Soil Health, Your Garden, and a Healthy You

My name is Dave Dearstyne. I am a Soil Scientist of over 35 years and an passionate advocate for soil health and it's may applications from large farms to small gardens. I am presently working for the Shavano Conservation District as Soil Health Technical Advisor.

I am also an avid gardener, with over 50 years of gardening experience, mostly in the area of vegetable gardening. I can remember helping my grandparents in their garden at the ripe old age of 5, mostly by picking and eating their peas and carrots, straight from the vine and ground. I have had the opportunity to garden in the states of New York, Florida, and Colorado.

Soil Health has brought about the opportunity for me to combine my interests of soils, healthy soils, gardening, conservation, and sustainability. I have been no-till in my garden for 6 years this summer. I have experienced personally, as my soils have gotten healthier, the reduced or eliminated needs for applications of pesticides and commercial fertilizers. I have also experienced higher quality of the foods I grow. They have more flavor and higher nutrient content and I know where they came from and what went into growing them. In essence, I have my own secure food source, knowing that they are pesticide free. That is one of the many benefits of gardening. I have also been a part of and witnessed the benefits of healthy soils on hundreds of other peoples ground, where applied soil health practices have improved their bottom economic line by reducing input costs, improved yields, increased produce quality, and reduced pest and weed pressure. And there are so many ways to approach soil health and many varied applications. Does it sound to good to be true? It isn't. Simply put, soil health is essentially managing your carbon cycling. This paradigm shift, from thinking gardening is simply growing plants and the soil is just a place for roots and holding water, to soil as a biological system, complete with workers and consumers, a symbiotic system of nutrient exchange based on the currency of carbon. And you are the boss who manages this living system. Your Soil Health Plan, simply put is how well you can mimic the natural processes. After all, the ecosystem you are managing developed through natural processes and as a result, functions better when these natural processes are understood and applied. To help us understand these processes better, they have been categorized into five principles of Soil Health. Four of them are easily applied to your garden and the fifth can also be worked into your production plan with a little creativity. The check is to ask yourself if what you are doing in or to your garden is a positive or negative to one or more of these principles.

So here they are in no particular order briefly described below.

1) **Keep the ground covered** Nature doesn't like to go naked. Naked soils are erosive soils. They also have wildly fluctuating temperatures and are moisture losers, especially in our arid climate. Weeds are nature's healing scabs, designed to quickly and efficiently cover up and protect that bare soil. They help to stabilize the soil and begin the process of carbon cycling - the basis for all life in the soil, plants, and you. Got bare ground? Got weeds? Probably so.
2) **Keep a living root** Scientists estimate that over ⅓ of the living species on the planet live in the soil ecosystem. Yet they have only identified an estimated 3% of these species. We know more about the functioning of deep water ecosystems and their living parts then what lives and goes on beneath our feet. Scientists have discovered that life in the soil teems around living roots. They have found that there are more than 10,000 times more bacteria within 2 millimeters of a live root than further away from that root. Why, it's all about symbiosis and what is being traded. Plants produce carbon through the photosynthetic process. They absorb CO2, take out the carbon, and return O2 to the atmosphere. They trade some of the carbon for nutrients, supplied by the soil biology, to use in combination to build plant tissue (and produce those wonderful things we like to eat). The longer the root lives, the more stable your system, and the more healthy functioning that system is. You wouldn't want to go into starvation mode for several months out of the year. Neither does the workers in your soil.
3) **Minimize disturbance** Simply put, nature has very little tillage and that is usually on a small and controlled scale that actually enhances the system. These tillers are in the form of earthworms and other earth crawlers, which actually don't disturb the system, but mix carbon and biology as they eat their way along. Did you know that one of those "night crawlers" can actually consume 36 tons of soil per year through their digestive tract (would have hated to be the grad student working on that project). Back to the topic, nature doesn't till. Tillage destroys. It not only kills over 99% of the mycorrhizal fungus (your system's connector and carbon banker/exchange), but it also destroys the soil structure that your plant roots have been working hard to develop to help them better mine nutrients and collect water. After a couple waterings, tillage eventually slows down the soils ability to infiltrate and store water. Scientists have estimated that soils that have been under constant tillage for a number of years, may have reduced the numbers and species of soil biology in their system by 90%. One of the main reasons why nutrient densities in our commercially grown foods have been reduced on average 50% in the past 50 years. Tillage also significantly reduces the amount of organic matter in the soil. This is as result of "fluffing" that causes an explosion of for a better term "weed bacteria", which rapidly process soil organic matter, putting CO2 back into the atmosphere. as they respire in a frenzy

to consume your carbon. Locally, through hundreds of soil tests, on average constantly tilled soils without carbon additives, have 1 percent or less soil organic matter. Soils under permanent vegetation or limited tillage often average 3 to 5% organic matter. This is significant for 2 main reasons. First, your carbon is money in the savings account of your system. It is there to help you through those lean years, such as drought. One percent soil organic matter stores on average 10,000 pounds of carbon, taken from the atmosphere. Second, our soil resource is the second largest carbon sink on the planet and the number one place to safely store and benefit us and the planet. Remember, your garden is simply a carbon exchange system that you are managing.

4) **Diversity** An oft used term in our world today. With regard to the soil ecological system, diversity rules. Different plants extract different amounts of nutrients and occupy different niches in the system. Nature is rare on monocultures. Diversity promotes healthy systems. Monocultures are more susceptible to pests and diseases. Plants in diverse systems often exchange nutrients and carbon through the mycorrhizal connections in a healthy soil system. Diversity builds in resilience to climate fluctuations, allowing different plants to prosper as environmental factors change.
5) **Livestock Integration** This is the tricky one for the gardener to incorporate. Most plants, especially the grasses, were part of grazing systems, where roving herbivores would come in, consume, and move on. They would leave behind their biologically enhanced fertilizers, returning 70 percent or more of the carbon they consumed in a readily available form to some of the soil biology community. This grazing process actually stimulates grasses in their recovery and causes them to become more productive. Overgrazing, where plants are grazed to hard or not given adequate recovery time, is detrimental to this system.

And then there are some startling and disturbing facts. It is estimated that 45 percent of the world's arable soils are either severyly or very severely degraded. An 2012 article in time magazine titled "What if the world's soil runs out" gave our soil resource about 60 years under presence management systems before it will be so degraded that it can no longer feed us. Then there is the fact that CO2 levels in the atmosphere have doubled in the past 100 years. That the world's mineable phosphorous supplies have about 30 years left. That fossil fuels, some of which are used to produce commercial fertilizers, are becoming more expensive and more limited. Then there is the water issues and irrigation.

But there is an answer and you can choose to be part of the solution while reaping the benefits of a healthy sustainable resource, your garden. For there is a magic bullet for the soil. That is simply organic matter. Increase your organic matter you increase/improve your soil tilth, your water holding capacity, your available nutrient holding capacity, your microbial community, your soil structure, your soil resistance to

environmental factors, your food quality, your productivity, and the list goes on. Organic matter is the basis for your garden system to be healthy and productive. You call the shots, you are the manager. Hopefully as you apply understanding to practices you will reap the benefits of a happy healthy garden.

I've included below some excerpts from a soil health guru for your enhanced benefit. Hope to see you around at our Soil Health Conference in Delta in February, our multi-part gardening series offered by the Montrose Library beginning in March. And events like these. Happy and healthy gardening. Have fun!

Your friendly neighborhood Soil Scientist,

Dave

(1) Over the last 150 years, many of the world's prime agricultural soils have lost between 30% and 75% of their carbon, adding billions of tonnes of CO2 to the atmosphere. Losses of soil carbon significantly reduce the productive potential of the land and the profitability of farming. Soil degradation has intensified in recent decades, with around 30% of the world's cropland abandoned in the last 40 years due to soil decline. With the global population predicted to peak close to 10 billion by 2050, the need for soil

restoration has never been more pressing. Soil dysfunction also impacts on human and animal health. It is sobering to reflect that over the last seventy years, the level of every nutrient in almost every kind of food has fallen between 10 and 100%. An individual today would need to consume twice

as much meat, three times as much fruit and four to five times as many vegetables to obtain the same amount of minerals and trace elements as available in those same foods in 1940. Dr David Thomas provided a comprehensive analysis of historical changes in food composition from tables published by the Medical ReSearch Council, Ministry of Agriculture, Fisheries and Foods and the Food Standards Agency. By comparing data available in 1940 with that in 1991, Thomas demonstrated a substantial loss in mineral and trace element content in every group of foods investigated.

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Mineral depletion in vegetables

1940 - 1991

Average of 27 kinds of vegetables

Copper - declined by 76%

Calcium - declined by 46%

Iron - declined by 27%

Magnesium - declined by 24%

Potassium - declined by 16%

Mineral depletion in meat 1940 - 1991

Average of 10 kinds of meat

Copper - declined by 24%

Calcium - declined by 41%

Iron - declined by 54%

Magnesium - declined by 10%

Potassium - declined by 16%

Phosphorus - declined by 28

Significant mineral and trace element depletion was also recorded in the 17 varieties of fruit and two dairy products tested over the same period. The mineral depletion in meat and dairy reflects the fact that animals are consuming plants and/or grains that are themselves minerally depleted. In addition to the overall decline in nutrient density, Thomas found significant changes in the ratios of minerals to one another. Given that there are critical ratios of minerals and trace elements for optimum physiological function, it is highly likely that these distorted ratios impact on human health and well being.

Restoring nutrient density to food

It is commonly believed that the significant reduction in the nutrient density of today's food is due to the 'dilution effect'. That is, as yield increases, mineral content falls. However, compromised nutrient levels are not observed in high-yielding vegetables, crops and pastures grown in biologically active soils. Indeed, the opposite applies. Only in rare instances are minerals and trace elements completely absent from soil. Most of the 'deficiencies' observed in plants and animals are due to soil conditions not being conducive to nutrient uptake. Applying chemical fertilisers to correct so-called deficiencies is an inefficient practice. Rather, we need to address the biological causes of dysfunction. Around 85 to 90% of plant nutrient acquisition is microbially mediated. The soil's ability to support nutrient dense, high vitality crops, pastures, fruit and vegetables requires the presence of a diverse array of soil microbes from a range of functional groups.The majority of microbes involved in nutrient acquisition are plant-

dependent. That is, they respond to carbon compounds exuded by the roots of actively growing green plants. Many of these important groups of microbes are negatively impacted by the use of ‘cides’ - herbicides, pesticides, insecticides,fungicides. In short, the functioning of the soil ecosystem is determined by the presence, diversity and photosynthetic rate of actively growing green plants - as well as the presence or absence of chemical toxins.

But who manages the plants - and the chemicals?

You guessed it ... we do. It is up to us to restore soil integrity, fertility, structure and water-holding capacity - not by applying ‘bandaids’ to the symptoms, but by the way we manage our food production systems. The key to restoration is to get the basics right.

Crop production.

Increasingly sophisticated machinery and a plethora of ‘cides’ have provided the means for the planet’s rapidly expanding population to create bare ground, dramatically reducing photosynthetic capacity over billions of hectares. Reduced levels of photosynthesis have resulted in reduced carbon flow to soil, significantly impacting on soil and landscape function, as well as farm productivity. One of the most significant findings to emerge in recent years has been the improvements to infiltration, water-holding capacity and drought resilience when barefallows have been replaced with multi-species covers. This improvement has been particularly evident in lower rainfall regions and in dry years. A healthy agricultural system is one that supports all forms of life. All too often, many of the life forms in soil have been considered dispensable. Or more correctly, have not been considered at all.

Microbes matter!!

It comes as a surprise to many to learn that over 95% of life on land resides in Soil. Indeed, the soil microbiome has been heralded as the new frontier in agricultural research, in parallel with the gut microbiome being recognised as the new frontier in human health. Most of the energy for this amazing world beneath our feet is derived from plants. Exudates from living roots are the most carbon-rich of these energy sources. In exchange for ‘liquid carbon’, microbes in the vicinity of plant roots - and microbes linked to plants via mycelial networks - increase the availability of the minerals and trace elements required to maintain the health and vitality of their hosts. Vigorous root systems and beneficial relationships with mycorrhizal fungi and other plant-associated soil biota are essential for maximising the ability of crop and pasture plants to obtain water, nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and a wide variety of trace elements including copper, cobalt, zinc, molybdenum and boron. Many of these elements are essential for resistance to pests and diseases and resilience to climatic extremes such as drought, waterlogging and frost. Soil function is

also strongly influenced by its structure. In order for soil to be well structured, it must be living. Life in the soil provides the glues and gums that enable soil particles to stick together into pea-sized lumps called aggregates. The spaces between the aggregates allow moisture to infiltrate more easily. Moisture absorbed into soil aggregates is protected from evaporation, so that soil remains moister for longer after rain or irrigation. This improves farm productivity and profit. Well-structured soils are also less prone to erosion and compaction and function more effectively as bio-filters. All living things - above and below ground - benefit when the plant-microbe bridge is functioning effectively. Sadly, many of the microbes important for soil function have gone missing in action. Can we get them back? Some producers have achieved large improvements in soil health in a relatively short time. What are these farmers doing differently? They diversify.

Diversity is not dispensable!!!

Every plant exudes its own unique blend of sugars, enzymes, phenols, amino acids, nucleic acids, auxins, gibberellins and other biological compounds, many of which act as signals to soil microbes. Root exudates vary continuously over time, depending on the plant's immediate requirements. The greater the diversity of plants, the greater the diversity of microbes and the more robust the soil ecosystem. The belief that monocultures and intensively managed systems are more profitable than diverse biologically-based systems does not hold up in practice. Monocultures need to be supported by high and often increasing levels of fertiliser, fungicide, insecticide and other chemicals that inhibit soil biological activity. The result is even greater expenditure on agrochemicals in an attempt to control the pest, weed, disease, and fertility 'problems' that ensue. Innovative farmers are experimenting with up to 60 to 70 different plant species to see which combinations perform best for soil restoration. Some grain and vegetable producers are setting aside up to 50% of their cash crop area for multi-species 'soil primers'. They believe the benefits far outweigh the costs. It has been reported that two full seasons of a multi-species cover can perform miracles in terms of soil health. However, it doesn't need to be complicated. Something as simple as including one or two companions with a cash crop can make a world of difference. Indeed, it is becoming increasingly common to see peas with canola, clover or lentils with wheat, soybean and/or vetch with corn,buckwheat and/or peas with potatoes ...and so on.

Limit chemical use

The mineral cycle improves significantly when soils are alive. It has been shown, for example, that mycorrhizal fungi can supply up to 90% of plants N and P requirements. In addition to including companions and multi-species covers in crop rotations, maintaining a living soil often requires that rates of high-analysis synthetic fertilizers and

other chemicals be reduced, to enable microbes to do what microbes do best. Profit is the difference between expenditure and income. In years to come we will perhaps wonder why it took so long to realise the futility of attempting to grow crops in dysfunctional soils, relying solely on increasingly expensive synthetic inputs. No amount of NPK fertiliser can compensate for compacted, lifeless soil with low wettability and low water-holding capacity. Indeed, adding more chemical fertiliser often makes things worse. This is particularly so for phosphorus (P) and nitrogen (N). An often overlooked consequence of the application of high rates of N and P is that plants no longer need to channel liquid carbon to soil microbial communities in order to obtain these essential elements. Reduced carbon flow has a negative impact on soil aggregation - as well as limiting the energy available to the microbes involved in the acquisition of important minerals and trace elements. n addition to having adverse effects on soil structure, plant health and the nutrient density of food, the application of high rates of inorganic water-soluble phosphorus is highly inefficient. At least 80% of applied P rapidly adsorbs to aluminium and iron oxides and/or forms calcium, aluminium or iron phosphates. In the absence of microbial activity, these forms of P are not plant available. It is widely recognised that only 10-15% of fertilizer P is taken up by crops and pastures in the year of application. If fertilizer P has been applied for the previous 10 years, there will be sufficient for the next 100 years, irrespective of how much was in the soil to begin. Rather than apply P, it is far better to activate soil microbes in order to access the P already there.

Mycorrhizal fungi are extremely important for increasing the availability of soil P. Their abundance can be significantly improved through cover crops, diversity and appropriate grazing management.

Inorganic N:

The other element commonly added to soil is nitrogen. The use of high-analysis N fertilizer poses a significant cost to both farmers and the environment, as only 10 to 40% is taken up by plants, with 60 to 90% of applied N lost through a combination of volatilisation and leaching. One of the many unintended consequences of the use of nitrogen fertilizer is the production of nitrous oxide in water-logged and/or compacted soils. Nitrous oxide is a greenhouse gas with almost 300 times the global-warming potential of carbon dioxide. It is often assumed that nitrogen comes only from fertilizer or legumes. However, all green plants are capable of growing in association with nitrogen-fixing microbes. Even when N fertilizer is applied, plants obtain much of their N from microbial associations. Farmers experimenting with ‘yearlong green’ farming techniques are discovering that their soils develop the innate capacity to fix atmospheric nitrogen. However, if high rates of N fertiliser have been used for some time, it is important to wean off N slowly, as free-living nitrogen fixing bacteria require time to re-establish.

Avoid aggressive tillage

Tillage may provide an apparent ‘quick-fix’ to soil problems created by lack of deep-rooted living cover, but repeated and/or aggressive tillage increases the susceptibility of the soil to erosion, depletes soil carbon and organic nitrogen, rapidly mineralises soil nutrients (resulting in a short-term flush but long-term depletion) and is highly detrimental to beneficial soil-building microbes such as mycorrhizal fungi - as well as keystone invertebrates such as earthworms.

(1) Exerpts from an article titled : Five Principles of Soil Health by Dr. Christine Jones, PhD

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