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Litter and topsoil in *Alnus subcordata* plantation on former degraded natural forest land: A synthesis of age-sequence

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ABSTRACT

Alder (*Alnus subcordata* C. A. M.), as N-fixing tree, are preferred plantation species that may change soil microbial community and play a vital role in nutrient cycling. Litter and topsoil in different ages of alder plantation by focusing on microbial and enzyme activities have not yet been studied. This study is aimed at examining the effect of 15, 20 and 25 years old of alder plantation compared to without tree cover (WTC) area in northern Iran. Thirty samples per site were collected from the litter and soil (20 × 20 × 10 cm) layers. Following variability of litter quality, soil physicochemical and biological properties, the microbial activities which related to soil C and N has been changed. Basal respiration (BR), substrate inducted respiration (SIR), microbial biomass carbon (MBC), metabolic quotient (qCO_2), microbial entropy (MBC:C), carbon availability index (CAI), carbon management index (CMI), particle organic carbon (POC) and dissolved organic carbon (DOC) were reported to be significantly higher in 25 years old plantation than in 20 and 15 years old plantation and WTC area. Also, NH_4^+, NO_3^-, and N mineralization, microbial biomass nitrogen (MBN), particle organic nitrogen (PON) and dissolved organic nitrogen (DON) were significantly higher in older plantations. Enzymes activities (*i.e.,* urease, acid phosphatase, arylsulfatase and invertase) were significantly higher in alder plantation compared to WTC area with an increase in 25 years old plantation. Our findings highlight the importance of monitoring the plantation effects on C and N cycling that can be involved with global warming phenomena.

1. Introduction

Forest degradation is worldwide concern due to greenhouse gas emissions it causes, the scale of forest change, and also anticipated to lost opportunities to derive multiple benefits from forested lands (Bahamondez and Thompson, 2016). The forests of Iran are among the oldest forests in Asia and the northern hemisphere. The Hyrcanian flora zone, is a green belt stretching over the northern slopes of the Alborz mountain ranges and covers the southern coasts of the Caspian Sea (Sagheb-Talebi et al., 2014). These forests are one of the last remnants of natural deciduous forests in the world (Kooch et al., 2015). Regarding that each year, natural forest areas are decreased due to intensive logging and regarding the other part, the necessity for woods had growing trend due to increase within population, consequently plantation with local species for rehabilitating degraded forests is fundamental (Yousefi et al., 2010). On one hand, plantation due to its special characteristics, affect physico-chemical characteristics of soil and improve some ecosystem services (Li et al., 2012aa,b; Kooch, et al. 2017a,b). Different ages of tree species growing on similar sites often differ in productivity, canopy structure and the quality and quantity of litter (Józefowska et al., 2017). There are numerous studies dealing with the effects of different tree species stages on soil properties (Luan et al., 2010; Vesterdal et al., 2013; Deng et al., 2016). Acquiring good knowledge how different species affect soil conditions impact change on it may promote manager's ability to predict species impacts on forest plantations.

Stand age as an indicator regarding forest successional status plays a fundamental function in finding out the soil organic matter (SOM) quality through modifications in the input and decomposition of plant litters (Zhao et al., 2016). As a plantation matures, stable organic compounds may become concentrated in the soil if the input of plant tissues is continuous and if the labile fraction is decomposed rapidly in response to environmental change (Pérez-Cruzado et al., 2014; Zhang et al., 2016). There is a vast body of early research on stand age effects on soil physico-chemistry under different tree species, and the importance of stand age on C and N uptake (Yang et al., 2011; Pitman et al., 2014). Nitrogen-fixing trees have been extensively extolled for their soil-improving characteristics which are related to their

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production of nitrogen-rich, often rapidly decomposing leaf litter (Swanson, 2016). N-fixing trees such as alder, are preferred plantation species, because their fast growth is expected to meet the extensive demands of wood for poles, pulp and fuel (Kiadaliri, 2003). Increased N stages below these species may also exchange soil microbial community, which drive a critical role in soil nutrient cycling (Chen et al., 2016). The traditional rotation age of alder plantations that are grown for timber production has typically been determined by a comprehensive consideration of the quantitative, economic and technical maturation age of stands (Wang et al., 2016). However, little is known regarding the optimal rotation age for alder plantations that might facilitate the greatest level of soil quality. Though some researchers (Frouz et al., 2001; Helingerová et al., 2010; Šnajdr et al., 2013; Abakumov et al., 2013; Bartuška et al., 2015) studied soil quality properties under alder, but the long-term impact on litter and topsoil in alder plantation on degraded natural forest lands of Hyrcanian region has not yet been studied. The objective of this study was to determine the influence of litter quality, soil physico-chemical and biological properties on microbial properties of C and N under different ages of alder plantation in a part of Hyrcanian zone, northern Iran. The working hypotheses of present research were: (i) plantation with alder in degraded forest lands can improve soil fertility via litter inputs in long-term, (ii) soil C and N microbial indices can be enhanced under older ages of alder plantation.

2. Materials and methods

2.1. Study area

This research carried out in Dallak Khil district of Mazandaran Province, northern Iran (36° 27′ N, 53° 04′ E; Fig. 1). Approximately 50 years ago, this area was dominated by natural forests containing native tree species such as oak (*Quercus castaneifolia* C. A. M. *macranthera* F. & M.), hornbeam (*Carpinus betulus* L.), ironwood *(Parrotia persica* C. A. Meyer*)*. In the 1980s, these forests were partially destroyed because of extensive exploitation carried out by local residents. Consequently, in 1987 these parcels were “clear-cut”, stumps eradicated, and then

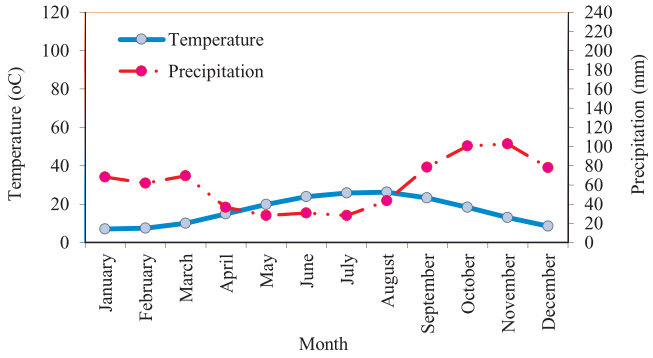

Fig. 2. Mean monthly temperature and precipitation in study area based on Sari city metrological station.

afforested in different years since 1991. The dominant forest types which were planted at a spacing of 4 × 4m, included alder trees. However, some parcels were not afforested up to now and are covered by sparse herbaceous species including *Asperula odorata* L., *Euphorbia amygdaloides* L., *Hypericum androsaemum* L., and *Polystichum* sp. The treatments investigated in the present research consisted of 15, 20 and 25 years old stands of alder, whereas barren lands located near the afforested stands (without tree cover; WTC) were selected as the control region (Fig. 1). The treatments were distributed within the study site in a distance of about 50 m apart each other. The study area, located between 350 and 360 m a.s.l., shows very similar physiographic, climatic conditions and management practices. Annual mean rainfall is 726 mm, average daily temperatures vary from 7.1 °C in January to 26.1 °C in August and mean annual temperature is 16.5 °C (Fig. 2). The dominant herbaceous species in the plantation areas were *oplismenus undulatifolius*: 45%, *carex sylvativa*: 20% & *microstegium vimineum*: 15% in the 15 years old plantation, *microstegium vimineum*: 35%, *carex sylvativa*: 25% & *oplismenus undulatifolius*: 20% in the 20 years old plantation and *rubus hyrcanus*: 70%, *tamus communis*: 10% & *oplismenus undulatifolius*: 5% in the 25 years old plantation (Anonymous, 2004).

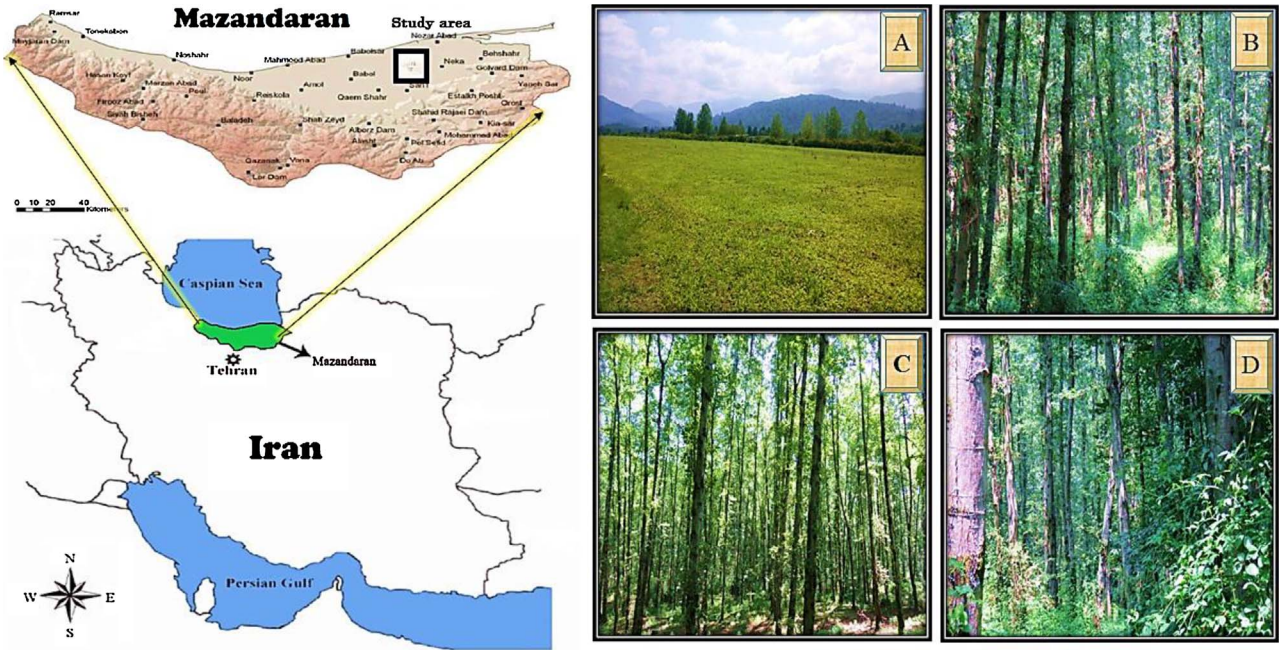

Fig. 1. Location of the study area in the Mazandaran Province, northern Iran (***left***). Treatments including without tree area (WTC) (A), 15 years old (B), 20 years old (C) and 25 years old alder plantations (D) (***Right***). The stands were never fertilized and according to Mehrabi (2017) report, the properties (mean ± standard error) including the diameter at breast height (cm), height (m) and canopy cover (%) varied among the 15 (17.08 ± 0.22 cm, 16.28 ± 0.19 m and 78%), 20 (22.29 ± 0.28 cm, 19.33 ± 0.22 m and 85%) and 25 (30.11 ± 0.32 cm, 23.21 ± 0.29 m and 91%) years old alder plantations in the study area.