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PHOTOSYNTHETIC CHARACTERISTIC OF AN ENDANGERED SPECIES *CAMELLIA NITIDISSIMA* AND ITS CONSERVATION IMPLICATIONS

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Abstract

Camellia nitidissima is a shrub and a famous ornamental species with golden-yellow flowers. The responses of net photosynthetic rate (Pn) to the incident intensity (PFD) and the diurnal course of variation in major physiological and environmental variables of young and mature *C. nitidissima* were studied with LI-6400 (Li-Cor Inc., USA) portable photosynthesis system. The results showed that the leaves of *C. nitidissima* had the highest photosynthetic ability in autumn, the middle level of photosynthesis in summer and spring, and a relatively lower level of photosynthesis in winter. Mature plants of *C. nitidissima* had both relatively high the maximum net photosynthesis rate (Pmax) and light saturation point (LSP), indicating a good adaptability to both strong and weak lights; young plants of *C. nitidissima* had both relatively low *Pmax* and *LSP*, indicating a good adaptability to weak light, but a depression under strong light. *C. nitidissima* is a shade loving plant and should be planted in shade habitat. Some suggestions for the management of the species are proposed.

Introduction

Photosynthesis determines how much light energy a plant absorbs and the amount of organic matter the plant accumulates, it is the foundation of other physiological processes and life activities, and it is highly related to the growth, development and survival of the plant. Thus, researches on the physiological and ecological characteristics of photosynthesis provide theoretical basis for further investigation into the intra mechanisms of the existence and distribution pf a plant species (Macarthur & Connell, 2002). Light is one of the major environmental factors influencing growth and distribution of plant species. Measuring photosynthetic responses to light can provide information on tolerance of a species to a range of light conditions and has been useful in agriculture and horticulture (Valladares *et al*., 2002).

Camellia nitidissima is a shrub and a famous ornamental species with golden-yellow flowers. It is distributed in a small region of Guangxi Province, South China, and North Vietnam (Liang 1993). In China, It is restricted to Nanning city, Fangcheng, Fusui and Long an counties, southwestern Guangxi (Su & Mo 1988). Due to the deforestation and destructive collection of the seedlings, its natural population size has declined greatly in recent decades, and it is now classified as one of the most endangered plant species in China (Fu, 1992). Various aspects of *C. nitidissima* have been studied including its morphology (Ye & Xu 1992), ecology (Su, 1994; Huang, 2001) and genetic diversity (Bin *et al*. 2005, Tang *et al*. 2006). However, photosynthetic characteristic of *C. nitidissima* is not well understood. The aim of this project was to study the photosynthetic characteristics of *C. nitidissima* in response to light and assist in the development of conservation strategies.

Materials and methods

The experimental materials were the 3 year and 17 year mature plants of cultivated *C. nitidissima* in Guangxi Botanical Institute, Yanshan, Guilin, China. The original seeds of the plants were collected from Fangcheng county of Guangxi province. The 17 year plants had an average height of 313.60±15.92 cm, base diameter 4.51±0.71 cm, and canopy range 277.6×219.2 cm (east-west × north-south). The 3 year seedlings had an average height of 30.60±1.8 cm, base diameter 0.81±0.21 cm, and canopy range 25.6×24.2 cm (east-west × north-south).

The diurnal change of photosynthesis and light response curve of the leaves of *C. nitidissima* were measured with a Li-6400 portable photosynthesis system (LI-COR, Lincoln, Nebraska, USA). The leaves in the middle on the sun facing 1 year branch in the outside layer of the middle part of the plant canopy were selected for the measurements, and 5 plants for 3 year and 17 year respectively were selected with 1 leaf each being measured.

The diurnal change of photosynthesis: The measurements were made under natural light (The irradiance below the canopy is about 35% of full sunlight) and ambient air CO_2 concentration on June 20, 2005, a sunny day. Measurements with 5 leaves of 17a plants at each time were made at 1h intervals from 7:00-18:00 local time. The following physiological parameters were determined: the net photosynthetic rate (P_n), transpiration rate (T_r), stomatal conductance (G_s), intercellular CO_2 concentration (C_i) and vapor pressure difference (VPD); the environmental parameters included photosynthetic active radiation (PAR), ambient temperature (T_a), ambient CO_2 concentration (C_a) and air relative humidity (RH).

Light response curve: The leaves were put under 380 $\mu mol\ m^{-2}\ s^{-1}$ with the red and blue radiation source in the photosynthesis system for 10 min, and then photosynthesis with an open air source was measured at flow rate of 500 $cm^3\ min^{-1}$, leaf temperature of 25°C, CO_2 concentration of 370 $\mu mol\ mol^{-1}$, and irradiances of 1 500, 1 200, 1 000, 800, 600, 400, 200, 100, 50, 20, 10, and 0 $\mu mol\ m^{-2}\ s^{-1}$. Each measurement was made for 3 min at each irradiance. Measurements were taken on sunny days from 9-11 am, respectively on January 20 (winter), May 20 (spring), July 21 (summer) and September 21 (autumn), 2005 for the determination of the gas exchange parameters of the leaves of *C. nitidissima*.

Data analysis: The apparent quantum yield (AQY) was calculated as the slope of the linear regression of the irradiance response curve below 200 μmol $m^{-2}s^{-1}$ (Li *et al*., 1998). The maximum net photosynthesis rate (P_{max}), light saturation point (LSP) and light compensation point (LCP) were found by the method of Bassman & Zwier (1991). The photosynthetic data were analyzed by one-way ANOVA with SPSS13.0 (SPSS, USA).

Results

Diurnal changes of the environmental factors at the investigation site are shown in Fig. 1. The apparent photosynthetic active radiation reaches the maximum value of 192.3 μmol · m^{-2} · s^{-1} at about 12:00, and declines to merely 7.5 μmol · m^{-2} · s^{-1} at 18:00. The light intensity maintains above 80 μmol · m^{-2} · s^{-1} for about 7 hours in the day, during which period the Pn remained in the range of 1-3 μmol · m^{-2} · s^{-1}. The air CO_2 concentration is the highest in the early morning, and declines rapidly before 11:00 hours, then slowly rises again after about 14:00 hours. Ambient temperature shows a similar diurnal pattern as light, but it lags behind light changes as it reaches the maximum at about 13:00 hours and declines afterward. The air relative humidity declines after sunrise, reaches the lowest value of 57.4% at about 13:00 hours, and rises after 14:00 hours.

Diurnal changes of the photosynthetic parameters: The diurnal changes of the photosynthetic parameters of *C. nitidissima* leaves are shown Fig. 2. Pn shows a diurnal pattern similar to that of the PAR. With the increase of PAR, the Pn of *C. nitidissima* increases and reaches its maximum value at about 12:00; then it decreases as light decreases. The diurnal changes of the G_s and Tr of *C. nitidissima* are similar to those of Pn, generally rising before 12:00, reaches maximum at this time and declines later. The highest C_i of *C. nitidissima* leaves occurs in the morning and the lowest at noon, and then rises in the afternoon, showing a pattern that is different from that of Pn.

The light response curves of *C. nitidissima* in different seasons are shown in Fig. 3. From light intensity 0 to150 μmol · m^{-2} · s^{-1} , Pn increases linearly; with further increases of light intensity, the increase of Pn slows down; after light intensity reaches the saturation point, variations in Pn are small with further light increases. In general, Pn of *C. nitidissima* leaves changes seasonally. When light is more than 50 μmol · m^{-2} · s^{-1}, the order of Pn from high to low is from autumn to summer, spring and to winter. The P_{max}, LSP, LCP and AQY of *C. nitidissima* are summerized in Table 1. The leaves of *C. nitidissima* displayed significant seasonal differences in P_{max} and AQY. P_{max} had the trend of autumn > summer > spring > winter, and AQY had the trend of autumn > spring = summer > winter.

The light response parameters of the leaves of the young and mature plants of *C. nitidissima*: The light response parameters of the leaves of the young and mature plants of *C. nitidissima* are given in Table 2. P_{max} and LSP of the mature plants are significantly higher than those of the young, and the LCP of the young plants is significantly higher than that of the mature.

Discussion

In the present study, the light intensity in the habitat of *C. nitidissima* was very low in the whole day. Under a forest it is mostly the scattered light which is utilized efficiently without the mid-day light depression phenomenon. The net photosynthetic rate was low due to weak light, and the diurnal change of the photosynthetic parameters may be mainly affected by the diurnal change of light intensity

There existed significant differences in Pmax of leaves of *C. nitidissima* in different seasons. The leaves of *C. nitidissima* had stronger photosynthesis in autumn than in summer and spring, the lowest was in winter. The LSP and LCP of the leaves of a plant reflect the light radiation condition required by the plant. Plants with both low LSP and LCP are typical shade plant, otherwise sun plant. Both the LSP and LCP of *C. nitidissima* were low in all the 4 seasons, indicating *C. nitidissima* was a shade plant. In a population of *C. nitidissima*, if the upper covering foliage of some plants disappeared which exposed them to full sunshine, the leaves of such plants turned yellow and the branches gradually withered, and the plants would die if the environment was kept unchanged (Su, 1994). In our field investigations we also found that *C. nitidissima* grew under forest with 75% coverage upper foliage, mostly in the shrub layer under a forest.

Photosynthesis is an important physiological process, and the photosynthetic ability is determined by the affection of heredity and environmental conditions (Zhu *et al*., 2004). Generally, the variation in the photosynthetic rates reflected the adjustment to the growth environment (Rawat & Purohit, 1991; Zhang *et al*., 2005). In summer, LSP, LCP, Pmax and AQY of mature plants of *C. nitidissima* were respectively 354.30μmol · m^{-2} · s^{-1}, 5.51μmol · m^{-2} · s^{-1}, 2.77 μmol · m^{-2} · s^{-1} and 0.039 μmol · mol^{-1} · the LSP, LCP, Pmax and AQY of young plants were respectively 308.99 μmol · m^{-2} · s^{-1}, 13.93 μmol · m^{-2} · s^{-1}, 1.61 μmol · m^{-2} · s^{-1} and 0.025 μmol · mol^{-1} photons. The sun-facing leaves of the general no-tropical evergreen trees have LCP of 10-30, LSP 600-1000, Pmax 6-12μmol · m^{-2} · s^{-1} (Zai *et al*., 1997); and for well-grown plants, the AQY is commonly among 0.04-0.07 μmol $μmol^{-1}$ (Long *et al*., 1994). *C. nitidissima* had a good adaptability to weak light with low LCP, yet its AQY was also low under weak light. Mature plants of *C. nitidissima* had both relatively high P_{max} and LSP, indicating a good adaptability to both strong and weak lights; young plants of *C. nitidissima* had both relatively low P_{max} and LSP, indicating a good adaptability to weak light, but a depression under strong light.

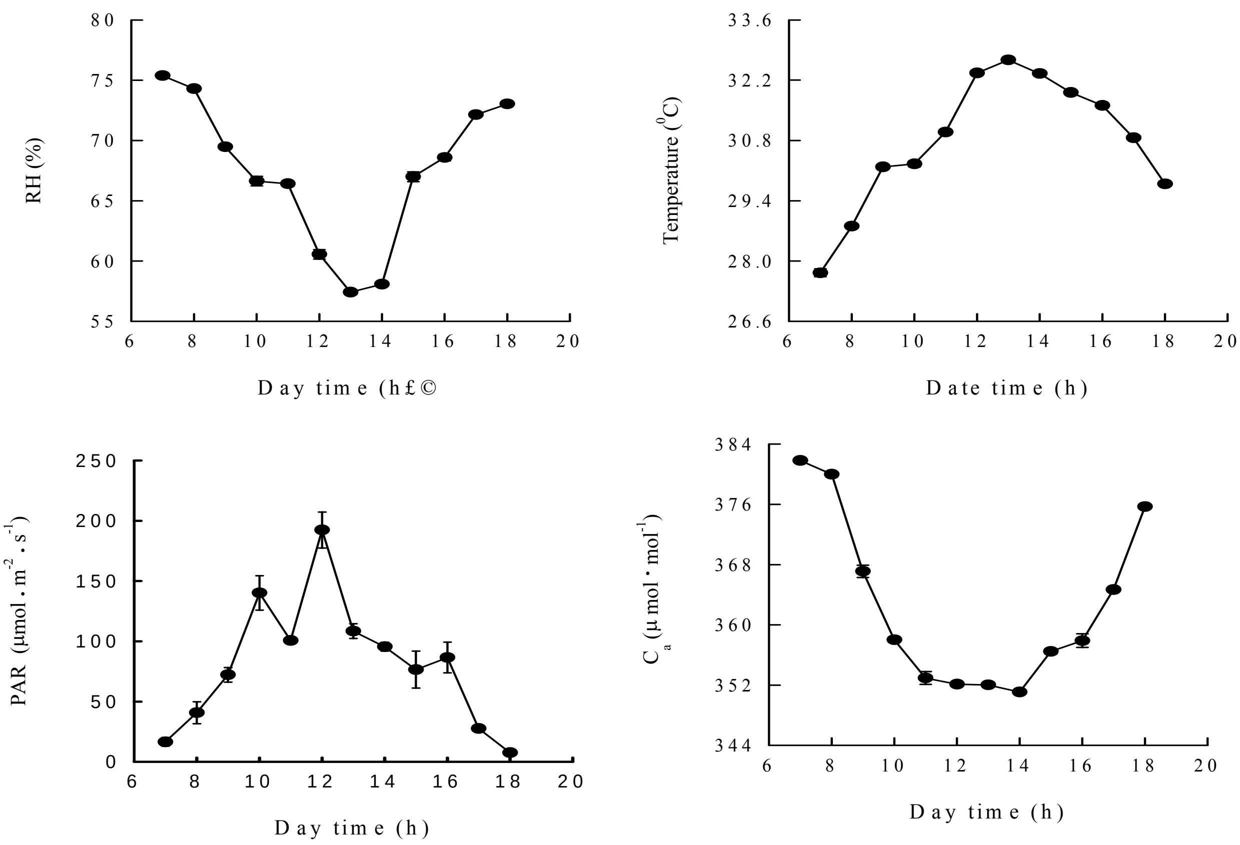

Fig. 1. Diurnal course of variation in environmental factors.

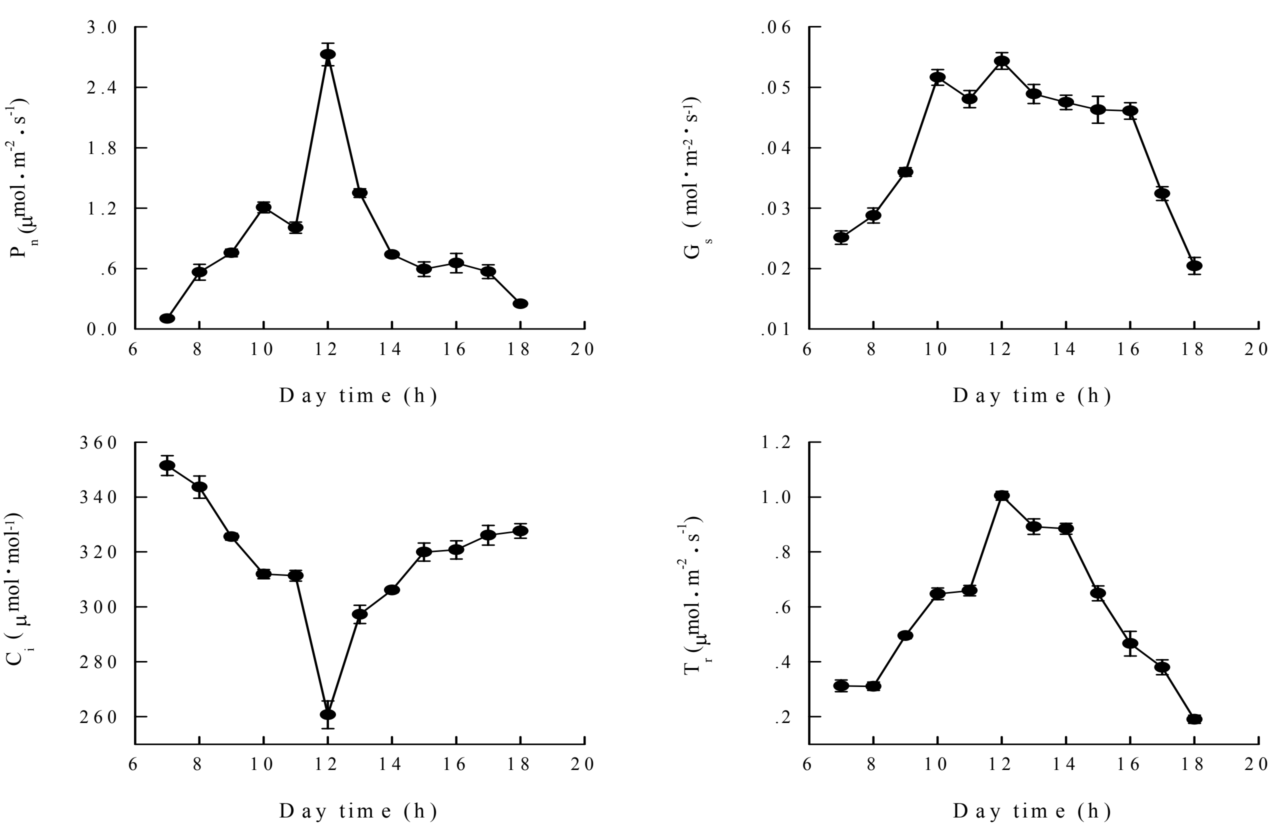

Fig. 2 Diurnal course of variations in photosynthetic variables of *C. nitidissima*.

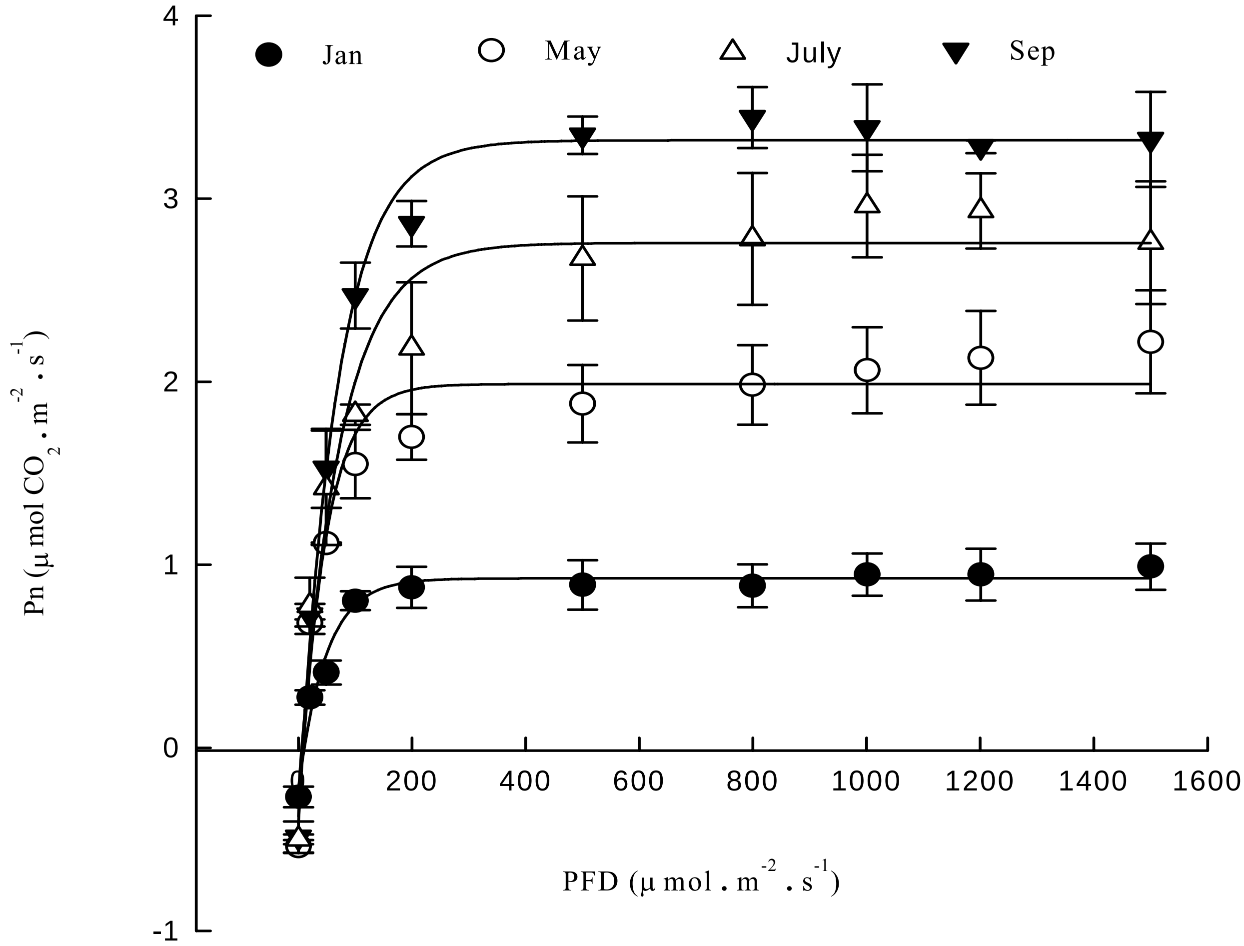

Fig. 3. Light responses of photosynthesis in the leaves of *C. nitidissima* in different seasons.

Table 1. The light-response parameters of *C. nitidissima* in different seasons

Parameters [1/]	**P_{max} (μmol · m^{-2} · s^{-1})**	**LSP (μmol · m^{-2} · s^{-1})**	**LCP (μmol · m^{-2} · s^{-1})**	**AQY (μmol · mol^{-1} photons)**
Spring (May)	2.14 [a]	275.0 [a]	8.23[a]	0.04[a]
Summer (July)	2.77[b]	354.3[a]	5.51[a]	0.04[a]
Autumn(September)	3.30 [c]	326 .0[a]	5.82[a]	0.05[a]
Winter (January)	0.96[d]	255.0[a]	11.48[a]	0.02[b]

[1/] Numbers of the same parameter marked by different letters are statistically different at 5% level

Table 2 The light-response parameters of young and mature *C. nitidissima*

Parameters [1/]	**P_{max} (μmol · m^{-2} · s^{-1})**	**LSP (μmol · m^{-2} · s^{-1})**	**LCP (μmol · m^{-2} · s^{-1})**	**AQY (μmol · mol^{-1} photons)**
Mature plant	2.77[a]	354.30[a]	5.51[a]	0.039[a]
Young plant	1.61[b]	308.99[b]	13.93[b]	0.025[a]

[1/] Numbers of the same parameter marked by different letters are statistically different at 5% level

According to the analysis of its photosynthetic physiology and ecological factors, *C. nitidissima* has stringent requirement for light radiation. In nature it grows in forests of shady wet places in valleys or by stream sides in mountains or hill at 50-500 m altitudes and scattered in northern tropical monsoon forests and southern subtropical evergreen broad-leaf forests with the upper canopy coverage above 75%, obtaining shade philic and tolerant characteristics to become a shade plant (Fu, 1992). Therefore, the original habitat environment of *C. nitidissima* should be protected as much as possible *in situ* conservation protection, especially the upper layer tree species, with adequate clearance of other same layer shrubs. It is important to shade the plants especially the young saplings for increased net photosynthetic rate and normal growth of the plant in artificial cultivation of *C. nitidissima*.

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