

# Effects of Shading on Photosynthetic Pigments and Photosynthetic Parameters of *Lespedeza Buergeri* Seedlings

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**Abstract.** The changes of photosynthetic pigments and photosynthesis of *Lespedeza buergeri* seedlings were observed under natural light and after 90 days of shading (45% natural light). Compared with natural light, shading significantly increased the contents of chlorophyll a, chlorophyll b, chlorophyll a+b, chlorophyll a/b ( $p < 0.05$ ), and the increase multiples were 1.67, 0.88, 1.46, 0.42, respectively. However, the content of carotenoids decreased under shading, but the decrease was not obvious ( $p > 0.05$ ). Shading significantly reduced net photosynthetic rate, stomatal conductance, transpiration rate, intercellular CO<sub>2</sub> concentration and carboxylation efficiency ( $p < 0.05$ ), and the reduction multiples were 4.56, 4.17, 4.64, 1.07 and 1.68, respectively. However, the water use efficiency increased under shading, but the improvement was not obvious ( $p > 0.05$ ). The results indicated that shading significantly inhibited photosynthesis of *L. buergeri* seedlings.

## 1. Introduction

Light is one of the key ecological factors that affect the growth, development and reproduction of plant seedlings. The physiological and ecological functions of light are mainly photosynthesis and photo morphogenesis. Light is also a key environmental factor limiting the survival and growth of forest species? With the intensification of global climate change, especially the reduction of atmospheric ozone layer, the role of light factor as environmental stress will become more and more prominent. Shading treatment can cause changes in light quality, weaken PAR [1-2], and then affect photosynthesis and photomorphogenesis [3-4]. Under shading conditions, maintaining high light use efficiency is very important for photosynthesis and photomorphogenesis of plants. The change of photosynthetic characteristics is an important means to study the light use efficiency of plants. *Lespedeza buergeri* is widely distributed in China and it is an important pioneer plant and light loving plant. It is vulnerable to forest shading. The experiment was conducted to study the effects of shading and natural light on photosynthetic pigments and photosynthetic parameters of *L. buergeri* seedlings in simulated understory (shading, 45% natural light) and gap (natural light) light environment, and to explore the adaptive mechanism of the seedlings to different light intensities.



## 2. Materials and methods

Field experiments on light control of *L. buergeri* in Miaodaoshan National Forest Park of Anqing, Anhui Province (N 30°47'31.9", E 116°06'19.9", altitude 1105m) were carried out. The average annual temperature is about 11.7 °C, the average annual rainfall is about 1450 mm, and the slope is between 10 degrees and 15 degrees. The soil is mainly mountain yellow brown soil.

In mid-July 2015, the seedlings of *L. buergeri* (about 1-2 a) were shaded. A survey of natural communities of *L. buergeri* revealed that the transmittance of the community was about 45%. For truly modelling the growth of seedlings, the light intensity of the shading was about 45% of the natural light intensity. Two treatments, natural light and shading by nylon net, were set up in the experiment. Each treatment had three replicates, and there was one seedling in each shading. After three months, leaf morphology and photosynthetic physiological indexes of *L. buergeri* under control and shade were determined.

The photosynthetic physiological indices of current-year leaves in different treatments were measured in the leaf chamber of the LED red-blue light source matched with LI-6400 photosynthetic apparatus at 9:00-11:00 Am in clear and windless conditions. The concentration of CO<sub>2</sub> was based on the local environmental CO<sub>2</sub> concentration. The gas flow rate was controlled at  $500 \pm 0.1 \mu\text{mol}\cdot\text{s}^{-1}$ . The leaf temperature in the sample chamber was controlled at  $32 \pm 3^\circ\text{C}$ , and the relative humidity was  $37 \pm 4\%$ . The PAR decreased gradually from 1000 to  $0 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  with 10 gradients. Each test was repeated 3 times. The net photosynthetic rate, stomatal conductance, transpiration rate, intercellular CO<sub>2</sub> concentration, water use efficiency and carboxylation efficiency were measured.

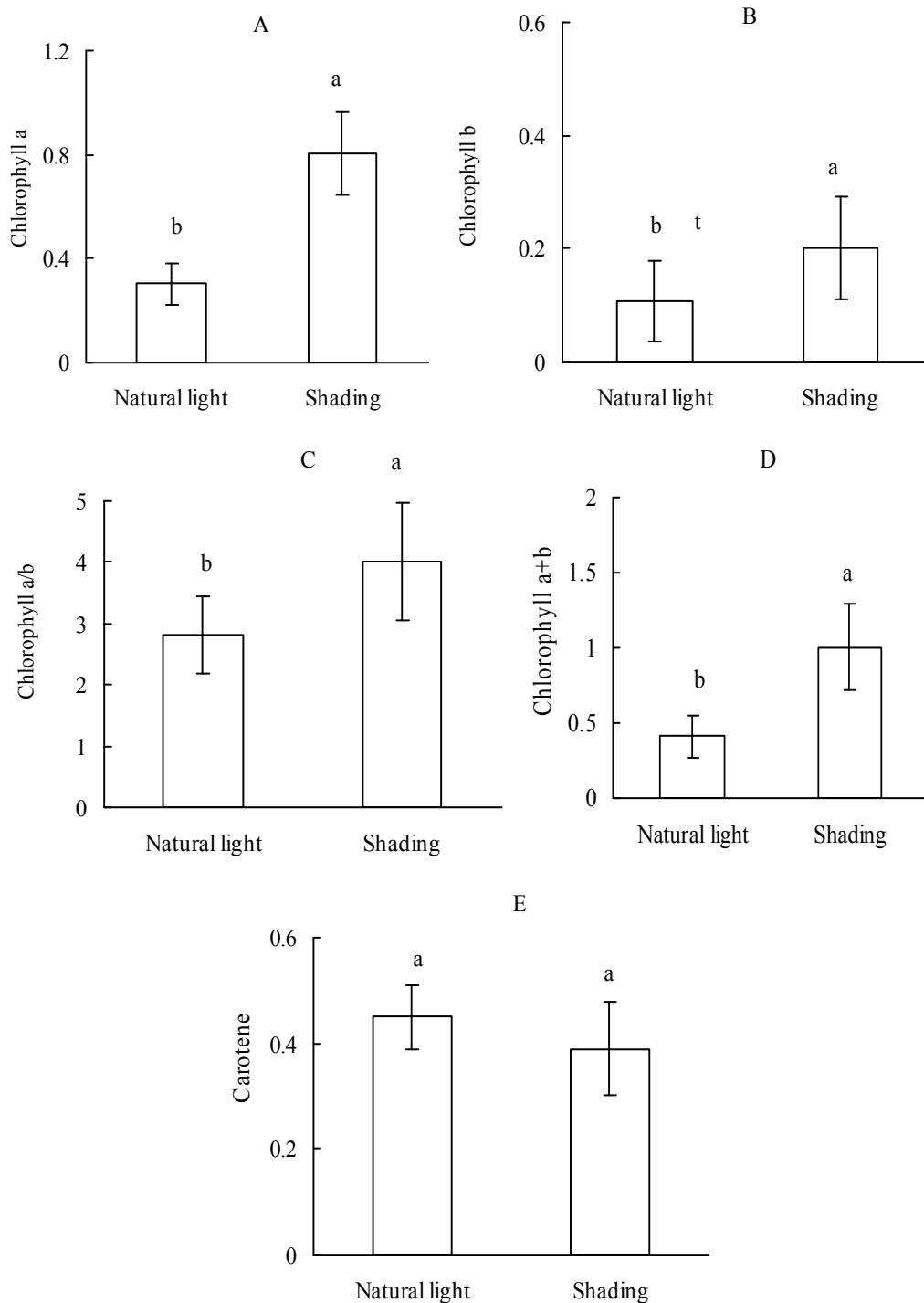
Five to ten healthy leaves were randomly collected from each plant. The photosynthetic pigments were extracted with 80% acetone. The absorbance values were measured by spectrophotometer at 663 nm and 645 nm, and the contents of chlorophyll a, chlorophyll b and carotenoids were calculated.

SPSS 13.0 (SPSS Inc., USA) software was used to analyze the differences of photosynthetic pigments and photosynthetic parameters of *L. buergeri* treated with natural light and shading.

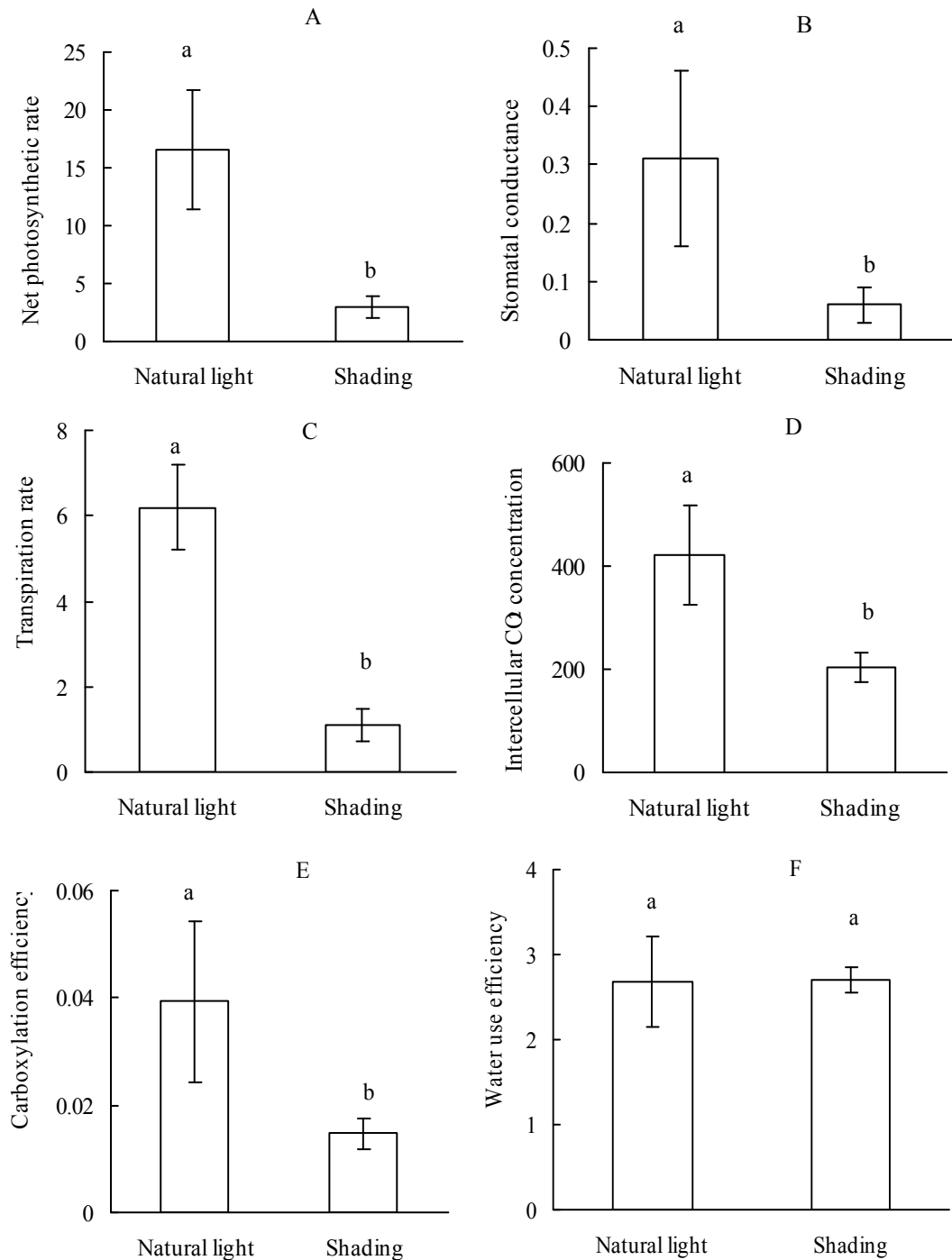
## 3. Results

Compared with natural light, shading significantly increased the contents of chlorophyll a (Fig. 1-A), chlorophyll b (Fig. 1-B) and chlorophyll a+b (Fig. 1-D) ( $p < 0.05$ ), with the increase multiples of 1.67, 0.88 and 1.46, respectively. In addition, shading significantly increased the chlorophyll a/b (Fig. 1-C) ( $p < 0.05$ ), and the multiple increased by 0.42. However, the content of carotenoid (1-E) decreased under shading, but the decrease was not obvious ( $p > 0.05$ ).

Compared with natural light, shading significantly reduced net photosynthetic rate (Fig. 2-A), stomatal conductance (Fig. 2-B), transpiration rate (Fig. 2-C), intercellular CO<sub>2</sub> concentration (Fig. 2-D) and carboxylation efficiency (Fig. 2-E) ( $p < 0.05$ ), with multiple reductions of 4.56, 4.17, 4.64, 1.07 and 1.68, respectively. However, the water use efficiency increased under shading (map 2-F), but the improvement was not obvious ( $p > 0.05$ ).



**Figure 1.** The leaf photosynthetic physiological characteristics of *L. buergeri* in natural sunshine and shading (A Chla,  $\text{mg}\cdot\text{g}^{-1}$ , B Chlb,  $\text{mg}\cdot\text{g}^{-1}$ , C Chla/b, D Chla+b,  $\text{mg}\cdot\text{g}^{-1}$ , E Car,  $\text{mg}\cdot\text{g}^{-1}$ )



**Figure 2.** The leaf photosynthetic physiological characteristics of *L. buergeri* in natural sunshine and shading (A Net photosynthetic rate,  $P_n$ ,  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ; B Stomatal conductance,  $G_s$ ,  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ; C Transpiration rate,  $T_r$ ,  $\text{mmol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ; D Intercellular  $\text{CO}_2$  concentration,  $C_i$ ,  $\text{mol}\cdot\text{mol}^{-1}$ ; E Carboxylation efficiency,  $CE$ ,  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ; F Water use efficiency,  $WUE$ ,  $\text{mmol/mol}$ )

Light is an essential ecological factor for plant growth and development. Naturally grown seedlings experience extreme fluctuations in the light environment, mainly long-term low light under the forest and unpredictable gap light. Leaf is the main organ of photosynthesis in plants, and changes its external or internal characteristics through a variety of ways to adapt to changes in heterogeneous light

environment. Therefore, leaf characteristics are a better characterization of plant response to light environment. Understanding the photosynthetic response mechanism of plants to this heterogeneous light environment is very important to reveal the ecological distribution and coexistence of plants. The shading environment under the forest can change the light quality, light intensity, light time and illumination angle, and then change the air humidity and temperature [3-4], which plays an obvious role in controlling the growth and development of plants [5-6].

The response of plant leaves to different light environments is a hot research topic. Different light environments are characterized by differences in light changes, thus forming different spatial-temporal heterogeneous environments such as water, heat and nutritional conditions to meet the needs of plant regeneration in different functional groups. The same plant responds to its heterogeneous light environment in one or more intrinsic and extrinsic ways, such as chlorophyll content (Chl) and leaf specific weight [7]. With the decrease of light intensity, plants increase the interception of low light by increasing chlorophyll content to ensure maximum photosynthetic carbon accumulation [8-9]. The results showed that chlorophyll a, chlorophyll b, chlorophyll a+b and chlorophyll a/b in the seedlings of *L. buergeri* increased significantly under simulated shading, which indicated that the seedlings adapted to the decrease of light duration and photosynthetically active radiation, which was beneficial to the photosynthesis of *L. buergeri* seedlings in low light environment.

Shading also causes the changes in photosynthetic parameters of plants [8-9]. Studies have shown that under low light, plant vapor pressure deficit increases, thereby reducing transpiration rate, affecting leaf absorption and transport of water and key mineral elements, further reducing plant photosynthesis. Our study also confirmed that shading also reduced the photosynthetic parameters of *L. buergeri* seedlings, such as net photosynthetic rate, stomatal conductance, transpiration rate, intercellular CO<sub>2</sub> concentration and carboxylation efficiency. The results showed that the leaves of *L. buergeri* seedlings under shade could compensate for the inhibition of low light on plant growth by reducing the yield of photosynthetic assimilates.

#### 4. Conclusion

Shading can obviously inhibit photosynthesis of plants, especially for *L. buergeri* with photosynthetic characteristics. In the scheme of vegetation restoration with *L. buergeri*, the change of pigment and photosynthesis of *L. buergeri* should be fully satisfied in its growth and development, so as to ensure a certain growth rate and quantity, thereby shortening the production cycle and improving the efficiency of community restoration.

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