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Building Soil Carbon

Most of our agricultural soils are lacking adequate levels of organic matter and good soil health to obtain optimal yields. The lack of humic substances and healthy soil biology reduces the soil's water holding capacity and the ability to release nutrients when the plants need them, leading to reduced crop quality and lower yields. Now that some carbon markets are paying farmers to store carbon, here are some ways to get paid to store soil carbon with added crop and soil benefits.

Understanding the carbon cycle is the first step to effectively building soil organic matter. There are three main ways to increase a soil's carbon content: carbon imports, carbon generation, and carbon induction. From an agricultural perspective, all three methods of carbon generation are great for agricultural production.

Importing Carbon: There are three primary carbon imports: humates, biochar and compost. Humates such as fulvic and humic acids can be added to a soil and generally provide good nutrient exchange. Biochar is charcoal that is produced when oxygen is limiting during burning. Biochar is a stable carbon import but not quite as active as humates. Compost is a carbon import with a strong biological component (high in beneficial microbes) that greatly improves soil health. Compost does have a lower level of stable humic substances and can degrade over a period of a few years, diminishing carbon soil storage over time. Each method provides soil-building components: compost provides biological inoculum while humates provide biological plant growth stimulants.

Carbon Generation: Farmers have several opportunities to generate or capture carbon on the farm that could otherwise be lost. Managing crop residues, reducing tillage, composting crop waste and animal manure, and cover cropping all provide farmers with a chance to capture and store more soil carbon. Any of these practices will help build a robust healthy soil system that increases the recycling of plant available nutrients.

Carbon Induction: Induction may have the greatest possibly for generating higher levels of soil carbon by optimizing the carbon cycle through improved plant performance. Carbon induction builds large amounts of stable humic substances, stimulates biology, and improves soil and plant health. Improving plant genetics, changing plant spacing, intercropping, and keeping the soil covered with many different species of plants by increasing soil health improves carbon storage through carbon induction.

Plants naturally recycle carbon by absorbing carbon dioxide from the air with photosynthesis to form simple sugars. These sugar compounds are the building blocks for complex carbohydrates and polysaccharides, proteins and amino acids, and plant lipids. All of these compounds contain an average of roughly 40 percent carbon. Plants release large amounts of these substances to feed the soil biology in exchange for soil nutrients. The healthier the plant, the greater the amount of root exudates are released, leading to higher soil carbon.

Healthy plants can release 60-70% of their total sugar production back into the soil as root exudates. This carbon induction occurs only in healthy plants with surplus energy. Generally, plants have about 50% of their biomass above ground and 50% below ground but in healthy plants this represents only 30-40% of the plant's total energy production. Farms based on perennials or forages are the most efficient at building soil organic matter and stable humic substances due to carbon induction.

Healthy plants with greater photosynthetic efficiency and higher levels of surplus energy start to form lipids (fats and oils). Lipids are a form of high energy storage from surplus plant energy which is stored as fat. As plant energy stores and lipid levels increase, the plant builds stronger cell membranes and reproductive tissue. Many lipids will be exuded from the roots to be used as a soil microbial energy source. Healthy plants out-compete most pests: reduced weeds, less or no insect feeding, and less or no disease. In addition, soils high in lipids have more beneficial soil microbes and store more stable humic compounds, high in soil carbon.

In tilled or bare soils, bacteria and harmful nematodes dominate the system. Bacteria consume many of the simple sugars and carbohydrates exuded by plants roots, but their soil carbon storage efficiency is only 20-30%. In no-till fields with cover crops, beneficial soil fungi (like mycorrhizae fungi) digest the root exudates slowly, improving soil carbon storage efficiency to 45-60% by forming more stable long chained humates. Improving soil health leads to higher carbon induction and greater carbon sequestration by forming stable soil humates high in soil carbon. Healthy soils reduce pests, improves crop quality and nutrient density, and improves crop yields; while improving the environment. Adapted from an article by John Kempf.