Crops for Carbon

CO_2 Sequestration

Globally Sustainable Agricultural Solutions for Developing Countries

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CURRENT METHODS OF CARBON DIOXIDE SEQUESTRATION

PURPOSE

The purpose of this document is to outline the scientific basis for improving crop yields through the use of specialized materials and to pay for these materials with carbon credits. It is believed that by implementing this program, farmers in developing countries can improve their soils, increase their yields, increase the quality of their produce and sequester carbon in the soil.

PREFACE

There are many developing countries throughout the world who are trying to determine how to feed their people. Modern agriculture introduced the use of mineral fertilizers as a means to increase production yields. However, many of these mineral and chemical fertilizers, when applied over years, leads to soil organic matter and soil mineral loss, as well as other environmental issues like greenhouse gas emissions, and water contamination. These key soil property losses in turn decrease crop health and yield and require even more fertilizer for the same yields.

Many of these areas are also challenged by poor soils to begin with, low rainfall and over-farming creating a difficult situation for the farmers. Technology to overcome problems as described above generally takes time for the cost to become affordable enough for developing countries to adopt. OrganoCat believes that the technology to improve soil fertility, increase fertilizer utilization, improve moisture holding capacity while increasing drainage, stimulation of soil microbes and new mineral formation, and many more beneficial results is now affordable and potentially profitable for these developing countries. The following text describes how specialized soil and plant materials can improve crop yield and support themselves through carbon credits.

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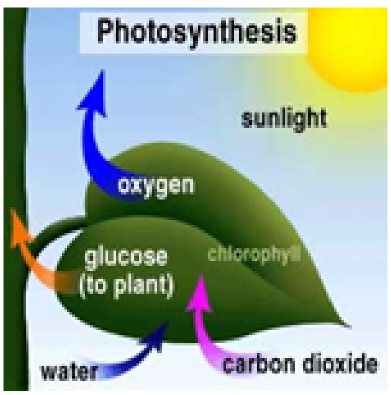
CARBON DIOXIDE SEQUESTRATION

The use of trees and other plants to absorb carbon dioxide has been extensively studied. Although carbon dioxide is absorbed into trees for some period of time, it is not permanently sequestered from the environment. This carbon is subject to release back into the atmosphere as a result of tree burning and decay.

It is well known that green plants uptake CO_2 through photosynthesis. In the presence of chlorophyll, plants use sunlight to convert CO_2 and water into carbohydrates that, directly or indirectly, supply almost all animal and human needs for food. Oxygen is released as a by-product of this process (see Picture 1).



Picture 1: Photosynthesis process.

The principal factors affecting the rate of photosynthesis are a favorable temperature, level of light intensity, and availability of carbon dioxide. Most green plants respond favorably to concentrations of CO_2 well above current atmospheric levels. While there are a number of ways to increase carbon dioxide uptake in biological systems such as plants, it has proven to be difficult to do cost effectively.

OrganoCat has developed a methodology of carbon dioxide sequestration based upon the application of Active Humic Acids (AHA) for stimulating native soil microorganisms

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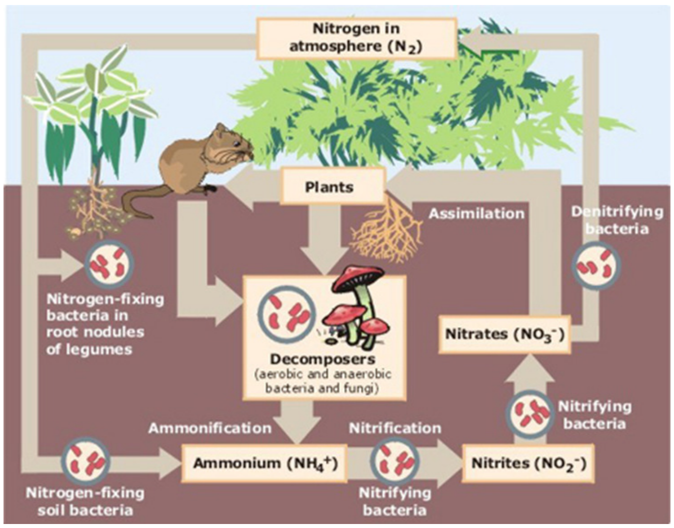
which absorb carbon dioxide from the atmosphere and form organic matter (see Picture 2 on *Nitrification process*).



Picture 2: Nitrification process.

Once applied, the AHA's protect soil organic matter from mineralization, which results in a reduction in carbon dioxide emissions. The AHA's also cause an increase in humification (humification is the biological process of plant matter conversion into humus) instead of mineralization, in order to form humic substances. Humic substances are the most stable fraction of organic matter in soils, persisting for thousands of years, thereby preventing the carbon from being re-released into the atmosphere for very long periods of time.

There are many types of microorganisms in the soil which may be divided into two large groups called Heterotrophs and Autotrophs. Heterotrophs use organic matter as a carbon and energy source, resulting in the decomposition of organic matter and carbon dioxide emission from the soil. This process, also known as organic matter

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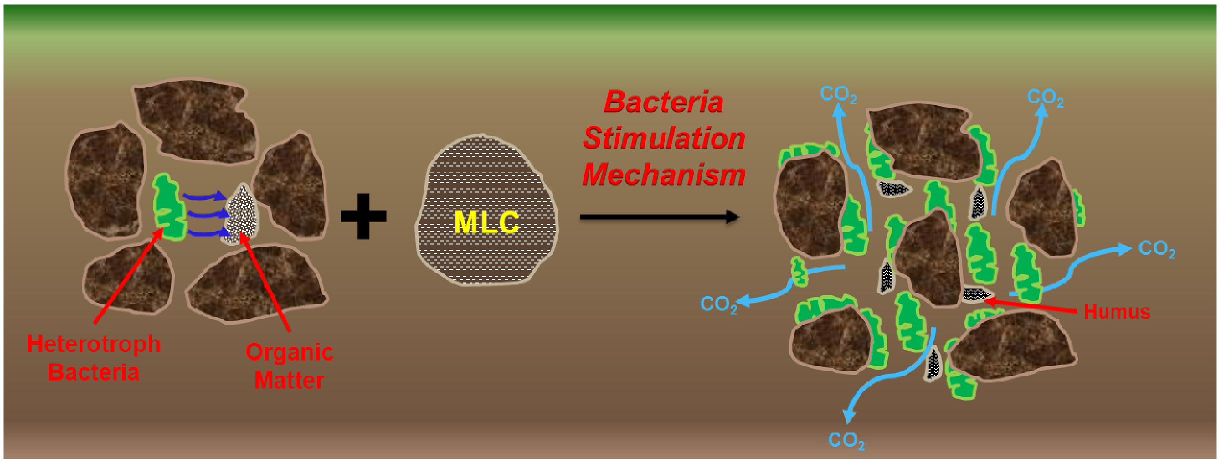
mineralization, results in the formation of simple mineral compounds such as CO_2, N_2, water, etc. (see Picture 3).



Picture 3: Heterotroph bacteria action in the soil after Monty's Liquid Carbon (MLC) application.

Autotrophs use energy that is released due to the oxidization process of mineral compounds. At the same time, this group of microbes uses carbon dioxide as a carbon source, resulting in CO_2 conversion into microbial biomass. This group of microbes plays a positive role in terms of carbon dioxide adsorption from the atmosphere and its conversion into organic matter. These bacteria are classified as nitrificators along with hydrogen, sulfur and iron oxidizing bacteria (see Picture 4).

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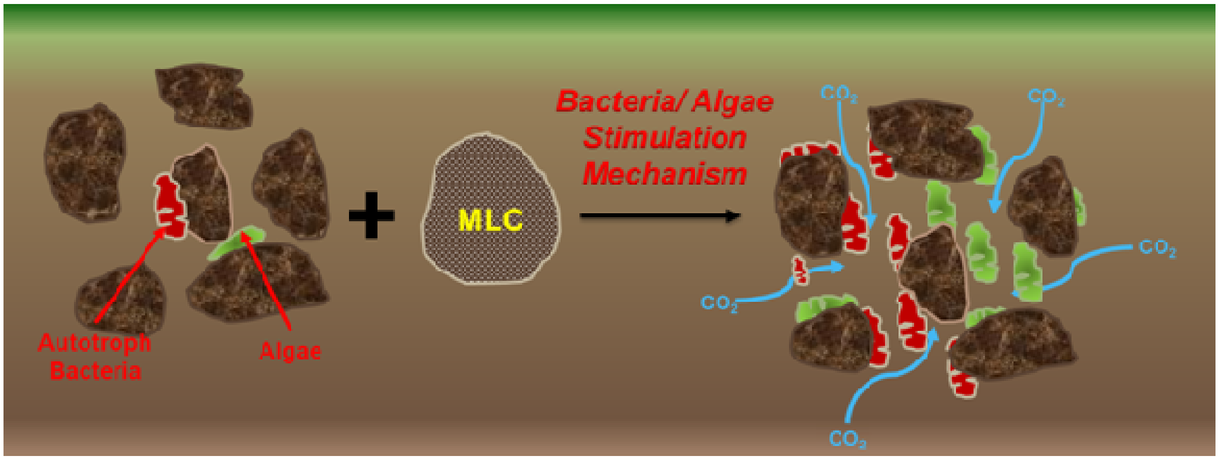

Picture 4: Autotroph bacteria action in the soil after MLC application.

There is another group of microorganisms that contains chlorophyll and is represented by blue-green, green and diatomaceous algae. These algae vary depending on each soil type and use light as an energy source and carbon dioxide as a carbon source, resulting in CO_2 absorption from the atmosphere.

The present invention creates favorable conditions for carbon dioxide consuming microorganisms, including bacteria and algae, so they will absorb CO_2 and convert it into soil organic matter. This allows for the simultaneous use of soil for both crop production and carbon dioxide sequestration. Once accumulated in the soil, organic matter in the form of bacterial and algae biomass can be protected from mineralization/decomposition so it does not re-release carbon into the atmosphere. Picture 5 depicts the current state of mineralization Vs. humification and the proposed state based on Monty's Liquid Carbon (MLC) applications.

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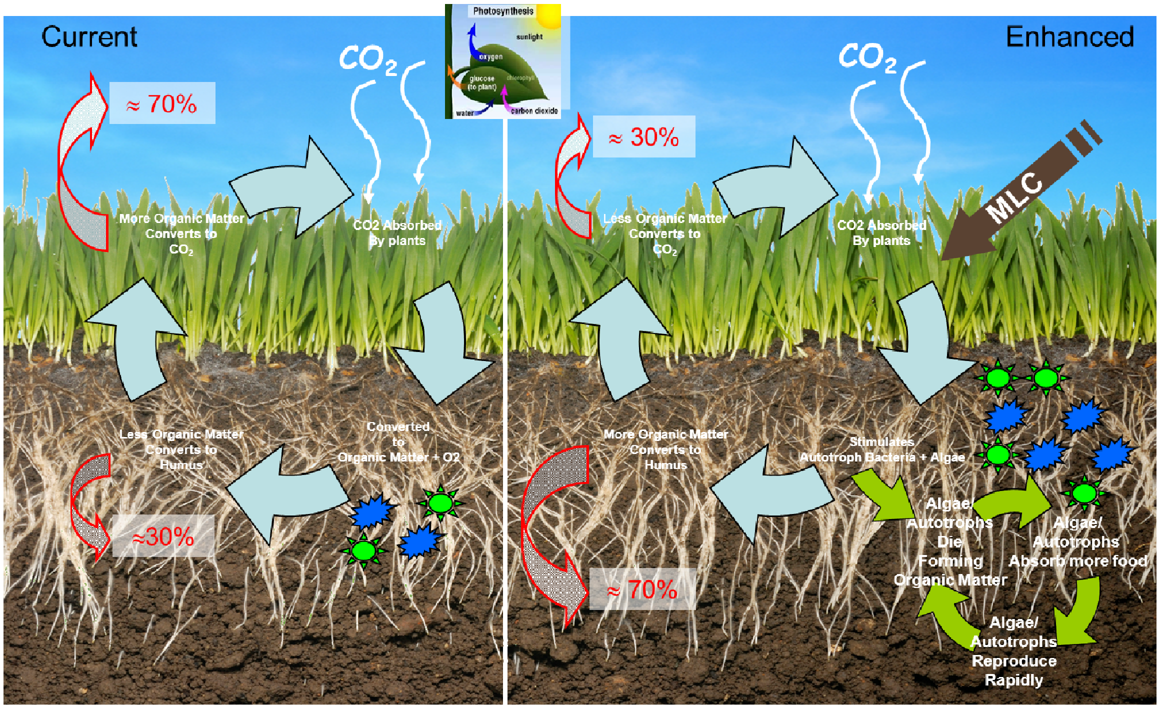

Picture 5: MLC impact on Humification and mineralization. "Current" is the normal process. "Enhanced" is the process after the application of MLC.

The way to protect the organic matter from mineralization/decomposition is through humification, which converts organic matter into stable humus and humus-like products which are very beneficial for the soil in terms of fertility, structure, water holding capacity, nutrient accumulation and uptake, etc.

These products also stimulate other types of microbial activity, but the presence of AHA's significantly reduces mineralization. AHA's take part in partially or fully decomposed organic matter conversion to stable native biopolymers called humus and humus-like organic matter which stores carbon for extended periods of time under normal conditions. The resulting product serves as a matrix for new soil mineral formation, which is very important for soils that have been degraded under intensive agricultural use. New soil minerals form organic-mineral complexes with soil organic matter, resulting in more organic matter stability. These products act as strong

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detoxifiers. The chemical activity of the products allows them to interact with all types of pollutants including heavy metals, pesticides, petroleum, polycyclic and polychlorinated hydrocarbons, etc., resulting in the reduction or elimination of the toxicity of these pollutants. The reduction or elimination of soil toxicity means better conditions for bacteria and algae growth and development. These products also stimulate plant growth and development and protect their residue from mineralization/decomposition by converting the organic material into humus and humus-like substances.

QUANTIFYING THE RESULTS

The relationship between soil organic matter, organic carbon and CO_2 are related (and calculated) using ISO standards. These calculations are based on actual soil readings of organic matter and provide a basis for scientifically determining the amount of CO_2 sequestered in the soil.

Calculations

There are well known equations that establish the correlation between carbon dioxide (CO_2) and organic carbon ($C_{organic}$), and organic carbon with organic matter ($Q_{organic\ matter}$) in the soil. These equations are:

$$C_{organic} = 0.272\ CO_2 \text{ (Note3)}$$

$$Q_{organic\ matter} = (1.7 \text{ to } 2.5)\ C_{organic} \text{ (Note4)}$$

There is approx. 2,000m^3 of soil per hectare (0.2m thick). Assuming a soil specific gravity of approx. 1.2 T/m^3, there is roughly 2,400 T of soil per hectare (assuming soil moisture of 50%). Therefore, an increase of 0.9% equates to,

$$0.009*2{,}400 = 21.6 \text{ T/ha (8.7 T/acre)}$$

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of soil organic matter in terms of wet weight. In terms of dry weight, there is 10.8 T/ha (4.35 T/acre).

Using the equations above for organic carbon:

$$C_{organic} = Q_{organic\ matter}/1.7 \text{ to } 2.5 = 8.6 \text{ to } 12.7 \text{ T/ha } C_{organic}.$$

Calculating CO_2:

$$CO_2 = C_{organic}/0.272 = 15.8 \text{ to } 23.4 \text{ T } CO_2\text{/ha sequestered in the soil.}$$

According to these equations, 10.8 tons of organic matter (dry basis) is equal to 15.8 to 23.4 tons of CO_2 removed from the atmosphere and sequestered in the soil.

Monty's regularly determines soil organic matter from its customers' soil tests. Table 1 below shows recent results after the application of MLC at 4.7 l/ha.

Table 1: Actual data from farm land in the USA.

Test Plot	Δ Organic Matter(%)[Note1]	Organic Matter(T/ha)[Note2]	Organic Carbon(T/ha)[Note2,3,4]	CO_2(T/ha)[Note2]
BC101510	0.5	6	2.4 - 3.6	8.8 - 13
JD101510	0.8	8.6	3.9 - 5.7	14.2 - 20.8
MB081310	0.3	3.6	1.5 - 2.1	5.4 - 7.7

Note 1: Detected through soil analysis.

Note 2: Calculated using equations above.

Note 3: ISO10694

Note 4: ISO14235

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SUMMARY

It is well documented that as the world's population grows, so too will the demands on the food supply. There is concern that new technology will need to be adopted to meet these demands and that developing countries may not have the resources to adopt them quickly enough.

Modern agricultural practices have increased crop yields dramatically, but in many cases it has come at the expense of soil quality/fertility, agrochemical efficiency and produce nutrition. New technology is needed to mitigate these adverse effects and support more sustainable agricultural practices.

Many developed countries who have signed onto broad environmental policies like the Kyoto Protocol are being forced to offset their growing industrialized economies greenhouse gas emissions with carbon credits. These carbon credits are being established out of developing countries. Therefore, there is a great opportunity for developing countries to seek and implement technologies that enables them to take part in the global carbon credits market, a mega-billion dollar commodity market.

OrganoCat proposes a technology that solves many of these global issues. It provides a soil improvement and crop management tool to reduce chemical fertilizer use by reducing their losses through volatilization, leaching and under-utilization; and rebuilds soil structure for increased fertility and efficiency all leading to increased yields and improved produce quality. These same technologies enable farmers to utilize their soil for carbon sequestration, opening the door for carbon credits and the ability to pay for their crop fertility program. This is not only a sustainable solution, but it is a globally effective strategy.

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