Chapter 10

Litter Production and Decomposition in Tropical Forest

Sumit Chakravarty
Uttar Banga Krishi Viswavidyalaya, India

Prakash Rai
Uttar Banga Krishi Viswavidyalaya, India

Vineeta
Uttar Banga Krishi Viswavidyalaya, India

Nazir A. Pala
Uttar Banga Krishi Viswavidyalaya, India

Gopal Shukla
Uttar Banga Krishi Viswavidyalaya, India

ABSTRACT

Plant litter production and decomposition is a crucial ecosystem process that defines and governs the plant-soil relationships by regulating the nutrient turnover and the build-up of soil organic matter. Litter is the principal source of organic matter for soils in the forest ecosystem. The litter, upon decomposition, makes available essential nutrients for the growth and development of a forest stand. Different tree components contain different amounts of nutrients; and build up of soil organic matter. The amount of nutrients added through litter decomposition varies with forest types, species, stand attributes, and variation in seasonal environmental conditions. Nutrient return from organic matter is estimated by the physico-chemical properties of the litter. Moreover, the rate of decomposition and the nutrient releases are highly influenced by magnitude of litter produced, litter quality and nutrients release, as well as, by climatic conditions and existing microbial communities in the soil system. Ecological impact of carbon and nutrient dynamics in the litter layer is considerable in a forest ecosystem.

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INTRODUCTION

Tropical forests occupy about 13% of the land surface and their total world biomass is around $90 \times 10^{10}$ tonnes (on a dry weight basis) with an annual average production of $4 \times 10^{10}$ t/yr. The primary production of tropical rain forest is 2,000 gm$^{-2}$ yr$^{-1}$ (Lieth, 1975). The net primary production of tropical rain forest, rain green forest, summer green forest, warm temperate mixed forest, boreal forest, tundra scrub, desert scrub, tropical grassland, temperate grassland, agricultural fields, lake & streams, coral reefs and open oceans are 2000, 1500, 1000, 500, 140, 70, 700, 500, 650, 500, 2000 and 125g/m$^2$/yr, respectively. The global soil organic carbon stock in the top one meter depth amounts to 30 tons ha$^{-1}$ in arid climate, which is the least, and 800 tons ha$^{-1}$ in organic soils of cold regions, the highest, but generally ranges from 50 to 150 tons ha$^{-1}$ (Lal, 2004). More than half of the net primary production is returned to the soil and 60 Pg C year$^{-1}$ goes to the atmosphere through litter decomposition (Wardle et al., 2004; Houghton, 2007). Soil respiration (Rsoil) releases annually 98 PgC to the atmosphere (Bond-Lamberty and Thomson, 2010) which is more than seven times the C-equivalent of fossil fuel emissions (Sotta et al., 2004). It is reported that global soil respiration (Rsoil) is annually increasing by 0.1 PgC in the atmosphere due to rise in air temperature (Bond-Lamberty and Thomson, 2010), changing soil CO$_2$ flux dynamics and litter decomposition (IPCC, 2014). Plant litter contributes 18-48% to the total global forests Rsoil (Han et al., 2015; Zhao et al., 2016).

The potential of trees to sequester carbon in forests are recognized through the quantity and quality of produced litter and its subsequent decomposition and release of nutrients (Rai et al., 2016). Litter production is defined as the shedding of vegetative and reproductive plant parts caused by senescence, stress, mechanical factors (e.g. wind), a combination of these factors, or by death and weathering of the whole plant in a given time period (Krishna and Mohan, 2017). Litter fall which phenologically indicates the effect of climate change on the forest (Hansen et al., 2009) and also sustains nutrient cycling is a vital source of nutrients and organic matter for regulating forest productivity and energy flow (Li, 2014). The proportion of leaves in the litter is always higher than the other form of litters like twig, roots or others and in tropical may totally decompose within a year (Meentemeyer, 1984). Litter decomposes gradually after they drop. Sustained nutrient cycling with faster turnover of litter through its decomposition regulates forest productivity (Vendrami et al., 2012). Decomposition of litter regulates soil fertility through soil organic matter production and nutrient cycling (Guendehou et al., 2014). Decomposition of litter is influenced by soil organisms, soil and climatic conditions and the nature and composition of litter (Bargali et al., 2015).

LITTER AND CLIMATE CHANGE

Litter decomposition and Rsoil has global potential in terms of climate change mediated shifts in relative abundance of vegetation and change in water availability and soil temperature which will have significant influence on global carbon budget due to litter quality and its decompositions (Pinto Jr. et al., 2018). The influence of climate change on litter decomposition and Rsoil spatially and temporally is still uncertain (Rohr et al., 2013).

Climate change mediated temperature, precipitation and soil moisture is expected to change forest productivity, phenology, mortality and species composition (Dalmolin et al., 2015). These changes in forest also change litter decomposition and Rsoil through alteration of soil and forest floor C quantity