Organic matter in soils

Organic matter is considered to consist of all compounds derived from the chemical decomposition of plant and animal remains, which serve to nourish soil and crops with minerals for the biological development of plants.

Organic matter can only be beneficial for crops if and when it can be biologically synthesized by the organisms that cause such matter to degrade. For that reason, the degradation of plant and animal remains is an essential process. In that process carbon is recycled into the atmosphere as carbon dioxide, and nitrogen is transformed into a form that can be used by plants, such as ammonium and nitrate.

In addition, associated elements such as phosphorus, sulfur and several microelements are released in a form available for higher plants. Later, part of the carbon is absorbed into the microbial tissues (microbial biomass), and part turns into humic substances.

As such, organic matter is fundamental for soil fertility and plant growth, because it incorporates nutritional elements and improves the soil's physical characteristics, not only increasing the soil's water retention capacity, but also its cation exchange capacity and pH buffer capacity. Organic matter thus restores soil fertility for the next crop.

Types of Organic Matter

- Untransformed or inactive organic matter: This is plant, animal, and/or microbial biomass in its raw state. Untransformed organic matter also corresponds to the most unstable portion of organic matter, since it represents all the raw organic remains their original state, without a state of decomposition.
- Semi-transformed organic matter: This is composed by organic remains in a process of transformation and bears little resemblance to the original material. It also represents the intermediate state leading to moderately transformed matter, where the biomass is susceptible to being attacked by microorganisms. Semi-transformed organic matter represents approximately 40% of total carbon in the soil.
- Transformed organic matter: This is the organic matter formed by humus in its strict sense, and is related to the clay-humus mineral complex involved in the biological growth of plants. Several researchers have indicated that such matter is found in 50% of total organic matter. It is hard for bacterial flora to attack such matter, since it has already transformed and contains the minerals necessary for plant photosynthesis.

How Organic Matter Forms the Soil Structure

When plant remains are incorporated into soil, several organic compounds decompose. Decomposition is a biological process where the physical collapse and biochemical

transformation of the molecules in the organic complexes of dead matter are turned into simple, inorganic molecules, which are transformed into humus.

Crop remains principally contain complex carbon compounds that originate in the cell walls. These carbon chains, with variable quantities of oxygen, hydrogen, nitrogen, phosphorus, and sulfur attached, are the building blocks for simple sugars and amino acids.

In addition, the successive decomposition of dead matter and modified organic matter leads to the formation of a more complex organic matter called humus.

Humus affects the soil's properties, to such an extent that, as the soil's color becomes darker, there is an increase in aggregation and the stability of the aggregates, thereby increasing cation exchange capacity and contributing nitrogen, phosphorus, and other nutrients as the humus gradually decomposes.

Humus also plays an important role in the soil's structure. Without humus, soils that have a high content of silt or clay would easily become compacted when worked, provoking erosion and loss of the nutritional components necessary for fertilization and agricultural development.

The presence of worms that contribute microbial mass capable of decomposing the organic matter in the soil is favorable for soil fertility, enhancing the soil's cation and carbon exchange capacity.

Earthworms living at plant roots create numerous channels along the depth and breadth of the soil surface when the remains are conserved at that level, increasing overall porosity. Vertical channels created by worms that dig deep contribute to significantly increasing infiltration of water under conditions of intense rains or of saturated soils. Worms also improve soil aggregation.

For its part, the presence of organic matter provided in the form of mulch makes a considerable contribution to the retention of soil moisture, which is necessary for root growth. Organic matter thus serves as an aid to soil fertility and represents one of the variables that should be taken into account in order to increase yields and improve agricultural productivity.

How to Increase Organic Matter in the Soil:

- Preventing soil erosion that could result from poor management of irrigation.
- Applying manure once a year or once every two years
- Incorporating green fertilizers
- Incorporating plant remains from harvests

Decomposition and Biodegradation

Natural organic matter transforms through biological conversions. Thus, even though all living things are organic matter, microorganisms, in particular, play a determinant role for geochemical change of soil fertility.

The action of the organisms and microorganisms is necessary for energy and nutrients to be obtained. These organisms are called consumers and are formed by microorganisms, such as bacteria and large invertebrates like earthworms and insects.

The principal function of such organisms and microorganisms in cultivated soil is to aid in decomposing crop remains by ingesting these remains and mixing them with the soil's parent mineral. In the process energy and nutrients from the plants are recycled.

These organisms and microorganisms are actually capable of transforming a large amount of organic matter into processed organic matter, which is indispensable for the biochemical development of the soil and the ecosystem's biosphere. Much of such transformation and decomposition takes place in the soil, where the largest percentage of energy and matter is transformed for reuse.

The decomposition of organic matter is a naturally occurring biological process. Its speed is determined by three principal factors: 1) the composition of the organisms in the soil, 2) the physical environment (oxygen, moisture, and temperature) and, 3) the quality of the organic matter. These factors interact with one another, such that the organisms and the interactions among them structure the food web of the soil.

Composting of Organic Matter for Planted Soil

Microorganisms feed on the carbon in organic matter. They digest it and excrete a finished product that stabilizes the nitrogen. This excreted, nitrogen-rich mass is what is commonly known as compost.

Benefits of Organic Matter in the Soil

A crop's development depends upon soil fertility to provide nutrients and minerals (carbon and phosphorus) for proper plant growth. For that reason, the availability of nutrients in the fertile soil is essential for a successful agricultural production.

Nonetheless, the availability of soil fertilization depends upon the composition of the soil's biotic system. The decomposition process of the sowed organic matter is determinant for such purpose, as has been mentioned time and again.

A fertile soil must necessarily have a suitable content of organic matter, ranging between 2% for sandy soils and up to 6% for humic soils.

Organic matter thus represents one of the techniques and strategies to be implemented for all crops and has rapid, positive effects on agricultural production. The benefits of organic matter in planted or cultivated soil are numerous, given that organic matter has physical, chemical, and biological effects on crops that are reflected in improved yields and better agricultural quality of the products. Some of the principal benefits of organic matter and biological activity in cultivated soil are as follows:

<u>Physical</u>:

- It improves soil structure of through the formation of stable aggregates.

- It reduces the apparent density of the soil.

- It reduces the adverse effects of agricultural machinery on the life in the soil.

- It contributes to reducing soil erosion caused by sun exposure, lack of water, and compacting, given that the organic matter has a lower thermal conductivity than the adjacent mineral fraction.

- It helps to maintain the temperature and biotic mass.

- It contributes to increasing the soil's hydraulic conductivity due to the empty spaces that form in the interface between the organic particles and the minerals.

Chemical:

- It has an influence on the availability of nitrogen that the roots can find in the biotic mass, since the generation of nitrogen principally depends upon the organic decomposition generated in the surrounding area.

- It aids the phosphorous nutrition of the plants by favoring the development of phosphorous-generating microorganisms, which act upon insoluble phosphates in the soil, enriching the soil and creating a more fertile, more nourishing environment for feeding the crop.

- It increases the availability of micronutrients for plants, such as iron, manganese, zinc, and copper.

- It promotes cation exchange capacity.

- It contributes to the absorption of water molecules over minerals that impede such absorption, due to hydroxylic, amino acids, amides and ketones.

Biological:

- Storage of metabolic energy.

- Source of macronutrients (Nitrogen, Potassium and Sodium).

- Ecosystem stability (increases the capacity for recovery of disturbed ecosystems).

- It plays a determinant role in plant growth, since it could either inhibit or promote plant development.

- It stimulates the development and activity of microorganisms, providing energy and nutrients necessary for life.

- It favors the presence of worms to improve the structure and fertility of the soil.

Plant Stubble: Ideal for the Generation of Organic Matter Humus

In today's world, agriculture is seeking ways to develop a sustainable system that ensures profitability and agricultural production. In said regard, sustainability lies in the capacity to reuse all resources in a way that generates "savings."

Plant stubble is the uncut biomass left behind following the harvest. It is commonly used in conventional agriculture to make thick layers of mulch or padding. These are ideal for protecting the soil against water erosion and water loss due to sun damage, thus ensuring soil moisture.

Implementation of this method for crops is an ideal way to conserve soil moisture, keep temperatures down, and facilitate the transformation of untransformed organic matter into transformed organic matter. The ways in which it helps are:

- Plant stubble lowers the kinetic energy of rain.

- It reduces surface water runoff.

- It favors water infiltration.

- It reduces direct evaporation of water from the soil.

- It generates organic colloids due to decomposition.

- It improves the structure and stability of aggregates.

- It prevents surface crusting of soils.

- It keeps temperatures in the soil from getting too high or too low.

- It contributes nutritional elements to plants and improves soil fertility through its decomposition.

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