TEN COMMANDMENTS OF SOIL AND HORTICULTURE

1. KEEP SOIL COVERED (MULCH, CROPS, COVER CROPS)
2. DO NOT WORK WET SOIL
3. PLANT TREES EVERYWHERE: PROMOTES A BALANCED ECOSYSTEM, STABILIZES THE WATER TABLE, SLOWS STORMWATER, SLOWS WIND. PREVENTS EROSION. SUPPLIES FOOD, FODDER, MULCH, FIREWOOD, COOLING, COVER FOR INSECTS, BIRDS, ETC. TREES MAKE RAIN
4. AVOID MONOCULTURE
5. CONSERVE, CATCH, CLEAN AND STORE WATER ON SITE SOIL HAS MASSIVE WATER STORAGE CAPABILITY
6. FEED SOIL MICROBES, WITH PROPER FOODS AVOIDING INORGANIC SALT FERTILIZERS. NUTRIENT DENSITY CREATES HEALTHY PEST AND DROUGHT RESISTANT PLANTS YIELDING NUTRIENT RICH FOODS. RAW MATERIALS FURNISH MICROBE FOOD WHICH FURNISHES PLANT NUTRIENTS. PLANTS FEED MICROBES IN RETURN THROUGH ROOT EXUDATES, BIOMASS.
7. BALANCE THE ECOSYSTEM: SOIL BACTERIA, FUNGI, PROTOZOA, MICROARTHROPODS, NEMATODES, ETC. EARTHWORMS, BIRDS, SNAKES, INSECTS (AQUATIC HABITATS:PLANTS, FISH, INSECTS)
8. ALL HEALTH AND WEALTH COMES DIRECTLY OR INDIRECTLY FROM SOIL. CAN'T EAT GOLD OR OIL.
9. RIGHT PLANT, RIGHT PLACE. CORRECT MICROBIAL COMMUNITY FOR CROP/TREES/GARDENS DESIRED. GROW ROOTS!
10. NO GMO! HERBICIDES, PESTICIDES, CHEMICAL FERTILIZERS-EVEN ORGANIC ALLOWABLE PEST CONTROL CAN DESTROY SOIL MICROBES.

HEALTHY PLANTS GROW HEALTHY SOIL

The process of photosynthesis in plants sequesters C02 from the air, producing sugars. These sugars are sent out through the root systems as root exudates that build organic matter in the soil. This process builds soil health which in turn builds plant health. Minerals need to be balanced as they are the base of everything that goes on in the soil. Using foliar feeding increases photosynthesis by sending more food through the roots to the microbes. Microbes work harder to supply minerals to the plant. The soil builds C, organic matter, and humus much faster.

1. When you increase plants' photosynthetic capacity from 15-20% (accepted as normal) to 40, 50 or 60%, the magic happens.
2. Because of the spike in photosynthetic efficiency, more sugar is produced and sent down through the root system as root exudates.
3. This results in very aggressive bacterial digestion that consumes the sugars and grows in population.
4. As bacteria grows, it starts mining minerals from the soil to incorporate them into its cells. They can't produce their bodies from sugar, they need minerals to do so. Bacteria also feed fungal communities.
5. Microbial cells are then incorporated back into root systems with all the nutrients.
6. As plants absorb these microbial metabolites, they become very energy efficient. They can now access an abundance of nutrition and with effective photosynthetic capacity, they are producing more energy than they need to sustain themselves.
7. Plants begin storing surplus energy in the form of lipids, plant fats and oils, and transmitting lipids out through the root systems in addition to carbohydrates and everything else.
8. Because bacteria can't digest lipids, this will trigger strong fungal digestion. The colony of mycorrhizal fungi and other beneficial fungi in the soil profile will increase due to the digesting of lipids.
9. As fungi metabolize lipids (along with carbohydrates) and digest them, they break it down over and over, eventually releasing it into the soil profile as humus. As soil quality reaches this level, insects cease to be a problem.

"IN THE SEED AND THE SOIL WE FIND THE ANSWERS TO EVERY ONE OF THE CRISES WE FACE. THE CRISIS OF WAR AND VIOLENCE, THE CRISIS OF HUNGER AND DISEASE, THE CRISIS OF THE DESTRUCTION OF DEMOCRACY." Vandana Shiva

Soil is the source of everything: Health, profit, well-being, climate, etc.

Conventional ag as practiced all over the world threatens the viability of the food supply on earth. Regenerative ag can solve the top 3 world problems: water scarcity, soil degradation and deforestation.

Careful stewardship of the soil is the most important investment to ensure food security.

"Major problems in the world are the result of the difference between how nature works, and the way people think." Gregory Bateson

You must manage soil nutrition, air, water and decomposition to determine nutrient uptake by plants. Our physical reality is made up of 90 or so naturally occurring minerals (elements), a lot of which we need to live, from Hydrogen to Yttrium and Vanadium. We need Fe to transport 02 in the blood, Ca and P for bone and teeth crystal lattice for examples. Lack of Zn causes sterility, loss of smell, and decreased brain development. When the immune system is threatened, it releases Cu from the liver and pulls Fe from the blood. Mn is important for quality seed development. Many metals are re-used over and over as catalysts in formation of proteins and amino acids.

If minerals are not in the soil, they are not in the food or animal ration. Conventional ag is producing quantity over quality due to toxic rescue chemistry to cover bad soil practices over the past decades. Food grown today can have 5 or 10 times less nutrients than in 1950 according to USDA testing.

Erosion from wind or water can remove the top inches of soil that holds most of the microbial population leaving the more sterile subsoil for the next crop. With the destruction of microbes and humus comes the nutrient loss as well since the

enzymes from microbes break down sand, silt, clay and organic matter to release nutrients in a form plants can use.

PERMANENT AGRICULTURE (permaculture) addresses these issues with the most elegant solutions. Permaculture is an ecological design system for sustainability in all aspects of human endeavor. It teaches how to design natural homes, abundant food production systems, regenerate degraded landscapes and ecosystems, develop ethical economies and communities and much more. A site is developed until it meets the needs of its inhabitants, including food, water, shelter, fuel and entertainment. (Bill Mollison). Permaculture methods include water storage, soil building, food forests, composting, aquatic systems, water filtration, waste management, animal husbandry, and food production returning surplus back to the land.

SOIL MINERALIZATION

Basic principles govern soil mineral balance: Cation Exchange Capacity (CEC or TEC)-a measure of the quantity of nutrients the soil can hold. The lower the capacity, the more soil life and plants have to struggle. If nutrients are in excess, they leach or build up and tie up other elements. CEC measures the ability of the soil to hold and release various positive ions called cations which are attracted to a negative charge in the soil clay or humus. Ca, Mg, Na, and K are the 4 which are adsorbed onto a clay particle or SOM (soil organic matter). The CEC measures how many negative sites are available. Experimentation with many ratios of nutrient cations came up with the conclusion that the healthiest, strongest and most nutritious crops came from a soil where the CEC was saturated with 65% Ca, 15% Mg, 4% K and 1-5% Na. This provides luxury levels of nutrients for crops and microbes as well as affecting soil texture and pH. Mg tightens soil-helpful in sand. Ca loosens soil which improves drainage for clay. SE soils are heavily aged and leached of minerals due to high heat and rainfall over thousands of years.

KCl for example, reduces exchange capacity by damaging the edges of the clay layers so exchange sites are no longer available-KCl is used in many fertilizers-Cl kills soil life.

Trading + and – ions: Soil, plants and microbes take cations from exchange sites where they are held by a weak electrical charge, "adsorbed". Roots and microbes give off H+ ions when close to the cation in exchange and the cation can then be taken up by roots or microbes. Balancing minerals puts the pH where it needs to be. The soil "eats" first-before plants. Feed the soil! The chemistry and health of the soil is related to mineral and trace element balance and availability. When an imbalance occurs, excesses of one element can become toxic to microbial populations, block uptake of other elements and negatively impact soil porosity, humus and organic matter. When soil chemistry is balanced, all elements needed are present and available. Unbalanced soil chemistry can be determined by observing poorly drained, compacted soil with little or no humus or organic matter. Other signs are excessive weed growth, pests, plant pathogens, slow plant growth and production. Obvious signs of improvement are crop health, reduction in pests and diseases, and weeds plus the return of earthworms and beneficial insects. Soil is more porous draining well while storing water appropriately.

Ca is associated with 1200 functions: The "trucker" of many minerals. As Ca goes up, pectin levels in the plant go up and insects do not like pectin. B must be in the soil to raise Ca-it is the gateway for Ca. Below 6.4, it is hard for Ca to get into the plant. Exchangeable Ca is what is used by the plant and H makes that happen. Hair roots grab Ca and leave H+ in the soil. Soil acidity occurs when much of the cation saturation has been used leaving a lot of H+ ions in the soil. Ca is only moved in the xylem upward which means it has to be very near the roots or it doesn't get moved into the plant at CPI (critical points of influence). Only with proper mineral balance in soil will the stable humus and optimum exchange capacity be formed and conserved. CPI, critical points of influence are times a crop must have good nutrition to affect quality, yield and pest resistance. CPI are bud initiation, bloom/pollination, cell division, fruit fill or expansion, senescence (seed). Bloom/pollination care can prevent many diseases but must be done in the fall for trees and perennial crops. Ca is critical for cell division.

The reason to increase humus is to lose it! Ways to increase humus and SOM:

Compost, humates (ancient vegetation), growing ROOTS and using biochar.

Humus "sews" the soil together preventing erosion using glue like substances that are secreted by microbes.

Biochar has 500m2/gram of surface area- 2" piece=tennis court! This surface is colonized by soil organisms and is very stable unlike humus. It can take time to become fully charged and shouldn't be used fresh without "charging". Biochar retains nutrients, holds water, loosens soil texture and provides microbe habitat.

2 soils compared in the Amazon: one with 213 CEC= 9064 ppm P and 17,545 ppm Ca. The other had 23 CEC= 273 ppm P and 115 Ca! Many of our SE soils are not even close to 23 CEC!

At least 30 elements are needed for nutritious food. Substances to help supply these include sea minerals, greensand, rock dust, seaweed, volcanic deposits, rock phosphates, etc. They add to the mineral composition of traces and minors but can't be used to supply major cations in large quantity that may be needed in some crops/soils.

Minor elements: Fe, Mn, B, Cu, Zn

Trace elements: Cr, Co, I, Mo, Se, Tin, Ni, F, V

Nitrogen is a function of being released from SOM which is 5% N by weight.

If there is 5% OM on soil test: .05x 2,000,000= 100,000# organic matter in soil.

100,000# OM/.05=5000# N per acre. Most crops need 80-100#/year. 15-20# released for every 1% OM in the soil. 20# x 5%=100#N

OM is the single most important indicator of soil quality.

NO3 and NH4 are correlated to some insect pests and weeds. With N imbalance, one form of N can be shunted to another form. Plants advertise stress and suffering after being force fed NPK for a quick "healthy looking" flush. Insects can smell an odorant on the wind from 10 yds to 1 mile and key in on the unhealthy plant part. Use of nitrate fertilizer can increase water needs by 50%. Three determinants used to grow a crop with less water: Soil texture, deep plant roots, soil organic matter (SOM). SOM is increased by growing fungal networks by

adding cover crops, mulch, compost which produce humus (stable organic matter). When it is digested, fungi play essential roles balancing the soil system. To increase fungal biomass, stop damaging the fungi that are present. (Don't till or use fungicides.) Apply microbial products including beneficial fungi along with fungal foods (brown carbonaceous debris, crustacean meal, fish oil). Fungi eat bacteria as well so increasing bacteria can help.

If you have problems with insects and diseases, you have a soil problem no matter what the soil test says. Insects smell frequencies with antennae and mouth parts. Scilla are tuned to frequencies like CO2 and floral compounds. Plants advertise when they are unhealthy and the 'decomposers' take them out which is mother nature's design. No insect goes to a healthy plant-they can't digest it. Alcohol is a universal odorant, a fermentation product produced by unhealthy plants.

Plants send out SOS signals customized for specific parasitic wasps to help fend off pests. Plants have a built- in defense signal more powerful that we know. Plants are losing these attributes through breeding and excess N fertilization.

Grasshoppers have been seen under the microscope with damaged mouth parts resulting from eating highly nutritious crops! Locusts and army worms have gone around healthy farms while eating neighboring crops.

Mosquitoes like digestible blood-unhealthy people. Researchers found most mosquitoes don't transmit malaria, dengue, yellow fever, zika etc. Insects have a state of health too-if their food sources are bad, their immune system is compromised and they are more susceptible to carrying diseases.

PLANT HEALTH PYRAMID

At the base of the pyramid is the production of carbohydrates through successful photosynthesis. Pectins and other polysaccharides build disease resistance to soil borne pathogens such as fusarium, verticillium etc.

Stage 2: Production of complete proteins which makes plants resist insects with simple digestive systems such as white flies, aphids, tomato hornworm, etc.

Stage 3: Storage of surplus energy in the form of lipids, fats and oils which build strong cell membranes which resist airborne pathogens (downy mildew, fire blight, rust, etc.), parasites and UV.

Stage 4: Production of Plant Secondary Metabolites (PSM) which act as plant protectors. Phenolics, terpenes, bioflavonoids, etc. are natural plant protecting compounds affecting Japanese beetles, Colorado potato beetles, cucumber beetles, etc. YOU CANNOT REACH THIS LEVEL WITH HYDROPONICS!!

SOIL FOOD WEB

Soil bacteria, fungi, nematodes, microarthropods, protozoa are all part of the soil food web. Bacteria and fungi hold mineral nutrition elements in their bodies and don't let go until eaten by larger predatory nematodes, macroarthropods, etc. These microbes grow around the root zone where they feed on the plant exudates and release nutrients back to the soil in the root zone in a form plants can use. Usually there can't be too many predators as the larger ones will come in to create balance: predatory nematodes, macroarthropods, and then larger predators such as earthworms, voles, birds. Earthworms live in the soil and compost worms such as Red Wigglers live on the surface in organic matter. To assess microbial community without a microscope, look at the number and species of mites. They are top predators and indicate a healthy food source (microbes) just as looking at top predators in the macro environment indicates a healthy population of balanced food sources.

Microbes stimulate the elongation of root hairs and exit at tips where the walls are thin. Microbes reform cell walls once outside the root hair. Microbes become intracellular in meristem cells as wall-less protoplasts. They exit when exhausted of nutrients that have been extracted. Microbes enter the root cell spaces carrying nutrition from the soil. After exiting, they recharge with nutrition in the rhizosphere.

Balancing fungal and bacterial community is important for many crops. A mature virgin forest would be fungal dominant where an early grassland would be highly bacterial. As the soil and plants age through succession, the soil becomes more

fungal. Most crops are in the middle of this cycle requiring some of each. An orchard thrives on more fungal communities. To increase fungi, feed bacteria and that in turn will feed the fungi. Crustacean wastes can feed mycorrhizae as well as brown carbonaceous mulching materials. Green 'manures' feed the bacterial colonies.

Biology comes before chemistry. Vigorous biology is a must to have successful crops/gardens/orchards. The biology can help overcome mineral imbalances in some instances but biology and mineral elements that have been lost or lacking must be added. Provide mulches, cover crops and balanced mineral nutrition for food. Foliars can help speed the process of building healthy soil and plants. Do NOT add excess nutrition!

Many plants have the genetic potential to yield much more product if the environment can be managed properly according to regenerative principles. The fastest way to build healthy soil is to grow healthy plants. Plants feed soil microbes and soil microbes feed plants. Maximize photosynthesis.

DON'T GUESS, TEST!