Effect of density of *Tephrosia candida* stands on soil characteristics

Zhiyang Lie, Zhumin Wang and Li Xue*

College of Forestry and Landscape Architecture, South China Agricultural University, Guangzhou 510642, P. R. China.

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**ABSTRACT**

With one-year-old *Tephrosia candida* trees as experimental material, influence of stand density on soil nutrient content and enzyme activity was studied. The results showed that density had little influenced on pH value in 2, 4 and 8 trees m\(^{-2}\) stands. The contents of soil organic matter, effective nitrogen and effective phosphorus significantly increased in 2 trees m\(^{-2}\) stands. The contents of soil organic matter and effective nitrogen significantly increased, whereas total N, total P, total K, effective N, effective P and effective K significantly decreased in 4 trees/m\(^{-2}\) stand. Soil organic matter and nutrients except for total P significantly decreased in 8 trees m\(^{-2}\) stand. Among the three density stands, the activities of urease, catalase and phosphatase were the lowest in 8 trees m\(^{-2}\) stand.

**Key words:** Density, Soil property, *Tephrosia candida*.

**INTRODUCTION**

Soil is the substrate for stand growth, supplying various nutrients needed by trees. Stand density has an influence on physical and chemical soil properties of soil (Kang *et al.*, 2009), which is essential for tree growth and nutrient cycling of forest ecosystems. Although there are many researches on forest soil (Eckstein and Donath, 2005; Ruf *et al.*, 2006; Adekalu *et al.*, 2007; Beaudet *et al.*, 2007; Muscolo *et al.*, 2007; Lu *et al.*, 2008; Xiong *et al.*, 2008; Chen *et al.*, 2010; SanClements *et al.*, 2010; Xu *et al.*, 2013; Xue *et al.*, 2014) and density effect on plant growth (Xue and Hagihara, 1998, 1999, 2001, 2002; Driever *et al.*, 2005; Montagu *et al.*, 2005; Grechi *et al.*, 2007; Milbau *et al.*, 2007; Verónica *et al.*, 2010; Xue *et al.*, 2011), little is known about the effect of stand density on soils with a few exceptions. For example, Xu *et al.* (2008) and Yang *et al.* (2013) reported the soil fertility of young *Acacia auriculiformis* stands with different densities, Ren *et al.* (2012) and Chen *et al.* (2013) studied density influence on soil chemistry of *Larix principis-rupprechtii* forest and soil moisture of oak mixed forests, respectively. Some workers studied density effect on soil carbon in *Pinus Tabuliformis* stands (Cheng *et al.*, 2014), soil respiration of *Eucalyptus* stands (Wu, 2014) and soil properties of *Pinus massoniana* stands (Kang *et al.*, 2009).

*Tephrosia candida* is a perennial shrub belonging to *Tephrosia, Papilionaceae*. This species can improve soil fertility by the enrichment of Rhizobium on roots (Deng *et al.*, 2006) and is often planted in southern China. The relationship between density and soil nutrient in *T. candida* stands has not been reported to data. The objective of this study is to examine density effects on soil nutrients of *T. candida* stands in order to improve density and soil management for this species.

**MATERIALS AND METHODS**

The study site is located at Yuejinbei Nursery (113°21'2.12 E, 23°6'26.72 N) in South China Agricultural University, Guangzhou City, Guangdong Province, China. It is humid monsoon climate with a short winter season and hot and long summer season. Average annual temperature is approximately 19.6°C and monthly mean temperature ranges from 13.3°C in January to 28.1°C in July. The annual rainfall averages 1714.4 mm, occurring mainly between April and September which accounted for 82% of annual rainfall. Average annual relative humidity is 79%. Nursery soil is exotic soil.

One-year-old seedlings of *T. candida* (average diameter and height were 0.35 cm and 27 cm, respectively) were planted with three different densities (density of I, II and III): 2, 4 and 8 trees m\(^{-2}\) in July 2011. Each density was respectively arranged area for 15 m × 20 m with three replicates. A control plot closing these plots was set up and main undergrowth was *Miscanthus sinensis* Andress.

The soil samples were taken from the 0-40 cm soil layer from 5 different points in each of the plots, and mixed as a composite sample. The analysis of soil chemical properties were followed the methods of Institute of Soil Science, Chinese Academy of Sciences (Institute of Soil Science, 1978). The pH was determined using an electrode pH meter. The soil organic matter, total nitrogen (N), total phosphorus (P) and total potassium (K) were analyzed using the potassium dichromate oxidation-outer heating method, semimicro-Kjeldahl Method, molybdenum-blue colorimetric method, molybdenum-blue colorimetric method.
method and flame photometer, respectively. The available N, available P and available K were determined using alkali N-proliferation method, molybdenum-blue colorimetric method and flame photometer, respectively.

Urease activity was determined using a modified Conway diffusion dish, acid phosphatase activity was measured using sodium thiosulfate titrimetric method, catalase activity was determined by KMnO₄ titration method with H₂O₂ as substrate (Guan, 1986).

All statistical analysis were performed using Excel 2003 and the Statistical Analysis System (SAS 9.0) in order to test the significant difference between soils of different density stands. Differences were considered significant at the P < 0.05 level.

RESULTS AND DISCUSSION

There were not significant differences in soil pH among different density stands (Figure 1). Soil organic matter in 2 and 4 trees m⁻² stands were significantly higher than the control, while 8 trees m⁻² stand was significantly lower than the latter (P<0.05). The total N in 8 trees m⁻² stand was significantly lower than other density stands and the control (P<0.05), and total P in 4 trees m⁻² stand was significantly lower than 2 and 8 trees m⁻² stands and the control (P<0.05). Total K decreased significantly with increasing density (P<0.05). Available N decreased in the order of 4 trees m⁻² stands>2 trees m⁻² stands> the control >8 trees m⁻² stands, whereas available P and K decreased in the order of 2 trees m⁻² stands> the control > 4 trees m⁻² stands> 8 trees m⁻² stands.

Compared with the control, soil organic matter, available N and P increased in 2 trees m⁻² stands; soil organic matter and available N significantly increased, whereas total P and K, available P and K significantly decreased in 4 trees m⁻² stands. Organic matter and soil nutrient except total P significantly decreased in 8 trees m⁻² stands.

Soil enzyme system is the most active biological substances during the process of material cycling in forest ecosystems. Figure 2 showed soil urease activity significantly decreased in 2 and 8 trees m⁻² stands (P<0.05) and phosphatase activity of three density stands was significantly lower than the control (P <0.05). Catalase activity was significantly high in 4 trees m⁻² stand and low in 8 trees m⁻² stand (P<0.05) compared to the control.

![Fig 1: Soil chemical properties (mean ± SD). ck, control; I, 2 trees m⁻²; II, 4 trees m⁻²; III, 8 trees m⁻². a,b and c are the results of multiple comparisons. The same letter indicates that the difference is not significant (P>0.05).](image-url)
Organic matter and available N and P in 2 trees m⁻² stand increased comparing with the controls, which indicated that lower density was favorable to the accumulation of effective nutrients. Understory vegetation can promote nutrient enrichment in surface soil (Su, 2007). Understory vegetation and leaf litter had significant effects on soil nutrients (Kang et al., 2009), and litter decomposition restricted the rate of stand nutrient circulation to a certain extent (Wang, 2010). Low density stands characterized by low canopy density have high coverage of understory vegetation, which can result in a large amount of leaf litter of understory vegetation, accelerate the cycle of soil nutrients (Bardgett, 2005) and promote the increase of soil available N (Yang et al., 2003). Urease activity in 4 trees m⁻² stand was similar to the control, which was favorable to organic matter humification and increase of available N, and this result is consistent with its high N content in soil. In the present study, activities of three enzymes in 8 trees m⁻² stand were significantly lower than the controls and 2 and 4 trees m⁻² stands. With increasing stand density, photosynthetic capacity of trees decreases and competition for soil nutrient increases, resulting in decrease in photosynthetic products in roots. In addition, decreasing organic matter caused the phosphatase activity and available P to be reduced. Among different density stands, phosphatase activity was the lowest in 8 trees m⁻² stand, the reason may be rich leaf litter of trees that limited catalase activity during litter decomposition (Gu, 2009).

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References


