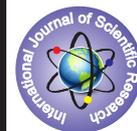


## Overviews on Carbon turn over in soil plant system and in rhizosphere



### Chemistry

**KEYWORDS:** organic carbon, soil, plant, rhizosphere

**MESFIN BIBISO**

College of Natural and Computational Sciences, Department of Chemistry, Wolaita Sodo University, Ethiopia,

### ABSTRACT

Soils play significant roles in global carbon cycle. The soil organic carbon (SOC) pool, an important component of terrestrial ecosystems, is a crucial regulator of carbon fluxes between the biosphere and the atmosphere. Much attention should be given to the study of carbon turnover, especially to the emission of carbon dioxide from the soil. This is related to the fact that CO<sub>2</sub> significantly contributes to the greenhouse effect, and an increase in its concentration in the atmosphere can result in global climatic changes. Plants can dramatically modify their soil environment through rhizosphere effect.

### Introduction

Rhizospheric microorganisms enhance the decomposition of humus when they need additional mobilization of nutrients (particularly, of nitrogen) from soil organic matter, or hamper it upon competition with plants for the limited amount of nutrients. These short term changes in the turnover rate of soil organic matter are related to priming effects (Kuziyakob, 2000). Similar interactions between plants and microorganisms in the rhizosphere are still poorly understood; they are reliably established only in a few works (Kuziyakob, 2001). Results on the contribution of cereals (wheat, barley) to C accumulation and turnover of soil organic matter have shown that agricultural plants seldom transfer more than 33% of assimilated C into the soil (Zagal et al., 1993).

Past studies have indicated that some cultivation practices such as tillage and its intensity, and crop rotations can affect SOC by changing the soil physical and biological conditions and by changing the amounts and types of organic inputs to the soil (Marland, et al., 2004). The sequestration of carbon in soils used for agriculture, forestry, and land reclamation has been recognized as a potential option to mitigate global change (Lal, R. 2003). Recent research suggests that mycorrhizal fungi might be an important component of the SOC pool, in addition to facilitating carbon sequestration by stabilizing soil aggregates.

Increased primary production would result in an increased C storage, whereas increased decomposition (i.e., reduced C turnover time) would have an opposite effect. Other Factors such as erosion, leaching, and fire also affect soil C dynamics, generally in lesser and variable degrees (Wang and Hsieh, 2002). SOC is an essential element of soil quality and it is generally associated with improved soil tilth, improved water-holding capacity, improved storage and availability of plant nutrients, and reduced soil erosion (Marland, et al., 2004). Therefore, this review aims to critically assess current understanding of carbon turn over in soil plant system and in rhizosphere.

### Carbon flow in the rhizosphere

For over a century it has been established that plants can dramatically modify their soil environment giving rise to the rhizosphere effect (Whipps, 2001). Although the initial trigger of this rhizosphere effect was not identified, subsequent research has shown that is largely induced by the release of carbon (C) from roots into the surrounding soil. Although roots can release large amounts of inorganic C which may directly affect the biogeochemistry of the soil (Cheng et al., 1993; Hinsinger, 2001; Hinsinger et al., 2009), it is the release of organic carbon that produces the most dramatic changes in the physical, biological and chemical nature of the soil. In its broadest sense, this release of organic C is often termed rhizo deposition (Jones et al., 2004).

### Carbon flow to mycorrhizas and bacterial symbiont

Most plants in natural and semi-natural vegetation systems form symbiotic associations with mycorrhizal fungi and there is increasing evidence to suggest that the flow of C to and through this symbiotic interface may be of significance in many plant soil

interactions, playing an important role in different biogeochemical processes (Finlay and Rosling, 2006; Finlay, 2008).

### Turnover of carbon pools and its contribution to soil CO<sub>2</sub>

Current increases in atmospheric CO<sub>2</sub> have the potential to lead to imbalances between C uptake and C loss by terrestrial ecosystems, with consequent feedbacks to atmospheric CO<sub>2</sub> accumulation and global climate change. The amount of carbon in soils represents about two-thirds of total ecosystem carbon (Schlesinger, 1997) and soil organic matter (SOM) includes C pools with the slowest turnover rates in the terrestrial biosphere (Trumbore, 1997). The conceptual C pools described in models, however, cannot always be directly compared with measurable soil C compartments, making it difficult to validate experimentally how C transfer between pools affects SOM cycling (Six et al., 2002). Various chemical and physical soil fractionation techniques have been applied to isolating SOM pools according to their stability and turnover rates (Lichter et al., 2005).

### Potential responses of soil organic carbon

Soil carbon inventories and turnover rates are influenced by climate, vegetation, parent material, topography, and time, the fundamental state factors outlined by Jenny (Trumbore, et al., 1996). A soil source results when net decomposition exceeds C inputs to the soil, either as a result of human activities such as clearing forests for agriculture or because of increased decomposition rates due to global warming. Net sinks of C in soils are postulated from the difference between net ecosystem C uptake and tree growth rates or from presumed increases in net C inputs from CO<sub>2</sub> or N-fertilization of plants. In both cases, the magnitude and timing of the response depends on the amount of carbon in pools that respond quickly to changes in climate and vegetation, and to the time lag between fixation of C by plants and its subsequent release to the atmosphere during decomposition (Thompson, et al., 1996).

### Soil carbon turnover in a recovering temperate forest

Converting native forests and grasslands to farms has released about a lot of C to the atmosphere over the past 150 years. (Houghton and Skole, 1990). Soils that are disturbed or undergoing a transition because of vegetation manipulation have different organic matter dynamics than soils that are in equilibrium with biological and environmental conditions. It is well-documented that soils that are intensively cultivated lose a substantial fraction of their organic matter, typically as much as 50% in the surface layer (Davidson and Ackerman, 1993).

### Soil carbon sequestration

Regrowth of temperate forests constitutes a large C sink that may be supplemented by enhanced tree growth and increased production of refractory soil organic matter associated with rising atmospheric CO<sub>2</sub> concentration (Houghton, 2003). To date, atmospheric CO<sub>2</sub> enrichment experiments have demonstrated significant increases in net primary productivity (NPP) and C storage in forest vegetation (Norby et al., 2002).

### Implications for Agricultural Practices

The amount of carbon being stored in abandoned agricultural land can be estimated using the recovering soil carbon turnover time, the rate of a forestation, and estimates of initial and final carbon concentrations. The rate of recovery diminishes as steady state is approached, so land that is recently abandoned recovers soil carbon faster than land that has been abandoned for several decade (Post and Mann, 1990). Various scientists have suggested that agricultural practices could sequester carbon in soil to mitigate the rise in atmospheric CO<sub>2</sub> from fossil fuel burning (Gebhart et al., 1994).

#### Effects of afforestation in soil carbon turn over

Soils play an important role in the carbon (C) cycle and afforestation has been proposed as an effective approach to sequestering more CO<sub>2</sub> in the short term and mitigating rising atmospheric CO<sub>2</sub> concentration over longer periods (Richards et al., 2007). Tropical and subtropical forest soils contain about 30% of the global soil organic matter. Recently, forests have been studied for their potential for C sequestration (Canadell et al., 2008). However, little is known about rates of soil C turnover and sequestration into SOM in subtropical and tropical plantations (Richards et al., 2007). Therefore, more knowledge of C stocks and SOM fractions is necessary to elucidate C storage in subtropical and tropical ecosystems (Paul et al., 2002).

#### Conclusion

Agricultural soil is one of the most effective places for accumulating carbon in terrestrial ecosystems. Most of carbon in the soil is preserved in the form of soil organic carbon (SOC). Plants can dramatically modify their soil environment giving rise to the rhizosphere effect. Soil organic carbon dynamics are fundamental soil biological processes, which govern soil nutrient cycling. Agricultural practices could sequester carbon in soil to mitigate the rise in atmospheric CO<sub>2</sub> from fossil fuel burning. Therefore, researchers, scientists, professionals and government should work together for carbon sequestration by the community.

#### REFERENCES

1. Canadell, J.G., Raupach, M.R. (2008). Managing forests for climate change mitigation. *Science*: 320: 1456–1457.
2. Cheng, W.X., Coleman, D.C., Carroll, C.R., Hoffman, C. (1993). In-situ measurement of root respiration and soluble C-concentrations in the rhizosphere. *Soil Biol Biochem* 25:1189–1196.
3. Davidson, B.A., Ackerman, I.L. (1993). Changes in soil carbon inventories following cultivation of previously untilled soils. *Bio geochemistry*, 20.
4. Finlay, R.D., Rosling, A. (2006). Integrated nutrient cycles in forest ecosystems, the role of ectomycorrhizal fungi. In: Gadd GM (ed) *Fungi in biogeochemical cycles*. Cambridge University Press, Cambridge.
5. Finlay, R.D. (2008). Ecological aspects of mycorrhizal symbiosis with special emphasis on the functional diversity of interactions involving the extraradical mycelium. *J Exp Bot*. 59:1115–1126.
6. Gebhart, G.L., Johnson, H.B., H. W. Polley, H.W. (1994). CRP increases soil organic carbon. *J. Soil Water Conserv.* 49(5):488–492
7. Hinsinger, P. (2001). Bioavailability of soil inorganic P in the rhizosphere as affected by root-induced chemical changes: a review. *Plant Soil* 237:173–195.
8. Hinsinger, P., Bengough, A.G., Vetterlein, D., Young, I.M. (2009). Rhizosphere: biophysics, biogeochemistry and ecological relevance.
9. Houghton, R. A., and D. L. Skole. (1990). Long-term flux of carbon between terrestrial ecosystems and the atmosphere as a result of changes in land use. *Carbon Dioxide Info. Anal. Cent.*, Oak Ridge.
10. Houghton, R.A. (2003). Why are estimates of the terrestrial carbon balance so different? *Global Change Biology* 9:500–509.
11. Jones, D.L., Hodge, A., Kuzyakov, Y. (2004). Plant and mycorrhizal regulation of rhizodeposition. *New Phytol* 163:459–480.
12. Kuzyakov, Y., Friedel, J.K., and Stahr, K. (2000). Mechanisms and Quantification of Priming-Effects: Review. *Soil Biol. Biochem.*
13. Kuzyakov, Y., Ehrensberger, H., and Stahr, K. (2001) Carbon Partitioning and Below-Ground Translocation by *Lolium perenne*. *Soil Biol. Biochem.* 33 (1): 61–74.
14. Lal, R. (2003). Global potential of soil carbon sequestration to mitigate the greenhouse effect. *Crit. Rev. Plant Sci.* 22: 151–184.
15. Lichter, J., Barron, S.H., Finzi, A.C. (2005). Soil carbon sequestration and turnover in a pine forest after six years of atmospheric CO<sub>2</sub> enrichment. *Ecology*. 86:1835–1847.
16. Marland, G., Garten, J.R., Post, C.T., and West, T.O. (2004). Studies on enhancing carbon sequestration in soils. *Energy*, 29: 1643–1650.
17. Norby, R.J., Cotrufo, M.F., Ineson, P., O'Neill, E.G., Canadell, J.G. (2002). Elevated CO<sub>2</sub>, litter chemistry, and decomposition: a synthesis. *Oecologia*. 127:153–165.
18. Paul, K. I., Polglase, P. J., Nyakuengama, J. G. (2002). Change in soil carbon following afforestation. *For. Ecol. Manage.*, 168:241–257.
19. Post, W.M., Mann, L.K. (1990). Changes in soil organic carbon and nitrogen as a result of cultivation, in *Soils and the Greenhouse Effect*. John Wiley and Sons, New York.
20. Richards, A.E., Dalal, R.C., Schmidt, S. (2007). Soil carbon turnover and sequestration in native subtropical tree plantations. *Soil Biol. Biochem.* 39:2078–2090.
21. Schlesinger, W.H. (1997). Carbon balance in terrestrial detritus. *Annual Review of Ecology and Systematics*. 8:51–81.
22. Six, J., Conant, R.T., Paul, E.A. (2002). Stabilization mechanisms of soil organic matter:

- implications for C-saturation of soils. *Plant and Soil*:241,155–176.
23. Thompson, M.V., Randerson, J.T., Malmstrom, C.M. and Field, C.B. (1996). *Global Biogeochem. Cycles*. 10: 711–726.
  24. Trumbore, S. E., Chadwick, O. A., Amundson, R. (1996). *Science*. 272:393–396.
  25. Trumbore, S.E., Harden, J.W. (1997). Accumulation and turnover of carbon in organic and mineral soils of the BOREAS northern study area. *Journal of Geophysical Research*. 102:28817–28830.
  26. Wang, Y. and Hsieh, Y. P. (2002). Uncertainties and novel prospects in the study of the soil carbon dynamics. *Chemosphere*. 49:791–804.
  27. Whipps, J.M. (2001). Microbial interactions and biocontrol in the rhizosphere. *J Exp Bot*. 52:487–511.
  28. Zagal, E., Bjarnason, S., Olsson, U. (1993). Carbon and nitrogen in the root zone of barley. *Plant and Soil*. 157:51.