Science of the Total Environment 568 (2016) 118–123

Contents lists available at ScienceDirect

Science of the Total Environment

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

Effects of salt stress on eco-physiological characteristics in *Robinia pseudoacacia* based on salt-soil rhizosphere

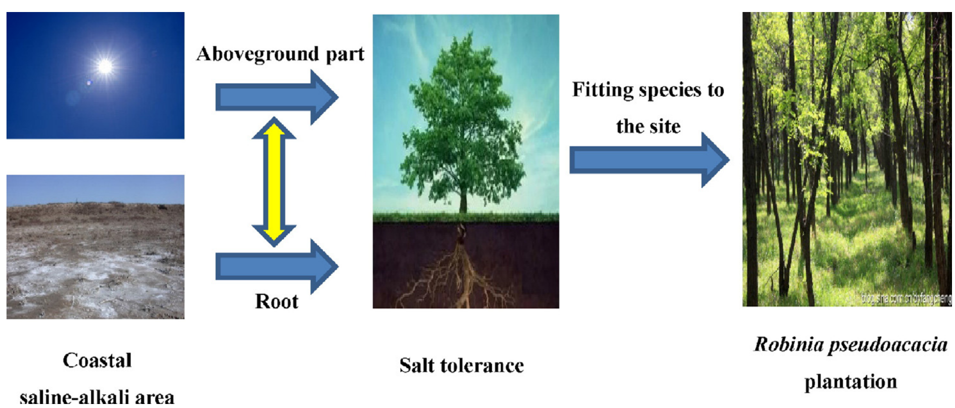
Peili Mao [a], Yujuan Zhang [a], Banghua Cao [a,*], Longmei Guo [a], Hongbo Shao [b,c,*], Zhenyu Cao [a], Qiankun Jiang [a], Xuan Wang [a]

[a] Key Laboratory of Agricultural Ecology and Environment, Shandong Agricultural University, Taian 271018, China
[b] Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences, Yantai 264003, China
[c] Institute of Agro-biotechnology, Jiangsu Academy of Agricultural Sciences, Nanjing 210014,China

HIGHLIGHTS

- Salt stress is the key limited factor of plantation construction in the Yellow River Delta.
- The growth of *Robinia pseudoacacia* seedlings was significantly inhibited by saline–alkali degrees.
- Eco-physiological adaptability of *R. pseudoacacia* was determined by above-ground parts and root.
- To control water uptake of *R. pseudoacacia* seedling by rhizosphere was an important way under salt stress.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 5 May 2016
Accepted 3 June 2016
Available online xxxx

Keywords:
Salt tolerance
Biomass
Root morphology
Root physiology
Maximum net photosynthetic rate
Salt-soil

ABSTRACT

Robinia pseudoacacia is the main arbor species in the coastal saline–alkali area of the Yellow River Delta. Because most studies focus on the aboveground parts, detailed information regarding root functioning under salinity is scare. Root traits of seedlings of *R. pseudoacacia* including morphological, physiological and growth properties under four salinity levels (CK, 1‰, 3‰ and 5‰ NaCl) were studied by the pot experiments to better understand their functions and relationships with the shoots. The results showed that seedling biomass decreased by the reduction of root, stem and leaf biomass with the increase of salinity levels. With increasing salinity levels, total root length (TRL) and total root surface area (TRSA) decreased, whereas specific root length (SRL) and specific root area (SRA) increased. Salt stress decreased root activity (RA) and the maximum net photosynthetic rate (Amax) and increased the water saturation deficit (WSD) significantly in the body. Correlation analyses showed significantly correlations between root morphological and physiological parameters and seedling biomass and shoot physiological indexes. *R. pseudoacacia* seedlings could adapt to 1‰ salinity by regulating the root morphology and physiology, but failed in 5‰ salinity. How to adjust the water status in the body with decreasing water uptake by roots was an important way for *R. pseudoacacia* seedlings to adapt to the salt stress.

* Corresponding authors.
E-mail addresses: caobanghua@126.com (B. Cao), shaohongbochu@126.com (H. Shao).

http://dx.doi.org/10.1016/j.scitotenv.2016.06.012
0048-9697/© 2016 Published by Elsevier B.V.

1. Introduction

A comprehensive understanding of the pattern of forest growth is important from both the economic and the ecological points of view. In an even-aged plantation, the above-ground net primary productivity usually decreases with age following the canopy closure (Ryan et al., 1997). The mechanisms and potential causes conducive to the decline in above-ground net primary productivity have attracted considerable attentions from forest ecologists and resource managers during the recent decades, and have become a hot topic of research in recent years (Bond et al., 2007; Martínez-Vilalta et al., 2007; He et al., 2012; Baret et al., 2015). A large number of studies have attempted to explain this decline by photosynthetic physiology and the effects of stand age on soil nutrient availability, on biomass allocation, and on stand structure (Mao et al., 2011). However, how below-ground biomass dynamics with stand development is not clear at present (Ryan et al., 1997; Yuan and Chen, 2012).

Root production accounts for 33–67% of the global terrestrial net primary production (Abramoff and Finzi, 2015), which plays a fundamental role in terrestrial carbon cycling (Jackson et al., 1997). For an individual tree, root biomass is roughly 18–45% of the total biomass (Fogel, 1983). Roots are predominantly responsible for the uptake of water and mineral nutrients from the soil (Norby et al., 2004), nutrient storage and transport (Ouimet et al., 2008), etc. Through the same scion cultivar of *Prunus persica* growing on the rootstocks with differing size-controlling potentials, Solari et al. (2006) found that rootstocks had a pronounced effect on shoot growth and photosynthetic capacity. Qi et al. (2012) thought *Zea mays* with greater root systems would lead to higher yield. Moreover, root systems are highly dynamic over various temporal and spatial scales (Brassard et al., 2009), and are responsive to changes in environmental conditions, such as soil nutrients (Kochsiek et al., 2013), moisture (Pedroso et al., 2014), salinity (Hill et al., 2013), etc.

Today, more than 7% of the world's land is salt-affected (Pitman and Läuchli, 2004). Salinization has become a major concern throughout the world (Liang et al., 2005; Setia et al., 2013) and especially in China (Liu et al., 2015). Roots are first affected by excess salinity (Córdoba et al., 2001; Cavalcanti et al., 2007). In general, plant root growth has been found to be reduced under salinity (Li et al., 2016; Farissi et al., 2013; Yan et al., 2016). Furthermore, many plant species decreased their total root length under salinity (Gómez-Bellot et al., 2013; Álvarez and Sánchez-Blanco, 2014; Li et al., 2016). However, some plants could partially compensate the decrease of root growth by increasing specific root area (Rewald et al., 2011; Hill et al., 2013). Plant photosynthesis and growth are largely determined by their ability to take up water under salt stress (Farissi et al., 2013). Increasing root/shoot ratio has been found in many salt-stressed woody seedlings/saplings (Fernández-García et al., 2014; González et al., 2012; Álvarez and Sánchez-Blanco, 2014), which was probably associated with the osmotic effect of salt stress (Fernández-García et al., 2014). Ranjit et al. (2016) suggested that roots and shoots had distinct mechanisms of responses to salt stress. However, root performance under salt stress has rarely been conducted in tree species (Hill et al., 2013).

The Yellow River Delta is the fastest growing delta in the world and a notably land–ocean interaction region. Secondary salinization is one of the most important characteristics in this region and other coastal areas (Cruz-Fuentes et al., 2014). Moreover, salinization is a crucial factor determining the vegetation distribution in the Yellow River Delta (Xiong et al., 2008). Vegetative bioremediation is an important reclamation approach on saline–alkali soils (Qadir and Oster, 2004). *Robinia pseudoacacia* plantation is the maximum area arbor forest in the Yellow River Delta, exerting significant protective function in reducing natural disasters (Cao et al., 2012). However, *R. pseudoacacia* plantation gradually showed obvious degradation for large areas and even the sheet death in the recent decades. Zhang and Xing (2009) thought that high salt content of soil was an important factor for the degradation of *R. pseudoacacia* plantation. Many researchers have studied the salt tolerance of *R. pseudoacacia* from seed germination (Cao et al., 2005), seedling growth (Meng et al., 2011), adult tree characteristics (Du et al., 2014a), etc. However, root performance under salt stress has rarely been addressed (Du et al., 2014b), which has been playing an important role in soil improvement (Qadir and Oster, 2004). In this paper, we measured the aboveground and underground characteristics of *R. pseudoacacia* seedlings under salt stress by pot experiments. The study aimed at exploring the morphological and physiological responses of seedling roots and whether there were significant correlations between root and shoot changes under salt stress.

2. Materials and methods

2.1. Study area

The study was carried out at the Forestry Experimental Station of Shandong Agricultural University, China (36°10′09″N, 117°09′24″E). It is a warm temperate continental monsoon climate in East Asia. The mean annual temperature is 12.8 °C, and the minimal and maximum temperature varied from −6.9 °C to 37.5 °C. The frost-free period is 186.6 days with an effective accumulated temperature of about 4283.1 °C. The average annual precipitation varies from 600 mm to 700 mm, whereas the precipitation falls seldom in spring and mainly in summer. The mean annual relative humidity is 65%.

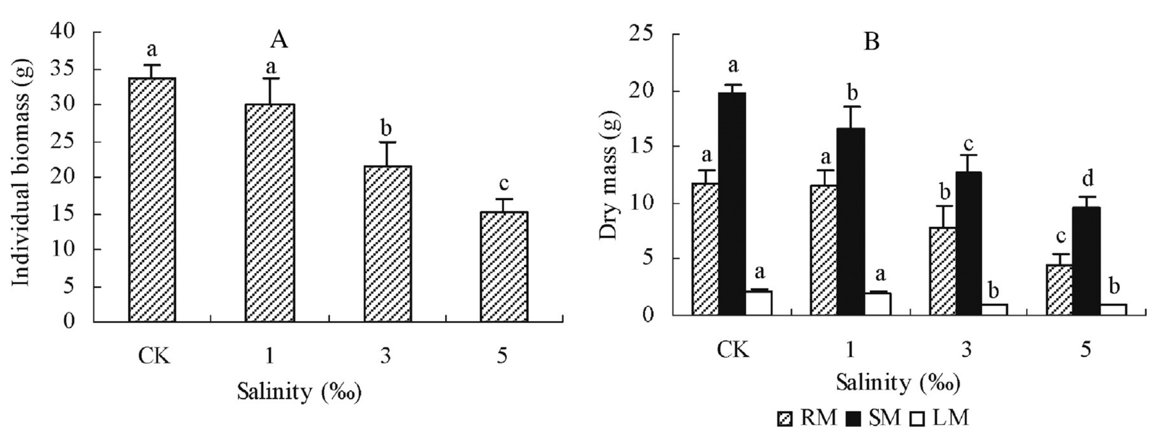


Fig. 1. Effect of salt treatment on biomass in seedlings of *Robinia pseudoacacia*. Values are the mean of three replicates and Bars represent SD. Different lowercase letters represent significant differences among salinity levels by LSD's test.