Forest Ecology and Management 326 (2014) 109–116

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Litterfall and leaf litter decomposition in a central African tropical mountain forest and *Eucalyptus* plantation

Landry Cizungu [a,b,*], Jeroen Staelens [a], Dries Huygens [a,c,d], Jean Walangululu [b], Daniel Muhindo [a,e], Oswald Van Cleemput [a], Pascal Boeckx [a]

[a] *Isotope Bioscience Laboratory – ISOFYS, Ghent University, Coupure Links 653, 9000 Gent, Belgium*
[b] *Faculty of Agronomy, Université Catholique de Bukavu, Avenue de la mission, BP 285, Bukavu, The Democratic Republic of Congo*
[c] *Instituto Multidisciplinario de Biología Vegetal - IMBIV, Consejo Nacional de Investigaciones Científicas y Técnicas de Argentina, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, 5000 Córdoba, Argentina*
[d] *Institute of Agricultural Engineering and Soil Science, Faculty of Agricultural Sciences, Universidad Austral de Chile, Valdivia, Chile*
[e] *Faculty of Agriculture, Makerere University, PB7062 Kampala, Uganda*

ARTICLE INFO

Article history:
Received 15 December 2013
Received in revised form 11 April 2014
Accepted 14 April 2014

Keywords:
Litterfall
Litter decomposition
Eucalyptus
Tropical mountain rainforest

ABSTRACT

Litterfall and leaf litter decomposition are important ecosystem processes that rarely have been quantified for African tropical forests. Litterfall was measured in the Nyungwe pristine forest (two years) (2°28′ S, 29°06′ E, 1915 m a.s.l.) and a nearby *Eucalyptus* plantation (one year) (2°26′ S, 29°05 E, 1889 m a.s.l.) in southwest Rwanda. To test the species effect and home field advantage on litter decomposition a 361-days experiment with single- and mixed-species leaf litter was carried out. The single-species litterbags were only installed in the pristine forest while the mixed-species litterbags were installed in both forest stands.

Total litterfall amounted to 4.1 ± 0.9 and 2.2 ± 0.5 ton ha^{-1} $year^{-1}$ during the first year in the pristine forest and the *Eucalyptus* plantation, respectively; and 4.0 ± 0.7 ton ha^{-1} $year^{-1}$ during the second year in the pristine forest. The contribution of leaf litter in the pristine forest was 69% in the first year and 75% in the second year. In the *Eucalyptus* plantation leaves contributed 79%. Litterfall peaked in the major (July–August) and minor (December–January) dry seasons and at the onset of the rainy season (September–October).

In the pristine forest, the initial decay rate was highest for *Cleistanthus polystachyus* (CP) leaf litter (0.0330 day^{-1}), followed by the forest litter mixture (PE + CP + CG) (0.016 day^{-1}), and was lowest for *Parinari excelsa* (PE) (0.0094 day^{-1}). The final decay rate of CP, *Carapa grandiflora* (CG) and *Eucalyptus* litter mixture were similar (0.0014, 0.0013 and 0.0017 day^{-1}) and lower than the final decay rate of forest litter mixture (PE + CP + CG) (0.0021 day^{-1}). Decay rates could be related to litter properties such as nitrogen, lignin, Ca and polyphenol content. Mixing litter species caused a negative additive effect on the initial, while a positive additive effect was observed on the final decay rate in the pristine forest stand. Taken together, mixed-species litter showed increased mass loss compared to the expected weighed-based mass loss from the individual litter types in the mixture. Finally, stand type only affected the final decay rate of forest litter mixture (PE + CP + CG) that was lower in *Eucalyptus* than in pristine forest and is suggested to be caused by reduced forest floor humidity.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Forest litterfall and organic matter decomposition stand out as a central component of ecosystem functioning in terms of carbon (C) and nutrient dynamics (Swift et al., 1979; Chapin et al., 2002). At the stand level, plant diversity and density, successional stage and canopy cover control litterfall quality and quantity (Deng and Janssens, 2006; Berg and Laskowski, 2006). Therefore, turnover of forest litter is affected to forest type and associated changes in plant community composition. The underlying mechanisms relate to plant specific variations in litter quality and quantity, timing of litter input, and changing microclimatic conditions (Prescott, 2002; Hättenschwiler, 2005; Hättenschwiler et al., 2005; Aponte et al.,

* Corresponding author at: Department of Applied Analytical and Physical Chemistry, Isotope Bioscience Laboratory, Coupure Links 653, 9000 Gent, Belgium. Tel.: +243 998665810, +32 483034974; fax: +32 92646242.

E-mail addresses: landrycizunngu@yahoo.fr, CizunguLandry.Ntaboba@Ugent.be (L. Cizungu).

http://dx.doi.org/10.1016/j.foreco.2014.04.015
0378-1127/© 2014 Elsevier B.V. All rights reserved.

2012). Hence, plant richness and functional biodiversity have extensively been reported to explain a major part of the variation in litter decomposition (Pérez et al., 1998). This holds particularly true for tropical ecosystems where environmental conditions such as temperature and humidity usually not restrict litter decomposition. Moreover, for species-diverse plant communities, litter effects on decomposition rates are rather driven by the composition of chemical compounds within plant litter mixtures than by simple metrics of plant species diversity (Meier and Bowman, 2008).

However, the mass loss of litter mixtures deviates frequently from the additive mass loss expected from the decomposition of the respective mono-specific litters (Gartner and Cardon, 2004; Hättenschwiler et al., 2005). Microbial communities and detritivores may derive their nutrients from different types of litter when chemically divergent leaf species are present in their habitat, leading to non-additive species effects on decomposition (Gartner and Cardon, 2004; Gessner et al., 2010). Specific compounds present in the leaf litter of some plant species may also stimulate or decrease microbial activity, thereby affecting the decomposition of other species present in the mixture (Nilsson et al., 1999; Madritch and Cardinale, 2007). Another mechanism behind litter mixture effects on decomposition involves active or passive transfer of nutrients from one litter type to another through common mycorrhizal networks or leaching (Schimel and Hättenschwiler, 2007; Gessner et al., 2010). Finally, leaf litter decomposition is not only controlled by the physicochemical leaf traits but also by the composition of the soil microbial community (Swift et al., 1979; Couteaux et al., 1995; Hättenschwiler and Vitousek, 2000; Aponte et al., 2012).

Litterfall fluxes and litter decomposition rates are valuable to validate process-based vegetation models (e.g. De Weirdt et al., 2012). Especially for African tropical forests very little information is available. Moreover, studies of specific effects of different litter species and combinations are rare in tropical forests and to our knowledge absent from African forests (Peh et al., 2012). Research on tropical forest C and nutrient cycling has mostly been carried out in Southeast Asia and South America. Studies on decomposition and nutrient release in African forests are mostly on exotic species (Teklay and Malmer, 2004). This study was carried out in the Nyungwe tropical mountain forest, which is of great ecological and economic value and represents a key area for rain forest conservation in central Africa. Similar to the rest of Rwanda, the area of natural forest in Nyungwe has decreased since 1960 while the area of exotic plantations increased. These plantations are mainly composed of introduced tree species of which *Eucalyptus* occupies 65% (FAO, 2000). In this study, we examined litterfall fluxes and leaf litter decomposition in a pristine catchment of the Nyungwe forest and an adjacent *Eucalyptus* plantation located in southwest Rwanda. We hypothesized that (1) stand composition has an impact on litterfall flux and litter fractions, (2) litter type and composition, and stand type have an effect on leaf litter decomposition rates. Therefore our objectives were (i) to quantify and compare litterfall dynamics between the pristine Nyungwe forest and the *Eucalyptus* plantation, and (ii) to determine decomposition rates of single-species and mixed-species leaf litter, thereby assessing litter composition and stand effects.

2. Material and methods

2.1. Study sites

The study was carried out in the Nyungwe tropical mountain rainforest, one of the most ecologically important mountain rainforests in Central Africa and a nearby *Eucalyptus* plantation. Nyungwe forest is located in the southwestern part of Rwanda (2°15′–2°55′ S, 29°00′–29°30′ E) in close vicinity of the Nile river basin to the east and the Congo river basin to the west. It covers an area of approximately 970 km^2 (Plumptre et al., 2002). The topography is entirely mountainous (1600–2950 m a.s.l.), except for some peat valleys or depressions. The climate of Nyungwe forest is tropical humid. The average minimum and maximum temperature is 10.9 and 19.6 °C, respectively (Sun et al., 1996). As a typical tropical rainforest, annual rainfall is in the range of 1800–2500 mm (Van Ranst et al., 1997); the major dry season occurs from July to August and the minor dry season in December to January. Vegetation consists of more than 200 different species where tall forest trees reside in fertile soils and shorter trees and thickets on dry ridges (Plumptre et al., 2002). The dominant tree species are *Entandrophragma excelsum* Sprague, *Parinari excelsa* Sabine, *Prunus Africana* Hookand *Ocoteaam barensis* Engl. The soil in Nyungwe is dominated by Acrisols, Alisols and Cambisols (WRB) developed on schist, micashist, quartzite schist and granite parent materials. Moreover, Minagri (2000) reported that Luvisols, Podzols, Regosols and Ferralsols occur in sloping terrain whereas Histosols and Gleysols are normally occupying small valleys and depressions.

In the present study, two paired catchments were selected, one in the pristine Nyungwe forest and another in a nearby *Eucalyptus* plantation in the buffer zone surrounding the forest. The distance between the two catchments is 1.4 km. On each site, three experimental plots (A, B, C) with a size of 20 m × 30 m (0.06 ha) were selected and marked permanently. For both catchments a tree inventory was made in the three plots during the major dry season. The number of trees per plot with a diameter larger than 6 cm at 1.3 m height was determined (Table 2). To estimate canopy openness a method based on digital image analysis was used. Canopy pictures were taken skyward from the forest floor in each litter decomposition subplot (three pictures per plot). Pixel values of pictures were analyzed using Gap Light Analyzer (GLA) software (Frazer et al., 1999; http://www.ecostudies.org/gla/). In Nyungwe forest, the three plots were located in a small catchment with an average slope of 11% (2°28′29.8″ S, 29°06′26.6″ E, 1915 m a.s.l.) (Table 1) and a canopy openness of 17.9, 38.5 and 39.3% in plots A, B and C, respectively. The three plots in the *Eucalyptus* plantation were located in another small catchment (2°26′21.8″ S, 29°05′38.7″ E, 1889 m a.s.l.) with an average slope of 13% (Table 1) and canopy openness of 38.9, 38.7 and 53.1% in plots A, B and C, respectively. The *Eucalyptus* plantation was a regenerated coppice plantation unmanaged and less than 15 years old, without fertiliser addition, and used by the local population for firewood collection.

2.2. Litterfall

Litterfall was collected monthly during two consecutive years from April 2010 to May 2012. In each of the three plots in the pristine forest eight litter traps with a collecting area of 0.242 m^2 at 1.5 m height were set up in a systematic design (8 × 8 m), whereby the position of the first litter trap was chosen at random. In the *Eucalyptus* plantation plots, eight litter traps of similar design were installed. After collection, litterfall was taken to the laboratory, air dried, weighed and sorted into six fractions (leaves, twigs, flowers and fruits, bark, mosses and a rest fraction). Twigs with a diameter of more than 2 cm were discarded. Leaves were further sorted according to the main tree species. After calculating for each plot the litter quantity per litter trap and per year for each fraction and species (leaves only), an average value per plot was used to extrapolate litterfall per hectare and per year.

2.3. Litter decomposition

Five dominant tree species were selected in the present study: *Parinari excels* (PE), *Cleistanthus polystachyus* (CP) and *Carapa grandiflora* (CG) in the pristine forest, and *Eucalyptus saligna* (ES) and

Download English Version:

https://daneshyari.com/en/article/6543533

Download Persian Version:

https://daneshyari.com/article/6543533

Daneshyari.com