Catena 150 (2017) 223–229

Contents lists available at ScienceDirect

Catena

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

The effects of broad-leaved tree species on litter quality and soil properties in a plain forest stand

Yahya Kooch *, Behnaz Samadzadeh, Seyed Mohsen Hosseini

Faculty of Natural Resources & Marine Sciences, Tarbiat Modares University, 46417-76489 Noor, Mazandaran, Iran

ARTICLE INFO

Article history:
Received 31 May 2016
Received in revised form 17 September 2016
Accepted 22 November 2016
Available online xxxx

Keywords:
Soil chemistry
Earthworm
Nematode
Microbial respiration
Temporal variability

ABSTRACT

The role of tree species on litter quality and soil characters is less known in mixed forest stand. For this reason, the effect of *Carpinus betulus* (CB), *Acer velutinum* (AV), *Pterocarya fraxinifolia* (PF), *Quercus castaneifolia* (QC) species on litter and topsoil physical, chemical and biological features was considered in northern Iran. Litter quality differs among species, with the highest total nitrogen (N) concentration (1.88%) and lowest organic carbon (C) (41.18%) under CB trees. Clay and water content did not differ among species, but soil bulk density and sand content were highest under CB (1.66 g cm^{-3} and 44.70%, respectively) with the least silt content (28%). Soil pH (7.10), EC (0.29 ds/m), total N (0.35%), available P (21.85 mg kg^{-1}), K (316.66 mg kg^{-1}), Ca (254.50 mg kg^{-1}), Mg (58.50 mg kg^{-1}), earthworm density/biomass (2.50 n m^{-2} and 29.59 mg m^{-2}, respectively) with more share of epigeic, total nematode (443.90 in 100 g soil) and microbial respiration (0.47 mg CO_2-C g_{soil}^{-1} day^{-1}) were significantly higher beneath CB trees whereas a higher content of organic C (3.15%) and C/N ratio (34.20) were found under QC. A greater quantity of fine root biomass was found under PF (92.80 g m^{-2}) trees. In all the studied tree species, earthworms (epigeic, anecic and endogeic) and nematodes had the highest activities in autumn while the maximum of microbial respiration was recorded in summer season. The findings obtained in this study can be prioritized in the selection of appropriate species for the restoration of degraded areas.

1. Introduction

There is little doubt that trees play a major role in structuring terrestrial systems (Scheu et al., 2003). By creating their own habitat and regulating resource availability, trees can influence other organisms through several pathways (Ayres et al., 2004). Water relations (Anderson et al., 2001), availability of light (Thomsen et al., 2005), litter inputs (Sayer, 2006) and soil properties (Reich et al., 2005) may be altered by trees; even individual trees can control surrounding vegetation and soil chemistry (Brooker et al., 2008). In forest ecosystems, tree species have great impacts on physical, chemical and biological properties of soil (Guendehou et al., 2014; Gartzia-Bengoetxea et al., 2016) through their physical structure, especially their litter inputs (Schwarz et al., 2015). Litter quality characters, as the main driving force for soil processes, especially relative proportions of carbon (C) and nitrogen (N) contents vary between different tree species (Guendehou et al., 2014). Neirynck et al. (2000) found that C/N ratio in topsoil was variable under different tree species (i.e. *Tilia platyphyllos*, *Fraxinus excelsior* and *Acer psedoplatanus*) that was related to litter quality of these species. A study carried out Lovett et al. (2002) revealed that tree species may affect the cycling of C, N and other nutrients in the soils under their canopies and this, in turn, can influence substantial processes at an ecosystem level. A study by Hagen-Thorn et al. (2004) revealed that tree species clearly have influence on different soil properties and this effect is more obvious at upper layer of soil. In a study, the soils under *Fagus sylvatica* demonstrated lower soil pH values, lower base saturation and higher C/N ratios when compared to forest soils under mixed deciduous forests comprising *Fagus*, *Fraxinus*, *Tilia* and other deciduous tree species (Thoms and Gleixner, 2013). Obviously, the impact of trees on the properties of ecosystem is likely to have important consequences for belowground communities (Ayres et al., 2004). Above and belowground inputs may be different between tree species in both quantity and quality. In particular, resource quality can be a strong determinant of soil community structure (Reich et al., 2005).

Soil fauna are an important component in forest ecosystems, due to their functional role in accelerating the decomposition of organic matter and nutrient transformations. The positive influence of soil fauna on the decomposition of plant litter is widely known and well accepted for many ecosystems (Yang and Chen, 2009). The activity of soil invertebrates helps to enhance the physical, chemical and biological properties of soils (Sarlo, 2006). Among soil organisms, earthworms are the recognized ecosystem engineers. They are the major component of the

* Corresponding author.
E-mail addresses: yahya.kooch@yahoo.com, yahya.kooch@modares.ac.ir (Y. Kooch), b.samadzadeh@modares.ac.ir (B. Samadzadeh), hosseini@modares.ac.ir (S.M. Hosseini).

http://dx.doi.org/10.1016/j.catena.2016.11.023
0341-8162/

decomposer fauna in many forest ecosystems (Lavelle and Spain, 2001) and are categorized into three main ecological groups; epigeic, anecic and endogeic species (Edwards, 2004). Epigeic and anecic earthworms, the functional groups most affected by litter quality, are more likely to be directly influenced by the interspecific differences in plant residues. However, endogeic earthworms have also demonstrated preferences of some plant residues over others (Sarlo, 2006). Earthworm abundance/biomass is typically associated with soils that contain high organic matter content, which greatly affects soil pH, soil nutrients, water-holding capacity and aggregation (Yatso and Lilleskov, 2016) and the whole of these features can be affected by the type of tree species (Schwarz et al., 2015). Furthermore, soil nematodes occupy a central position in the detritus food web (Cesarz et al., 2013). They can be used as indicators of the structure and function of soil food webs and of general conditions of the ecosystem (Zhang et al., 2012). In forest ecosystems, the distribution and abundance of soil nematodes is determined by factors such as tree species, soil type, soil fertility, litter depth and forest management (Yeates, 2007). Although the effects of plant community composition on soil nematodes are inconclusive, Yeates (2007) suggested that soil nematode communities can provide important information about the role of forest species in structuring soil food webs. According to the report of Keith et al. (2009), the changes in the nematode population could be attributed to changes in the availability of food resource and environmental conditions. Plant species in forest ecosystems have important roles in determining the composition of the soil biota through both above- and belowground resource inputs and by altering abiotic conditions (Cesarz et al., 2013).

Soil microorganisms are important drivers of soil processes, and they play a key role in the decomposition of recent plant material (Thoms and Gleixner, 2013). Soil respiration is the sum of the autotrophic component produced by roots and the heterotrophic component derived from soil microorganisms that decompose organic materials in litter. Tree species significantly contribute to soil respiration and deposition of C in the forest areas (Zifcakova et al., 2016). In forests dominated by different tree species, the forest floor may contain several different types of substrates for microbial growth, and variations in forest floor characteristics may produce differences in the composition and function of microbial communities (Jagadamma et al., 2014). The environmental conditions beneath the forest canopy (generated by trees and/or pre-existing differences between the sites) influence soil microbial community and respiration. Microbial respiration from soils is regulated by environmental factors such as temperature and moisture and biotic factors (Makita and Fujii, 2015). The activity of soil biology in temperate broad-leaf forests is strongly affected by the seasons through changes in biotic and abiotic factors (Kaiser et al., 2010). Unfortunately, studies considering the impact of tree species on soil organisms through seasonal cycles are rare (Collignon et al., 2011). In a study, for example, strong seasonality in the abundance of earthworm populations in mixed forest sites has also been demonstrated and has been attributed to differences in litter decomposition and fluctuations in the soil C pool over the years (Thoms and Gleixner, 2013). Tree fine roots (<2 mm) are dynamic and short-lived, supplying considerable belowground litter inputs and accounting for up to 75% of the net primary production of forest ecosystems. After root death, the decomposition of fine roots will be an important heterotrophic source of CO_2 (Makita and Fujii, 2015). Fine roots are very dynamic and play a key role in forest ecosystem C and nutrient cycling and accumulation. Generally, fine root biomass is affected by the type of tree species (Lei et al. 2012), availability of nutrient and other environmental conditions (Zhou et al., 2014).

The Hyrcanian vegetation zone, also called Caspian forest, is one of the last remnants of natural deciduous forests in the world (Talebi et al., 2014). The natural forest vegetation is temperate deciduous forests containing broad-leaved species that are very similar to forests typical of central Europe, northern Turkey and the Caucasus (Adel et al., 2014). While the Caspian coastal areas included a milder climate, the inland plateau experiences extremes of hot summers and cold winters (Talebi et al., 2014). Despite the importance of Hyrcanian forests, earlier study that evaluated the effects of dominated individual trees on litter quality and also spatio-temporal variability of soil characters at the stand level wasn't considered. This study aims to investigate: (i) if different tree species affect litter quality, soil physico-chemical properties and also earthworm density/biomass, nematode population and microbial activity, (ii) seasonal changes in soil organisms activity under different forest species within the forest and, (iii) which factors determine earthworm, nematode and microbial activity in these temperate forests. We hypothesized that (1) the influence of individual trees on soil properties is detectable even in mixed stands and the soil landscape may be considered a mosaic of profiles reflecting the litter chemical characters through individuals of the various tree species present, and (2) expected changes in climate will potentially have a stronger impact on soil biological activity than changes in forest diversity.

2. Materials and methods

2.1. Study area

The study area is located at the Experimental Forest Station of Tarbiat Modares University, north of Iran (51° 46″ E, 36° 47″ N). The experimental plots were located at an altitude of 15 m above sea level. The area is on flat and uniform terrain (slope 0–3%). Mean annual rainfall is 803.4 mm and mean annual temperature is 17 °C at the Noushahr city metrological station, which is 1 km away from the study area (Anonymous, 2010). Based on the metrological station at study time, there is a dry season between May and August (Fig. 1). The parent material is dolomite limestone which belongs to upper Jurassic and lower Cretaceous period. The soil order name is Alfisols. Soil texture is silty clay loam. The natural forest vegetation is temperate deciduous forests containing broad-leaved species dominated by oak (*Quercus castaneifolia* C. A. M. *macranthera* F. & M.), hornbeam (*Carpinus betulus* L.), Caucasian wingnut (*Pterocarya fraxinifolia*), false walnut (*Pterocarya carpinifolia* Lam.), maple (*Acer velutinum* Boiss., *Acer cappadocium* Gled.) with some associated species such as ash (*Fraxinus excelsior* L.), alder (*Alnus subcordata* C. A. M., *Alnus glutinosa* Gaertn.), elm (*Ulmus glabra* Huds.), wild cherry (*Prunus avium* L), wild service tree (*Sorbus torminalis* Crantz), and lime tree (*Tilia platyphyllus* Scop.) (Mirzaei et al., 2007). These forests are uneven-aged mixed stands and the trees diameter at breast height (D.B.H.) varies from 10 to 110 cm (Anonymous, 2010).

2.2. Data collection

Following a field trip, clumps of tree species were identified in the study area. Samplings were performed under individual tree of *Carpinus betulus* (CB), *Acer velutinum* (AV), *Pterocarya fraxinifolia* (PF), *Quercus*

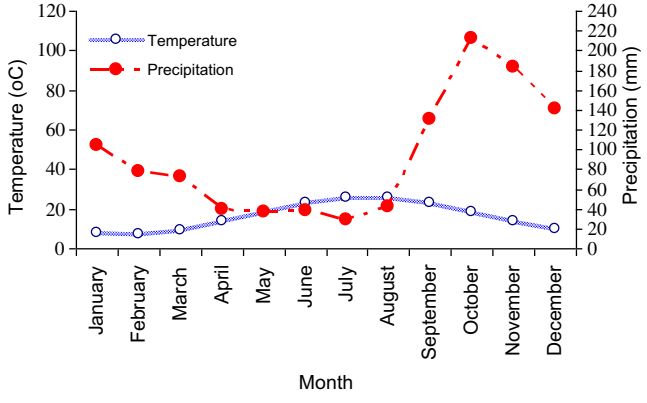

Fig. 1. Mean monthly temperature and precipitation in study area based on Noushahr city metrological station.