International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-9, Issue-4, July 2021
https://doi.org/10.55524/ijircst.2021.9.4.20
Article ID 219420, Pages 83-86
www.ijircst.org

A Review on Increasing Soil Carbon Storage: Mechanisms, Effects of Agricultural Practices and Proxies

Dinesh Verma

Assistant Professor, Department of Agriculture, Vivekananda Global University, Jaipur, India

Correspondence should be addressed to Dinesh Verma; dinesh.verma@vgu.ac.in

ABSTRACT- The worldwide 4 per 1000 project seeks to assist governments and non-governmental organizations in their efforts to improve soil carbon (C) stock management. These stocks are depending on soil C emissions and inputs. They are the result of interconnected fine-scale mechanisms that stability or dissolve C carried by biological materials. The Carbo SMS cooperation has drawn together French academics specializing in these phenomena and their influence on C stores in the context of regional and global change since 2016. This article summarizes the first seminar of this partnership. In the first part, we discuss recent advances in our understanding of soil C anchoring methods, which comprise abiotic stresses processes that occur concurrently and interact. Plants (the principal source of carbon via debris but also root systems), microorganisms (fungi and bacteria), and 'environment engineers' all have an impact on soil organic carbon stocks (earthworms, termites, ants). Abiotic mechanisms that are related to soil crystal properties, opacity, and material fraction on the other hand, affect these stocks. We demonstrate how agricultural methods influence soil C stocks in the second half. Land use and management methods affect both biotic and abiotic processes. We address several proxies and models that describe particular processes and their activity. In diverse soil and environmental situations, as well as how to incorporate them into large-scale models to improve soil C stock change estimates. Furthermore, this literature review highlights future scientific investigations targeted at preserving or even increasing C stocks, with a focus on procedures, farming practices' effects on them, and C inventory forecasting models.

KEYWORDS- Agricultural Practices, Indicators, Microorganisms, Mineralization, Soil Organic.

I. INTRODUCTION

Human activities result in an increase in atmospheric concentrations of GHGs, produced by combining carbon (CO_2, CH_4), have been related to climate change. Caused by man carbon emissions are partially countered by carbon sinks in oceans, trees, and soil. Organic C is carried in organic materials are composed of organic C soils store about three times more carbon than that of the atmosphere. Soils may function as a C sink or supplier on decadal time spans, depending on their characteristics, climate, land use, and other factors. Global models that connect concentration Of carbon dioxide to temperatures suggest that reducing CO_2 by 3.5–4 Gt/year would confine temperature increase to +1.5/2 °C by 2050, i.e. the boundary beyond which climate science might have a substantial effect. Improving C levels there in top 30 m depth boundary by 0.4 percent might result in a yearly decrease in CO_2 carbon dioxide levels (4 per 1000) per year [1]–[6].

In this perspective, The 4 per 1000 Sequestration in Soils for Nutrition Security and Climate initiative in France, launched in 2015 away at the end of COP21 in Paris, aims to bring along public and private and non-governmental partners dedicated to better soil C inventory system. The global objective of increasing carbon stocks in agricultural zones (croplands, grasslands, and forests) where human activity may indeed be directed into C storage is expected to have beneficial effect on soil security and climate. Indeed, high soil OM stocks may help improve soil fertility because OM mineralization can provide nutrients to plants. However, this will need adapting agricultural methods to local conditions that will increase soil C intake while maintaining outputs, or declining, maximizing soil C storage [7].

Von Lützow et al. identified three soil concept C pools based on their degradation rates. Labile OM turnover may take anything from a single day to a whole year the transitional water is where you will find yourself, OM turnover takes a few years to decades. Plant, animal, bacterial, and fungal residues make up the majority of both pools. OM byproducts from the labile pool also feed the intermediate pool. Because this OM pool is dynamic and has a high turnover rate, soil management techniques have a significant impact on it. Finally, over temporal spans spanning from hundreds to decades, that stable OM pool changes change.

It is made up of leftovers from plants, animals, bacteria, and fungi, as well as microbial metabolic products. OM may be present as In the stable pool, aggregates and/or precipitated of mineral surfaces The purpose of the 4 per 1000 effort is to increase the size of medium and irreversible C pools in effort to expand the long-term endurance of excess C storage, i.e. how long this extra C stays in the soil. Small-scale physiological and metabolic reactions spanning within the soil and inorganic core operate in these pools drive C storage and release. Understanding these processes and interactions is critical for anticipating and controlling given an ever-changing environment, fluctuations in soil C concentration. Many research institutions are pursuing these scientific topics in the hopes of filling in the shortcomings in empirical evidence of these processes. But, correlating this data on multiple spatial and temporal scales is problematic, leading to the creation of a countrywide research institute in French (to be expanded globally) to federate our scientific establishment's capacities on this issue [8]–[12].

II. DISCUSSION

A. Current status of soil C storage methods

The current state of soil C conventional methods is as follows: Abiotic (spatial distribution and depletion patches in the soil, organo mineral contacts) and behavioral (living soil population and soil heterogeneity (plants, creatures, microorganisms)) processes influence the stability and destabilization of total organic C. Although these processes operate concurrently in soils, complementing or neutralizing their effects, they will be described sequentially in the next section for clarity.[7]

1) Living biomass' impact on organic soil C dynamics

Plants have two impacts on OM in the soil. As prokaryotes, vegetation are the principal source of soil organic C via litter production (shoots with roots), organic residues (released through direct and indirect processes), and friendship (nitrogen-fixing and mycorrhizal) linkages. Furthermore, plants contribute to the stabilization of soil OM by producing weakly posable compounds and promoting the formation of stable clusters. Plants aid in the maintenance of soil organic matter by preventing erosion. The influence of plant root systems on soil OM varies plant part and root functional properties (architecture, morphological, metabolism, composition, including symbiotic associations relationships) [13]

Fluxes of organic matter (OM) from crops to soils Waste from above and below ground (leaves, branches, stems, roots, etc.) along with rhizodeposits and chemicals directly transmitted to mycorrhizal fungus, are all sources of carbon in the soil. In grassland soils, root litter accounts for approximately a third of the global litter inputs, whereas in forest soils, it accounts for half. Rhizodeposition accounts for approximately11% of the emissions (C) absorbed into the body, or 27% of the carbon (C) provided to roots Plant phylogenetic identity, as well as environmental conditions, such as plant nutrient availability, influence the kind and intensity of mycorrhizal linkages, and therefore C translocation to mycelial hyphae. According to certain recent and controversial research, management refers to the management inputs have a substantial influence in the long-term stability of OM in soils. The distribution of root surface for diverse plant species and soil types corresponds with the determination of soil organic C, especially in deeper soil strata. Root litter decomposition is approximately 30 percentage lower than leaf decomposition. Additionally, only a portion of available soil litter is carried into growing medium (Garten 2009), where its rate of disintegration decreases with depth [14].

The effect of OM input quality on the rate of breakdown The chemical composition The concentrations of C, lignins, nitrogen (N), and iron and zinc (Mn) in subterranean and root development litter inputs, as well as endophytic fungi [e.g., C, lignins, nitrogen (N), and iron oxide (Mn)] vary dramatically across plant species and influence OM breakdown rates over time intervals ranging from per year on a year. It is well acknowledged that a significant lignin content increases the contribution of green manures to the medium OM pool by causing particulates OM to concentrate in the soil. Litter Mn promotes the formation of lignin breakdown by forming Mn peroxidases, which are engaged in phenol oxidation. High amounts of nitrogen in plant residues and residues accelerate breakdown and lead to the buildup of bacterial residues that remain in the soil. High N levels in plant residues, on the other hand, impede lignin specific breakdown, most likely owing to N recombination with partly degraded lignin molecules [15].

Effects of plant residue additions on OM decomposition in soil (priming effect) Exudates from the roots, industrial effluent, and thus the labile component of the litter which are readily used by soil microbial decomposing organic matter, may also promote native soil OM breakdown. Three possibly co-occurring processes may explain this so-called priming effect: [1] [2] enhancement of microbial communities adapted to the diminishment of less biodegradable precursors (K-strategists), which again is highly reliant on soil nutrients in soils (Fontaine); [3] excitability of microbial communities adapted to the diminishment of less biodegradable substrates (K-strategists), which again is dependent on nutrient concentration in soils (Fontaine); [4] stimulation of microorganisms adapted to the breakdown of less biodegradable substrates (Fontaine) [16]

Cohesion of soil layers and aggregate stability Through fine roots and mycorrhizal connections, plants help the development of stable aggregates OM protected against deterioration, in soil. Through a number of mechanisms, mediate root or inoculum hyphae densities improve soil structure. [1] additional supply of leguminous plants, such as glucans, where it act as a glue between clay particles, [2] improve the soil particulate trapping enabled by root and hyphae entrapment, [3] increased wetting-drying cycle repetition in soil in regards to water acquirement by heritage, and [4] input of dead plants involving specific fellow citizens Although the methods vary by plant species, they always depend on the mycorrhizal fungus to work. Hyphae with a diffuse form, which encourages soil–hyphal exchanges, may therefore have a greater impact on soil aggregate growth than rhizomorphic hyphae. Finally, polysaccharides made by N2-fixing microbes have a unique structure beneficial impact on the development of soil aggregates.[17]

2) Mechanisms for abiotic organic soil C stabilization

Soil is a diverse environment, and the dynamics of soil organic C are influenced by this. Soil heterogeneity is influenced by soil texture and minerals, as well as topography and methods of management at the level of the landscape Variations at the plot size is driven by agricultural practices and native species. The enclosed space of the soil, which is characterized by the spatial arrangement of lightweight aggregates (mineral particles, OM) the openings through whatever flows, decomposers, and accessible chemical pass, measures the extent of variety at the microscopic process scale. Recognizing how the plant's physical nature affects OM dynamics is critical for maintaining or perhaps growing soil organic C reserves. Climate change, particularly the water regime, has an impact on environmental circumstances at the micro habitat scale, whereas land uses as agricultural activities have a significant impact on soil structure. As previously stated, biotic activities such as plant roots, macrofauna digesting mineral and organic Microorganisms operating on their immediate employed in this research environment at the nanoscale, as well as soil chemicals functioning together may all have a significant impact on aggregation. As a result, biotic and abiotic C stabilization processes are inextricably connected [18]

The presence of organic C in aggregates slows down the dynamics of soil organic C. Experiments have shown that aggregation reduces the rate of soil OM mineralisation since the mid-twentieth century. Experiments were conducted to determine the amount of CO2 produced after soil aggregates were ground and compared to the amount of CO2 released by same soil with maintained aggregates. Grinding enhanced organic soil C mineralisation, with the rate increasing as the granularity of the grinding increased. Many research using physical separation methods have since helped separate various kinds of aggregate particles and understand their functions in OM protection [19]–[21].

B. Mechanisms of OM dynamics affected by agricultural practices

The amount of carbon in the soil is mostly influenced by land-use patterns. In French soils, Martin et al. discovered that such 0 to 30 cm basic layers had an average of 80 tC ha1 in forested and pastoral soils, 50 tC ha1 in soil fertility, and 35 tC ha1 in grapevine soils .As a result, every change in land use has a significant impact on the C stock. The development of forest vegetation has resulted in significant C loss, according to meta-analyses on the topic. Guo and Giffor found that when Soil C falls when agriculture replaces natural forest (42%) and pastures (59%) in a contextual predicated on 74 papers. It also revealed a 10% decline in C stocks from grassland to plantings and a 13percent annual drop in C stores between natural forests to seedlings. Decreased C contributions and faster OM densification order to satisfy the demand to more intense plowing, which mixes subsurface subsoil and partly removes grouping, might explain the rapid drop in C stores in farmed soils [22].

C. Plant species selection

The kind of plant used has an effect on the enzymatic quality of the soil OM. and changes the mechanisms controlling soil organic C dynamics. Although softwood and hardwood trees produce comparable amounts of aboveground litter in forests, the litter degradation processes vary. Litter decomposes faster and leftovers are more thoroughly incorporated in the subsoil in boreal forest owing to the pharmacological features of their compartments and their influence on soil physical and chemical properties, influencing, for example, the number and activity of grubs. As previously indicated, these bacteria have a considerable influence on soil OM oscillations. Cover crop symbiosis occurs in prairies interactions encourage the storage of carbon in the soil. To improve yields in agricultural systems, cultivars that allocate more nutrients to the harvested portion (grain) are often chosen. The biomass provided to vegetation component, such like roots, is reduced as a result of this selection to the intermediary OM pool than some other plant organs [23]

D. Practices that encourage both primary and secondary production as well as decomposition

Tillage, soil compaction following heavy machinery passes, and stump clearance after evident a forest stand are examples of activities that have an effect on Food sources and soil OM outputs have aided, as have Mb factors, and as a consequence, soil to atmosphere C fluxes. These activities have an impact on soil characteristics, including structure, decomposer activity, and, as a result, soil organic C reserves. In certain cropping zones or in urban gardens, facilities for watershed management, use of inorganic additions, or systematic fertilization have an effect on primary producers and decomposer activity. Fertilization techniques in forests and impoverished agricultural regions, on the other hand, are severely restricted for economic reasons [24],[25]

III. CONCLUSION

Soil C input flows may be increased by using management techniques that are tailored to the local environment. These activities have an impact on soil C inputs, as well as soil C stabilization and destabilization processes, and thus soil C outputs. Recent research has advanced our knowledge of the biotic or abiotic Associated Processes in Soil Structure C stabilization and destabilization. Soil C storage and destocking are heavily influenced by belowground plant contributions. In contrast to aboveground litter, which may rapidly mineralize, root inputs can help to stabilize C levels they may promote over mineralization of native OM in soils, especially when nitrogen sources are scarce. Plant residues create intermediate and weakly soil C pools, and their composition regulates their dynamics. Because roots and mutualistic interconnections stimulate aggregate formation, they too have an indirect influence upon that permanent C pool. Bacteria and soil aquatic ecosystems play an important role in biomass and carbon data transfer and 2002). For example processes because they consume and convert OM. Their metabolic activity creates CO2 and CH4 when they consume applied (exogenous) or endogenous (autocrine) OM (destocking). It is commonly thought, however, that soil organisms produce tertiary compounds that contribute significantly to soil C stability, either by chemical intolerance whether through interactions with soil mineral salts on surfaces. Nutrient recycling, natural ecosystems, and soil organisms are all dependent on soil microbes.

Biodiversity preservation. Many of these co-benefits point to greater C storage capacity in soils biological activity. Their administration, on the other hand, requires a greater understanding of the interacting processes and is more difficult to implement. In terms of balancing greater soil C stabilization with C mineralization, the 4 per 1000 effort must include these oppositional biotic processes in its suggestions.

REFERENCES

[1] A. M. Bolger et al., "Computational aspects underlying genome to phenome analysis in plants," Plant Journal. 2019.
[2] D. J. McClements and L. Grossmann, "The science of plant-based foods: Constructing next-generation meat, fish, milk, and egg analogs," Comprehensive Reviews in Food Science and Food Safety. 2021.
[3] G. F. Veen, E. L. Fry, F. C. ten Hooven, P. Kardol, E. Morriën, and J. R. De Long, "The Role of Plant Litter in Driving Plant-Soil Feedbacks," Front. Environ. Sci., 2019.
[4] J. Kattge et al., "TRY plant trait database – enhanced coverage and open access," Glob. Chang. Biol., 2020.
[5] B. Salehi et al., "Antidiabetic potential of medicinal plants and their active components," Biomolecules. 2019.
[6] Z. Pang et al., "Linking Plant Secondary Metabolites and Plant Microbiomes: A Review," Frontiers in Plant Science. 2021.
[7] M. F. Dignac et al., "Increasing soil carbon storage: mechanisms, effects of agricultural practices and proxies. A review," Agronomy for Sustainable Development. 2017.
[8] G. Berg, M. Köberl, D. Rybakova, H. Müller, R. Grosch, and K. Smalla, "Plant microbial diversity is suggested as the key to future biocontrol and health trends," FEMS Microbiology Ecology. 2017.
[9] T. T. S. Lew, V. B. Koman, P. Gordiichuk, M. Park, and M. S. Strano, "The Emergence of Plant Nanobionics and Living Plants as Technology," Adv. Mater. Technol., 2020.
[10] M. A. Bhat et al., "Mechanistic Insights of the Interaction of Plant Growth-Promoting Rhizobacteria (PGPR) With Plant Roots Toward Enhancing Plant Productivity by Alleviating Salinity Stress," Frontiers in Microbiology. 2020.
[11] N. Brummitt, A. C. Araújo, and T. Harris, "Areas of plant diversity—What do we know?," Plants People Planet. 2021.
[12] C. Song, F. Zhu, V. J. Carrión, and V. Cordovez, "Beyond Plant Microbiome Composition: Exploiting Microbial Functions and Plant Traits via Integrated Approaches," Frontiers in Bioengineering and Biotechnology. 2020.
[13] A. P. Whitmore, G. J. D. Kirk, and B. G. Rawlins, "Technologies for increasing carbon storage in soil to mitigate climate change," Soil Use Manag., 2015.
[14] G. Xu, Y. Lv, J. Sun, H. Shao, and L. Wei, "Recent Advances in Biochar Applications in Agricultural Soils: Benefits and Environmental Implications," Clean - Soil, Air, Water. 2012.
[15] G. Settineri, C. Mallamaci, M. Mitrović, M. Sidari, and A. Muscolo, "Effects of different thinning intensities on soil carbon storage in Pinus laricio forest of Apennine South Italy," Eur. J. For. Res., 2018.
[16] W.-K. Park et al., "Effect of Carbonized Rice Hull Application on Increasing Soil Carbon Storage and Mitigating Greenhouse Gas Emissions during Chinese Cabbage Cultivation," Korean J. Soil Sci. Fertil., 2016.
[17] W. T. Tinkham, A. M. S. Smith, P. E. Higuera, J. A. Hatten, N. W. Brewer, and S. H. Doerr, "Replacing time with space: Using laboratory fires to explore the effects of repeated burning on black carbon degradation," Int. J. Wildl. Fire, 2016.
[18] K. Minamikawa and N. Sakai, "Soil carbon budget in a single-cropping paddy field with rice straw application and water management based on soil redox potential," Soil Sci. Plant Nutr., 2007.
[19] A. K. Saxena, M. Kumar, H. Chakdar, N. Anuroopa, and D. J. Bagyaraj, "Bacillus species in soil as a natural resource for plant health and nutrition," Journal of Applied Microbiology. 2020.
[20] R. M. Shelake, D. Pramanik, and J. Y. Kim, "Exploration of plant-microbe interactions for sustainable agriculture in CRISPR era," Microorganisms. 2019.
[21] P. Vejan, R. Abdullah, T. Khadiran, S. Ismail, and A. Nasrulhaq Boyce, "Role of plant growth promoting rhizobacteria in agricultural sustainability-A review," Molecules, 2016.
[22] B. A. Hungate et al., "The economic value of grassland species for carbon storage," Sci. Adv., 2017.
[23] B. Minasny and A. B. McBratney, "Limited effect of organic matter on soil available water capacity," Eur. J. Soil Sci., 2018.
[24] C. B. Gottshall, M. Cooper, and S. M. Emery, "Activity, diversity and function of arbuscular mycorrhizae vary with changes in agricultural management intensity," Agric. Ecosyst. Environ., 2017.
[25] D. A. T. Boncan et al., "Terpenes and terpenoids in plants: Interactions with environment and insects," International Journal of Molecular Sciences. 2020.