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Role of carbon-enriched soil amendments to improve soil properties

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Role of soil carbon (C): Organic carbon is an important resource which is required to be managed and sustained in the soil for an efficient ecosystem functioning, and different SOC fractions depend on the agro technical managements. Soil carbon (C) is an important indicator of soil health and an integral part of the physical, chemical, and biological properties of the soil. Loss of soil carbon can lead to soil degradation and loss of productivity. Soil carbon is lost from the soil through erosion, residue removal, intensive tillage, and land-use changes. Carbon-enriched soil amendments, including animal manure, bio-solids, municipal compost, and biochar, among others, can restore soil productivity (Fig. 1).

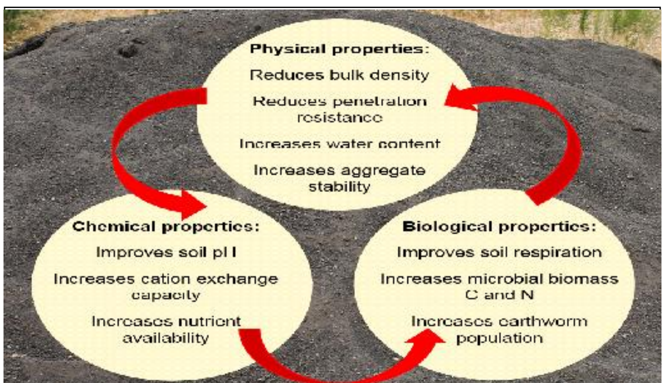

Fig. 1: Benefits of C enriched amendment (Crop Watch UNL. EDU)

Soil organic matter is made up of four major pools – plant residues, particulate organic carbon, humus carbon and recalcitrant organic carbon. These pools vary in their chemical composition, stage of decomposition and role in soil functioning and health.

Carbon pools and soil function: Each of the different carbon pools decomposes, or turns over, at a different rate and is involved in different soil processes (Fig. 2).

Plant residues: These are shoot and root residues found on the soil surface and in the soil. They are broken down relatively quickly (weeks to years) and provide an important source of energy for soil micro-organisms.

Particulate organic carbon: Is defined as pieces of plant debris 0.053–2 mm in size. Particulate organic carbon also decomposes relatively quickly (years to decades) and provides an important source of energy for soil micro-organisms. It also plays an important role in maintaining soil structure and providing soil nutrients. Plant residues and particulate organic carbon are often referred to as 'labile carbon' because they cycle in the soil relatively quickly.

Humus : Is composed of decomposed material less than 0.053 mm in size and is usually found attached to soil minerals. This type of carbon is more resistant to decomposition by soil micro-organisms and so tends to

Fig. 2 : Different soil processes

turn over more slowly (over decades to centuries). It plays a role in all key soil functions and is particularly important in the provision of nutrients.

Recalcitrant organic carbon : Is organic material resistant to decomposition and in Australian soils, is dominated by charcoal. Recalcitrant organic carbon can take centuries to thousands of years to decompose and is largely unavailable to micro-organisms. Highly weathered soils and soils with a history of burning have a high proportion of recalcitrant organic carbon.

Why soil amendment? A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. The goal is to provide a better environment for roots. To do its work, an amendment must be thoroughly mixed into the soil. If it is merely buried, its effectiveness is reduced, and it will interfere with water and air movement and root growth.

Organic and inorganic amendments: There are two broad categories of soil amendments: organic and inorganic. Organic amendments come from something that was alive. Inorganic amendments, on the other hand, are either mined or man-made. Organic amendments include sphagnum peat, wood chips, grass clippings, straw, compost, manure, biosolids, sawdust and wood ash. Inorganic amendments include vermiculite, perlite, tire chunks, pea gravel and sand. Organic amendments increase soil organic matter content and offer many benefits. Over time, organic matter improves soil aeration, water infiltration, and both water- and nutrient-holding capacity. Many organic amendments contain plant nutrients and act as organic fertilizers. Organic matter also is an important energy source for bacteria, fungi and earthworms that live in the soil.

Points to be consider when choosing an amendment:

There are at least four factors to consider in selecting a soil amendment:

– How long the amendment will last in the soil,

– Soil texture,

– Soil salinity and plant sensitivities to salts and

– Salt content and pH of the amendment.

Research on impacts of high-carbon soil amendment on soil properties: Biochar refer to the carbon rich materials (charcoal) obtained from the thermochemical conversion of biomass in an oxygen limited environment (pyrolysis). Biochar was first found in the Central Amazon basin. Applying biochar to agricultural soils is considered to improve carbon sequestration and decreased greenhouse gas emissions from agriculture. Biochar is not a pure carbon, but rather mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions.When the biomass is pyrolyzed heated in the absence of oxygen over 40 per cent of the total carbon from the waste biomass is retained in biochar and sequestered in the soil for thousands of years, effectively removing that carbon from the atmosphere. The carbon in 1 ton of biochar is equivalent to about 3 tons of CO_2 removed from the atmosphere. The key chemical and physical properties of biochar are greatly affected by the type of feed stock being heated and the conditions of the pyrolysis process. Biochar's immense surface area and complex pore structure (a single gram can have a surface area of over 1000 square yards) provides a secure habitat for micro-organisms and fungi. Because of its high C content, a primary purpose of applying biochar to soil is to increase SOC levels. Depending on C stability, biochar can enhance SOC via either its decomposition by soil microbes or by preserving the existing natural SOC. The mineralization rate of biochar depends on the mineralizable C content in biochar, the quantity of which varies with the type of feedstock and temperature of pyrolysis. Most biochar C is released in the first few days following biochar addition because of the labile organic matter in biochar available for microbial activity. Two basic approaches for reducing nutrient leachability and boosting their retention rates: Biochar may act as a slow releasing nutrient agent and adsorption sites are enhanced as a result of biochar application, which contributes to nutrient retention. In general biochar has a high C/N ratio (meanvalue of 67) which indicates that immobilization of nitrogen can occur when applied to soil. Because of the carbon stability it can not easily be digested by microbes and therefore N mineralization can occur.

Benefits from applying biochar:

Productivity improvements are more likely on sandy soils, and the benefits include:

– Increased nutrient retention and reduced leaching

– Increased cation exchange capacity

– Improved soil structure and water-holding capacity

– Decreased soil acidity and increased habitat for microbes.

As biochar attracts and holds soil nutrients, it reduces fertilizer requirements. As a result, fertilization costs are minimized. Chemical fertilizers are typically fossil-fuel based, thus biochar provides additional indirect climate change benefits by reducing fertilizer needs.

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