Ecological Indicators 91 (2018) 249–258

Contents lists available at ScienceDirect

Ecological Indicators

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

Original Articles

Water utilization characteristics of typical vegetation in the rocky mountain area of Beijing, China

Ziqiang Liu, Xinxiao Yu*, Guodong Jia*

Beijing Forestry University, Key Laboratory of Soil and Water Conservation and Desertification Combating of Ministry of Education, 100083, Beijing, China

ARTICLE INFO

Keywords:
Stable isotopes
Water utilization characteristics
Vegetation community
Iso-source mixing model

ABSTRACT

Seasonal drought are expected to occur more frequent and intense in the some regions due to global climate change, which may significantly influence in the competitive interactions of water uptake depth for vegetation communities. We investigated the impacts of seasonal drought on water utilization for vegetation communities using hydrogen-2 and oxygen-18 stable isotope techniques in Beijing rocky mountainous area. Our results indicate that the water sources of the four plant species varied by season. *Platycladus orientalis* largely absorbed water from middle (31.5% in May and 35.9% in November) and deep (32.8% in May and 38.4% in November) soil layers during the dry season and switched its main water source to surface layers (50.3% in July and 37.2% in September) during the wet season. Contrary to *P. orientalis*, *Quercus variabilis* mainly absorbed water from surface and middle soil layers during the dry season and changed its dominant water sources to the deep soil layer throughout the wet season; at same time, this species utilized water from natural springs in July and the middle soil layer in September. *V. negundo var. heterophylla* mostly utilized water from deep soil layers (38.7%) in May and transferred its main water source to surface (43.5%) and middle (33.1%) layers in July. This species primarily utilized water from surface (29.2%) and middle (30.8%) soil layers in September, and from middle (35.4%) and deep (27.8%) layers in November, similar to the findings of *P. orientalis* in this season. In contrast the above three plant species, *C. heterophylla Fisch* mainly absorbed water from surface and middle soil layers throughout the year, having very little reliance on water from deep soil layers. *P. orientalis* and *Q. variabilis* showed the opposite characteristics of water utilization, which suggests that these two species are suitable for a mixed forest vegetation when selecting plant species for afforestation. However, since the water sources of *P. orientalis* and *V. negundo var. heterophylla* were from similar soil depths, there may be potential competition for moisture between these two species. Our findings provide an indication as to which vegetation species are suitable to grow together when undertaking restoration in drought prone environments.

1. Introduction

Forest plays an important role in hydro-logical cycles and ecological functions in terrestrial ecosystem (Craigd et al., 2010; Yan et al., 2011; Jiang et al., 2013; Rowland et al., 2015). The area of artificial forest is the largest among all forest types in China, and the majority was widely distributed in the mountainous area due to the limitations of geographical conditions (Cheng et al., 2010). As one of the typical mountainous areas, the rocky mountainous area of North China also distributed large area of artificial forests. It was dominated by thin soils and high gravel concentration, and was frequently and severely impacted by seasonal drought. The rainfall in this area has an uneven distribution throughout the whole year, and result in this area experienced a long period of drought. The long period of deficiency of soil water caused by seasonal drought may be a key factor that limits vegetation growth and distribution (Zhang, 2011; Zhai et al., 2014). Because limited water input will intensify competition of water sources among species and affect the physiological activity of vegetation probably (Tezak, 1999). Nevertheless, the artificial forests, such as pure forest and mixed forest in this area was good to survive depend only on natural precipitation. It was suggested that vegetation within an ecosystem can vary their water source depending on water availability to maintain community coexistence and diversity (Schwinning et al., 2005; Saha and Miralles-Wilhelm, 2009; Kambatuku et al., 2013). Most vegetation was able to survive and live together, primarily owing to trees showed considerable plasticity in absorbing water sources according to the moisture, physiological characteristics and tree species allocation (Flanagan and Ehleringer, 1992; Kray et al., 2012; Zhou et al., 2015). Whereas, several tree species only uptake water from the deep or shallow soil layer, exhibited no changed of water source

* Corresponding authors.
E-mail addresses: yuxinxiao1111@126.com (X. Yu), jgd3@163.com (G. Jia).

https://doi.org/10.1016/j.ecolind.2018.03.083
Received 27 April 2017; Received in revised form 9 March 2018; Accepted 26 March 2018
1470-160X/ © 2018 Elsevier Ltd. All rights reserved.

(Asbjornsen et al., 2008; Eggemeyer et al., 2009; Nie et al., 2011). A number of previous studies have mainly focused on conducting water source of vegetation community under conditions of plentiful rainfall (Schenk and Jackson, 2005; Yang et al., 2015), or single tree species in the arid area (Kray et al., 2012; Wu et al., 2016), or contrasting water use strategies in agroforestry system (Xi et al., 2013; Xiao and Huang, 2016), or the tree species with a thick soil layer (Xu et al., 2011; Jian et al., 2016). However, few studies focused on the water use patterns of the symbiotic of woody-shrub under a seasonal drought in the rocky mountainous area, which is characterized by thin soils and high gravel concentration. Moreover, seasonal drought will become more frequent and intense in some regions due to global climate change, which may lead to significant changes in the absorption depths and competitive relationship of plant water sources (IPCC, 2013). Thus, it is important to investigate how vegetation community uses water from different soil depths, to explore whether there was a water competition among the vegetation communities and to acquaint how they adapt to the fragile ecological environment.

The artificial mixed forests of *Platycladus orientalis–Quercus variabilis* are widely distributed in the mountainous area of North China, which have significant functions in ecological barrier of North China Plain. Therefore, acquainted the water use strategy and symbiotic mechanism of coexisting species in this region was significant implications for selection, allocation and later management of future artificial forest construction. To fill these gaps in our knowledge, we applied stable isotope techniques to investigate the absorption ratio of the vegetation community to each water source and using TDP to explore the water consumption of them. The objectives of this study are to (i) analyze the competitive interactions of the water utilization characteristics for two tree species (*Platycladus orientalis* and *Quercus variabilis*) and two undergrowth shrubs (*Vitex negundo L. var. heterophylla* and *Corylus heterophylla Fisch*), (ii) investigated the impacts of seasonal drought on water sources in this vegetation community. This study will help us acknowledge how vegetation adapts to the environment and advancing our knowledge of how vegetation communities survive competition during seasonal variations in limited water supply, as well as find the possibilities to ameliorate these changes through management or the recovery of artificial vegetation communities.

2. Materials and methods

2.1. Study site

Our study was conducted at the National Forest Ecosystem Research Station (40°03′N, 116°05′E), which is located in the mountainous area of Beijing. The study area, located 30 km from Beijing (Fig. 1), has an average altitude of 450 m and a warm temperate semi-humid monsoon climate. Each season has distinct characteristics in this region, with more rainfall in the summer (June to September) than in the other seasons. The average air temperature is 11.6 °C, with monthly means of − 19.6 °C in December and 27.6 °C in July; more than 10 °C of the effective accumulated temperature ranges from 3385–4210 °C in the course of a year. The annual mean rainfall is 660 mm with approximately 70–80% occurring in the wet season, especially in July and August, and the cumulative precipitation in other seasons was less than 30%. Mean annual evapotranspiration is approximately 1100 mm. The soil in the study region is thin with a depth of 80–100 cm. The soil types are mainly clay, which has higher soil humus contents in the surface layers and a higher density of gravel content in deep soil layers.

2.2. Vegetation species in the community

This study area, belonging to the typical Northern rocky mountainous area, has a mixed artificial forest vegetation of *Platycladus orientalis* and *Quercus variabilis* which was mainly planted by the local government in the early 1950s. *Vitex negundo L. var. heterophylla* and *Corylus heterophylla Fisch* are present under the stand. *Platycladus orientalis* is an evergreen coniferous tree that is widely distributed across China. This tree is the main afforestation tree species in the Beijing mountain area due to its strong resistance to cold and drought. *Quercus variabilis* is a deciduous broadleaf tree that has strong adaptability to climate and soil. This tree species is important in afforestation and ecological shelterbelt construction due to its well-developed taproot and lateral roots, and it has strong wind resistance. *V. negundo L. var. heterophylla* and *C. heterophylla Fisch* is sheepberry, which are mainly grown under forest woodland on the sunny slopes. In this community with an area of 400 m^2, there were 129 and 134 shrubs of *V. negundo var. heterophylla* and *C. heterophylla Fisch*, respectively. In comparison, there were 37*P. orientalis* and 43 *Q. variabilis* trees (Table 1). The average height of *P. orientalis* was 7.16 m with a mean tree diameter at breast height (DBH) of 7.60 cm, which was lower than the average height (9.18 m) and DBH (11.59 cm) of *Q. variabilis.*

2.3. Collection of soil, branch, precipitation and natural spring samples

Firstly, the basic meteorological parameters showed the information of seasonal drought in the study area. Secondly, analysis of the isotopic compositions of precipitation and the soil water content can provide more information of water sources, and show the impacts of seasonal drought on water sources. Thirdly, using the isotopic values of soil water and natural spring samples to calculate the contribution ratio of water sources for tree species during the growing season (May and November represent the dry season; July and September represent the wet season. May is in the transition from the dry season to the wet season; November is in the transition from the wet season to the dry season; July and September is in the wet season). Finally, contrasting the water sources of symbiotic of woody-shrub showed the competitive interactions between them and acquainted the impacts of seasonal drought on water sources in this vegetation community.

In the Beijing mountainous area, the deciduous tree species begin to grow leaves in the middle of April and shed their leaves in November, thus April to November is referred to as the growing season. To reflect the characteristics of water sources and use by plant communities for the whole growing season, all of the soil, branch, precipitation and natural spring samples were collected during May, July, September and November 2012. All samples were collected once a week during each month.

In the study plot, three mature sample trees of *P. orientalis* (according to their average height and DBH) were randomly selected for analysis. Non-green, ripe and suberized branches of 0.3–0.6 cm in diameter in the same direction and height from the ground were collected by scissor, and the sampling was repeated three times per trees. Three *Q. variabilis* trees were identified close to the studied *P. orientalis* trees and its branch samples were collected using the same method, and repeated three times at each tree. Under the canopy of the six trees, we chose three *V. negundo L. var. heterophylla* and three *C. heterophylla Fisch* sample shrubs and cut branch samples 0.5 cm from the base of the stem, and repeated three times at each tree. Samples were collected from each tree/shrub at each sampling period (once a week in each month) and all of the branch samples had their bark immediately removed before the samples were placed into the clean polyethylene bottles (50 ml), sealed with parafilm M®, frozen at –4°C to avoid evaporation fractionation, and then stored until isotopic analysis.

Soil samples were collected close to the tree/shrub sample locations using a soil auger at depths of 0–20 cm, 20–40 cm, 40–60 cm, 60–80 cm and 80–100 cm (below 80 cm was bedrock) in each sampling period, and repeated three times at each soil layer. Pebble gravel and litter were removed from the soil samples before they were divided into two parts: one part was immediately placed in clean polyethylene bottles (50 ml), sealed with Parafilm M® and stored in a refrigerator at –4°C for isotopic analysis, while the other part was sealed in a polythene bag and used to calculate soil water content by drying method (105 °C).

Download English Version:

https://daneshyari.com/en/article/8845315

Download Persian Version:

https://daneshyari.com/article/8845315

Daneshyari.com