers are salt-based. With the soil microbe biome, this is part of their biological process. Biologic farmers learn that plants in soil with ***poor chemistry and good biology can out produce the same crop in soil with great chemistry and poor biology***. Salts are also the reason so much of the fertilizers used on farmland runoff into waterways.

Nematodes sometimes get a bad rap because a small percentage (10%+) feed on plant roots. But in healthy soil, the majority of nematodes don't eat plants. Instead, they are active participants in this nutrient cycling from



bacteria and fungi. What's more, some feed on other pathogens, like the larvae of insects like fungus gnats and thrips, which would otherwise mature to attack the crop. The result of having biodiversity in nematodes is an overall lower level of crop pests, bypassing the need for chemical pesticides.

The second trophic level, like the first, has some pathogens, but in a healthy ecosystem the beneficial microbes outcompete the bad microbes.

Soil with significant biodiversity of the amoebae, flagellates and beneficial nematodes will generate complex foods for the plants – improving flavor, plant health and crop yields. In cannabis plants, it will increase THC or CBD and terpene levels.

Biochar, while not biology and chemically inert, acts like a Velcro for the electron exchanges, making it easier for the soil microbes to add or subtract electrons in their digestion/enzymatic processes. This facilitates the chemical reactions that create the nutrient cycling that benefits plants. In addition, biochar is a soil conditioner whose porous nature creates homes for soil microbes of different sizes.

The third and fourth trophic level are the *wee critters* that consume the protozoa, as well as fungi and bacteria. Some arthropods are too small to be seen with the naked eye (springtails and mites). Worms, insect larvae, larger arthropods (spiders, sow bugs, millipedes and other insects) consume the smaller lifeforms, as well as each other, adding yet more complexity to the chemistry to the soil. They also transport bacteria and fungal spores and create pockets for air and water, which allows all of the aerobic microbes to live.

In all, a healthy soil usually has over 20,000 species and at least 7 types of life: **bacteria** and **archaea**, the smallest building blocks, **fungi**, protozoa of various types (**amoebae**, **flagellates**), **nematodes** (most of which are beneficial), and **micro-arthropods**. There are other life forms, but these are the keystone, or most critical ones for soil health.

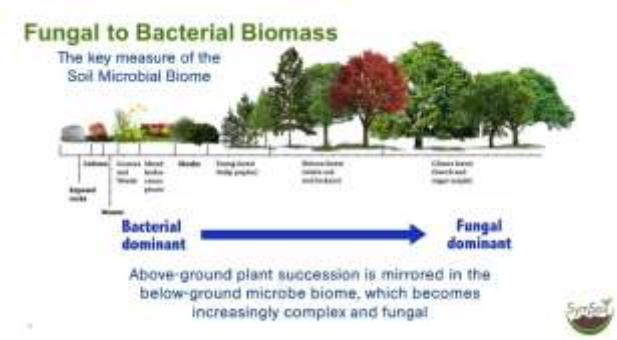
The Right Microbe Biome Balance for Your Crop

Soil Nerds who find these life forms and their interactions fascinating, often forget to step back and discuss how this microbial community changes as the grower's crops change. In the wild, as above-ground ecosystem complexity increases, the soil ecosystem diversity will also increase, with old forests having the greatest fungal dominance and total biodiversity.

Robust Compost, or BioComplete Compost, has broad biodiversity across those seven critical life forms. Most discussion focus on **the ratio of the fungal biomass to the total bacterial biomass, the F:B ratio**. Think of the soil microbe biome as an investment portfolio based upon the S&P 500. There are funds that invest in value stocks with high yields, and other funds focused on growth stocks. Some funds emphasize technology companies or healthcare companies.

Similarly, there is not one single best F:B ratio for every farm. The best F:B ratio for you depends upon the historic origin of your crop. In the wild, the soil of the grasslands is bacterial dominate, and the soil of old hardwood or redwood forests are fungal dominate.

- Brassicas, for example, originated in the grasslands, and do best with an F:B ratio of 0.5. Brassicas include cabbage, mustard, cauliflower, kale, bok choy, broccoli, and brussels sprouts.



- Other crops that originated at the edge of the forest, prefer a F:B ratio close to 1.0. Cannabis plants, for example, produce the maximum THC levels at 0.9 to 1.0. Hemp plants, maximize CBD production when the soil's F:B ratio is closer to 1.2.
- Most vines, including grapes, prefer a higher ratio. Grapes for wine, for example, maximize their flavor and productivity when the soil's F:B ratio is 1.6 to 2.0.
- Most orchards need a high ratio. Olive trees, for example, would find 4.0 to 10.0 to be the optimal ratio. Most nut trees would prefer even more fungi.

In other words, while it is difficult to attribute a specific ratio healthy soil, it is possible to move towards ratios that are optimal for a specific crop and to monitor biological composition in order to detect changes in the soil environment.

On a farm, properties such as water quality, ambient temperatures and soil moisture affect the composition of the soil microbe biome. Of course, fungal and bacterial activity follows seasonal fluctuations, with a peak during optimal conditions of temperature and soil moisture. Monoculture farms will have lower biodiversity than farms that use crop rotation. Adding organic materials will increase the amount of biology in the soil. Adding products with broad biodiversity, such as robust compost or compost extracts or teas will reseed the soil microbe biome.

A sure way to decrease your F:B ratio is to till your soil, which is why most biological farmers use minimal tilling. Tillage disturbs both the non-living and biological components of soils, with fungi being among the most sensitive to these changes. Tillage destroys fungal hyphae, reduces the stability of soil aggregates. To increase the F:B ratio, focus on robust compost products with a high *fungal potential*, that is, a high spore count in your robust compost.

Measuring Your Biology

One of the most important characteristics is the water quality. If you are working with well water, we strongly recommend having your water tested. With city water, you have chlorine and can get information on the minerals and hardness from your water utility. In general, low pH is associated with fungal dominance, whereas a high pH is more typically found in soil with bacterial dominance.

SymSoil has a soil lab, and soil tests (with and without consultation) can be ordered through our website. You can also use any Soil Food Web Lab to get a biological assessment.

The SymSoil lab offers basic biological assessment, for example, if you want to know if there is a specific pathogen. At the other extreme, the Soil Mavens can review your chemical soil tests, as well as your water tests and your full biological assessment and offer a comprehensive analysis and recommendation based upon your farms' challenges and goals.

SymSoil's – Engineered Soils

All Growers have the same goal: To have financially successful business. Farmers, planting in the ground, are also stewards of the land and need sustainable farming. SymSoil believes this is based upon healthy biology, based upon the soil microbe biome. For farmers, healthy soil should improve over time, reducing costs, growing better tasting crops and increasing yields over the years.

Complex chemistry in the soil is necessary for complex flavors. SymSoil has a number of products which positively impact soil health, increasing the soil microbe biome and thereby increasing the complexity of the soil chemistry. Master cannabis cultivators know that the more complex the soil biology, the more complex the terpene and cannabinoid profile.

Robust Compost, sold under the brand name **SymSoil® RC** is our complete biological solution. A DNA analysis found over 2,000 species, including 184 species/families of fungi and almost 300 families of bacteria. It also contains a significant number of amoebae, flagellates, and beneficial nematodes.

For most farmers, we recommend use of RC in a compost extract or tea, as a soil drencher to infuse biology into soil and lower value compost. We recommend the GEOTea 250, which can turn 1 cubic foot into 250 gallons of compost extract or 1 cubic yard into over 6,500 gallons. Most farmers are using 20 to 50 gallons per acre per year.

For cannabis growers, and others with a high value crop, RC can be blended into soil – at a ratio of 25% to 30% or as a ½" soil topper.

Fungal Infused Biochar, sold as SymSoil® FIB, is conditioned biochar, loaded with fungal spores, fungal food and biochar. This product is a soil conditioner for a long-term improvement in soil quality. (Biochar is inert carbon, and has a half life of over 1,000 years!) FIB helps soil hold water, and has pockets on its surface which create homes for soil microbes of various sizes. FIB also contains 10% SymSoil® RC. We have discovered that the complete soil microbe biome is necessary to activate the beneficial fungi spore, even the mycorrhizal fungal spores.

SymSoil® V50 is our most popular product with cannabis growers and is a 50/50 blend of RC and FIB. A complete biological solution combined with a soil conditioner; most growers add one cup when transferring the clone to a pot. The roots then grow through the material, and the biology expands with the rhizosphere. One cubic foot contains 120 cups.

The biochar and fungi increase the plant's tolerance to drought, and saved many growers crops in 2019 when the Northern California electrical grid was challenged. One of the early customers who used V50 was a winner in the Emerald Cup's Sun Grown category, considered one of the most competitive.

SymSoil® Amazing Grow Cubes are our newest product.

Two years in development, these cubes are infused with the full range of biology from SymSoil® RC. Additional biology has been licensed to increase the plant health and to reduce growers' costs through nitrogen fixing. Customers report higher THC and terpene levels, with more nodes, larger blooms and stronger branches to support the flower.

Assume, an indoor grow, with 1.4 pounds of flower per light, 4 plants per light, and $300/lb. price for cured flower, then **each SymSoil® Amazing Grow Cubes will add $20 per plant** to the grower's bottom line, after the cost of the cube. If a grower is getting $1,000 per pound of flower, the national average in 2019, each cube is expected to add more than $50 per bottom line. Contact a Soil Maven for a calculator to use your own assumptions.

This calculation does not include the higher clone success rate, nor the impact of healthier plants with greater resistance to powdery mildew, root aphids, fungus gnats, thrips and fusarium.

Customized Solutions, Soil Maven Consulting and On-Farm Composting

SymSoil's science team has 35 years of experience in the area of soil health and are focused on solutions to growers' problems based upon a deep understanding of the complete soil microbe biome.

Among our solutions are active biocontrol's, beneficial organisms that actively attacking crop pests and keeping them in check. Some of the microbes release antibiotic compounds to combat pathogens. Others can stimulate the plant's own immune system to resist attack. The picture on the right shows fungi killing a thrip.

SymSoil offers living products which use biology to solve specific problems. **SymSoil's Astro Nematodes**, as an example, are a living, biological product (nematodes) that reduce insect pests. The nematodes eat insect eggs, larvae and adults.

SymSoil's Grow Cubes, are infused with all 2,000+ species of SymSoil's RC, plus additional biology added because of its ability to reduce pathogenic fungi, insects, increase nitrogen absorption and THC production by a cannabis plant.

Functionally-targeted microbial inoculants represent the next-generation of green technologies which will support cannabis and mainstream agriculture in the 21st century. Talk to us about your challenges.

20th Century Farming vs Biological Farming in the 21st Century

Chemicals were primary tools for the past 75 years, and have left farmers trapped in a cycle of using expensive chemical fertilizers and pesticides. The future success of cultivation practices will depend on biological solutions, as opposed to agrichemical solutions, for sustainable improvements in plant quality, soil health and land productivity for decades to come.

While there is no doubt that our crops require specific elements to thrive and produce, soil biology is the key to the cycling of these nutrients. New insights and understanding of the soil microbe biome allow growers to harness natural ecosystems – improving agricultural productivity and plant health.

To summarize, in the 1800's humanity began to understand the process whereby nature kept plants healthy and fed. This earliest understanding assumed that ***all*** that mattered was three elements, Nitrogen (N), Phosphorus (P), and potassium (K).

In the early 1900's, other elements were added, including calcium (Ca), sulfur (S), magnesium (Mg), iron (Fe), boron (B), chlorine (Cl), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo) and nickel (Ni).

Using Justus von Liebig's Law of Minimum, farmers understood that each of these was necessary for the health of plants. That said, in the past 75 years, most farmers have

forgotten that *most* soil has sufficient amounts for the small amount of these elements for nutrient cycling with the help of the soil microbe biome.

After WWII, mass manufacturing of chemical fertilizers became available. As their usage increased, the soil microbe biome began to fall out of balance. Soon, there was demand for pesticides to kill the pathogens that were no longer kept in check by the beneficial components of the soil microbe biome. Unfortunately, pesticides killed many beneficials while fertilizers starved others, pushing the complex web of life even further out of balance.

Humans have been farming for thousands of years, but significant reduction in biodiversity in the soil microbe biome has only occurred in the past 75 years. Coincidentally, this is the same period when agrichemicals became the dominant tool for farmers.

Consumer demand for organics, combined with farmers rethinking the cost of conventional agrichemicals are creating the biological farming movement, of which SymSoil is a leading participant.

If a stool has ten thousand legs, and each year, a few hundred disappear, how long until the stool falls over?

SymSoil Inc. is an evidence-based, soil health company with products and services for regenerative agriculture. Our flagship products are Robust Compost, Fungal Infused Biochar and Grow Cubes for the cannabis and hemp cultivators. Our science team has 35 years of experience developing solutions to growers' problems based upon a deep understanding of the complete soil microbe biome. A core belief is regional soil microbes can be restored to regenerate the soil, which will significantly increase plant health, crop yields, flavor profile and nutrient density, as the plants access nutrients the way nature intended.