LIST OF PUBLICATIONS

Research papers published

1. J. Dinakaran and N.S.R.Krishnayya. (2010). Variations in Soil Organic Carbon and Litter Decomposition across Different Tropical Vegetal Covers. Current Science, 99 (8), 1051-1060.
2. Dhaval Vyas, Nirav Mehta, **J.Dinakaran**, N.S.R.Krishnayya. (2010). Allometric equations for estimating leaf area index (LAI) of two important tropical species (*Tectona grandis* and *Dendrocalamus strictus*). Journal of Forestry Research, 21(2), 197-200.
3. J. Dinakaran and N.S.R.Krishnayya. (2008). Variations in type of vegetal cover and heterogeneity of soil organic carbon in affecting sink capacity of tropical soils. Current Science, 94 (9), 1144-1150.

Variations in soil organic carbon and litter decomposition across different tropical vegetal covers

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The present study shows variations in soil organic carbon (SOC) and litter decomposition across different vegetal covers. Tropical vegetal covers occupied by teak, bamboo and mixed species were used for the study. SOC was analysed in the soils up to a depth of 1.25 m at different intervals. Physical fractionation was done in the collected soil samples. Respiration was measured in the soils of the three types in summer, monsoon and winter. Litter-bag experiment was carried out to understand the process of decomposition in the three types of litter at three different depths, viz. top, 25 cm and 50 cm. SOC values from the three different types of vegetal cover showed significant differences. The annual fall of leaf-litter was maximum in mixed vegetal cover followed by teak and bamboo. Litter-bag experiment showed that the litter got decomposed within a year on storage. Higher soil respiration in all the three vegetal covers supports faster rates of decomposition. The decomposition was faster in bags kept at the top layers of the soil compared to the ones in the deeper layers. There was an increase in SOC of samples from the litter-bag study, indicating that tropical soils can absorb additional carbon. Physical fractionation of SOC showed uniformity in the proportions of mobile and recalcitrant pools across soil profiles of the three vegetal covers. A proton NMR study carried out to understand the chemical nature of SOC revealed complete absence of carboxyl group, whose presence is generally reported in the SOC of temperate soils. The groups observed were alkyl, *O*-alkyl and aromatic. Fluctuations were seen in the proportion of alkyl groups. Uniformity seen in the chemical composition of SOC from the proton NMR study revealed that barring initial steps, decomposition of organic matter would follow more or less the same path in tropical soils, irrespective of differences in plant litter.

Keywords: Litter decomposition, physical fractionation, soil organic carbon, soil respiration, tropical vegetal cover.

FOREST soils are regarded as one of the major sinks of carbon. Different explanations are offered for the movement of carbon in these soils. Decomposition and movement of soil organic carbon (SOC) is explained as a mechanistic process[1–3], negative exponential model and first-order kinetics[4–6] with global constants for rates of decomposition[7]. Influences of variation in the proportion, composition and type of vegetal cover on carbon sink potential of soils have been looked into. An earlier study[8] mentioned that under the 'business as usual' scenario, the terrestrial biosphere acts as an overall carbon sink until about 2050, but turns into a source thereafter. Variations in the accumulation of carbon by young and old-growth forests have been reported[9–11]. Influences of land-use change on the dynamics of soil organic matter were reported[12–14]. Most of these changes are because of variation in plant cover. In spite of all these studies, conceptual clarity is still elusive for the role of vegetal cover and litter decomposition on the sink potential of soils. A better understanding of the tropical forest carbon dynamics is clearly needed to predict the future trajectory of carbon stocks under global change[15–18]. Improved monitoring and modelling of the tropical environment is required to better understand this trajectory[19]. Physical and chemical fractionation studies categorized SOC into a mobile and a recalcitrant pool[1,13,20]. The mobile pool is a dynamic one, whereas the recalcitrant pool is said to be stable for longer periods of time. Evaluation of the chemical nature of recalcitrant pools is gaining prominence[2,21,22]. Quantity and chemical quality of these pools is largely influenced by the type of plant litter and its pattern of decomposition. Currently little information is available for *in situ* litter decomposition in tropical soils. The stability and residence times of SOC present in the deeper layers when fresh organic matter (litter) is added is unclear. Chemical break-up of SOC present in the deeper layers of tropical soils is not available.

The probability of the soil turning into a source from a sink increases once its vegetal cover is altered. We presume that (i) as long as the land-use pattern remains unaltered, the soil remains a sink rather than a source to whatever small extent it may be and (ii) the potential of addition of soil carbon in the tropics is much higher than what it is understood to be. Another aspect that is said to be altering the sink status of soils is the stimulation of microbial mineralization by the supply of carbon derived

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RESEARCH PAPER

Allometric equations for estimating leaf area index (LAI) of two important tropical species (*Tectona grandis* and *Dendrocalamus strictus*)

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Abstract: Leaf area index (LAI) of Teak (*Tectona grandis*) and Bamboo (*Dendrocalamus strictus*) grown in Shoolpaneshwar Wildlife Sanctuary of Narmada District, Gujarat, India was obtained by destructive sampling, photo-grid method and by litter trap method. An allometric equation (between leaf area by litter trap method and canopy spread area) was developed for the determination of LAI. Results show that LAI value calculated by the developed allometric equation was similar to that estimated by destructive sampling and photo-grid method, with Root Mean Square Error (RMSE) of 0.90 and 1.15 for Teak, and 0.38 and 0.46 for Bamboo, respectively. There was a perfect match in both the LAI values (estimated and calculated), indicating the accuracy of the developed equations for both the species. In conclusion, canopy spread is a better and sensitive parameter to estimate leaf area of trees. The developed equations can be used for estimating LAI of Teak and Bamboo in tropics.

Keywords: bamboo; canopy spread area; leaf area index; specific leaf area; teak; tropical forest

Introduction

Leaf area index (LAI) is an important parameter in the functioning of forests controlling plant productivity and exchange of energy between vegetation and atmosphere (Moser et al. 2007). It provides apt information for the evaluation of primary production of forest ecosystem. LAI is defined as the cumulative one sided surface area of the leaves in the canopy per unit ground area. Finding out a suitable allometric relationship between leaf area and other biophysical parameters of trees (diameter at breast height (DBH), tree height, and litter mass) is also an important aspect of tree research. However, LAI is one of the most difficult parameters to quantify properly, owing to large spatial and temporal variability (Breda 2003). Many studies were carried out for LAI of temperate forests (Sellin 2000; Temesgen and Weiskittel 2006; Weiskittel and Maguire 2006; Urban et al. 2008). A few studies on the LAI have also been conducted for tropical ecosystems (Maass et al. 1995; Nascimento et al. 2007). LAI can be determined by harvesting, litter trap or by optical methods. The common indirect optical methods are radiation measurement based on Beer-Lambert law, using canopy analysers (Li-Cor, Delta T devices), hemispherical photography, and remote sensing (Blackburn and Steele 1999; Dovey and Toit 2006; Nascimento et al. 2007; Urban et al. 2008). However, all the indirect methods have their own limitations. For instance, optical sensors fail to function perfectly in dense, multi-layered canopy system commonly in tropics (Moser et al. 2007).

Direct methods for leaf area (LA) estimation are expensive and time consuming, and easily lead to the destruction of the sample. It is equally impossible to execute for large tracts of vegetal cover. Therefore, indirect methods have been used to determine LAI with low accuracy for some important tropical forest trees (Maass et al. 1995; Dovey and Toit 2006). The cross-validations between direct and indirect methods have pointed to a significant underestimation of LAI with indirect methods (Breda 2003). Mass-based (direct) approaches are comparatively more accurate than optical (indirect) approaches for LAI measurements across environmental gradients (Khan et al. 2005). Plant ecologists are interested to determine LAI preferably by indirect method (even with lesser accuracy) in order to prevent destruction of the sample. An easy and accurate method is needed to estimate the LAI of vegetation, especially tropical forests. Tropical deciduous trees are unique in having complete leaf shedding in short span of time. In deciduous stands, a non-destructive method consists of collecting leaves in traps distributed below the canopy during leaf fall (Breda 2003). Khan et al. (2005) found a relationship between leaf area, above ground biomass and DBH of mangrove trees. Allometric equations relating to litter mass and DBH can be used to estimate LAI by having specific leaf area (SLA) (Gower et al. 1999). Many studies have shown a relationship between foliage mass and other biophysical parameters such as litter dry matter content, tree diameter and crown surface

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Variations in type of vegetal cover and heterogeneity of soil organic carbon in affecting sink capacity of tropical soils

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Understanding the role of the soil–vegetation system in the carbon cycle is important. Movement of carbon inside the soil across different physical and chemical pools is crucial to maintain the soil as a sink or turn it into a source. Understanding these processes at the tropics becomes more imperative because of the heterogeneity of the carbon pool, and also of the diverse vegetal cover. The present study aims at assessing the influence of different vegetal covers, changes in land-use pattern and heterogeneity of physical fractions of the soil organic carbon (SOC) pool on soil carbon. A tropical sanctuary area with some anthropogenic activities was taken as the study area. A total of 306 soil samples were collected for analysis. SOC was measured at different depths for soils with different vegetal covers. Physical fractionation (soil aggregate separation) was done to measure carbon in four different pools. ANOVA was performed to test the levels of significance across different vegetal covers, different depths of soil, and different physically protected carbon pools. All the differences were found to be significant (at 0.05 level). SOC was much higher in soils with natural tree cover. Difference in vegetal cover not only influenced SOC content of the top layer, but also of the deeper layers. Changes in land-use pattern severely reduced sink capacity of soils. Physical SOC fractionation gave a better understanding of SOC movement in the soil. We conclude that the type of vegetal cover has a significant impact on SOC up to a depth of 1.5 m. SOC content in soils with natural vegetal cover (trees) is sufficiently large, indicating their sink capacity. From physical fractionation of the carbon pool we hypothesize that the SOC gets decomposed from one fraction to another in an unidirectional manner towards the recalcitrant (<53 μm) pool. Seasonal herbaceous cover in tropical systems can be taken as a potential sink as more proportion of carbon moves downwards compared to the inputs.

Keywords: Physical fractionation, recalcitrant pool, sink capacity, soil organic carbon, tropical soils.

SOIL–VEGETATION systems play an important role in the global carbon cycle. Soil is the largest pool of terrestrial organic carbon[1–6]. Soil organic carbon (SOC) is dynamic on decadal timescales and is sensitive to climate and human disturbance[7]. Soil contains about 1.5–3 times more organic carbon than vegetation[8] and about twice as much carbon than is present in the atmosphere[8]. About half of the 6.5 billion tonnes of carbon emitted globally by burning of fossil fuels is taken up by vegetation[9] and stored as organic matter (OM). Soil OM is a heterogeneous mixture consisting of plants, animals and microbial materials in all stages of decay, combined with a variety of decomposition products of different ages and levels of complexity[10–12]. Depending on the changes happening to soil OM, soils can act as a sink or a source for carbon in the atmosphere. Equilibrium between the rate of decomposition and rate of supply of OM is disturbed when forests are cleared and the land use is changed[5,10]. Soil OM can also increase or decrease depending on numerous factors, including climate, vegetation type, nutrient availability, disturbance, land use and management practices[11,13,14]. A recent report[14] mentions that less CO_2 may be taken up by the Southern Ocean, and more by the tropical land areas than previously thought. This re-emphasizes the importance of terrestrial systems in carbon cycle processes.

Temporal dynamics following stand-replacing disturbances in forests does indeed account for a large fraction of the overall variability in carbon sequestration[15]. Land-use alteration can convert a soil system from a sink to a source of carbon (C). Such changes are more prevalent in tropical systems of fast-growing countries like India, thereby modifying the sink capacity of the soils. Globally, agriculture activity[7] reduces the original soil C content by ~30%. Deforestation is one of the single biggest threats to the terrestrial carbon sink and climate change along with soil management practices influences sink capacity of the soils[16]. Many uncertainties persist in the estimation of net flux of CO_2 from the soils of tropical forests largely due to inconsistency in land-use and land-cover pattern[17–19]. The rate of cycling of C at different depths and in different pools across different vegetal covers is still not clear for the fast-growing tropical systems. In the tropical systems, the dynamic nature of deep soil C is important in the decadal-scale soil C process[20]. There is not, as yet, enough information to predict how the size and residence time of different fractions of SOC vary

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