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Study on Leaf Photosynthetic Characteristics of Field Sandbur (*Cenchrus pauciflorus* Benth.) in China

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Abstract: The photosynthetic characteristics of *Cenchrus pauciflorus* was investigated during full sunny days of July, 2010, which is an invasive weed in China. The diurnal variations of *C. pauciflorus* transpiration rate (Tr) and photosynthetic active radiation (PAR) showed a single-peak. The maximum value of Tr was 4.94 mmol/(m^2•s) and the maximum value of PAR was 1704 μmol/(m^2/s).The net photosynthetic rate showed a double-peak with a considerable noon inhibition that was a the stomatal limitation type. The first peak value of the Pn was 0.94 μmol/(m^2/s) at about 11am and the second was 2.14 μmol/(m^2•s) at about 2 pm. The first peak value of the PAR was 0.149 mol/(m^2/s) at 8am of the day time and the second was 0.167 mol/(m^2/s) at about 3 pm. The Apparent quantum efficiency (AQY) of *C. pauciflorus* was 0.0132 mol/mol. The change was positively related to variations of Gs and Tr. The light saturation of *C. pauciflorus* was about 1500 μmol/(m^2/s) with compensation points 20.68 μmol/(m^2/s) and apparent quantum yield 0.0132 mol/mol. The results indicated that *C. pauciflorus* showed an obvious midday depression photosynthetic characteristic with a high LSP and a low AQY. It was concluded that *C. pauciflorus* was a typical sun loving plant with a poor shade tolerance.

Key words: Invasive plants · *Cenchrus pauciflorus* Benth · Photosynthesis · Sunlight

INTRODUCTION

Cenchrus pauciflorus Benth, which is also called Field sandbur, Coastal sandbur, *Tribulus terrestris* grass or nettles, belongs to an annual family gramineae xeric herb species native to America [1]. It is included in the list of harmful plants by Russia, the U.S and other countries [2, 3]and also one of the 22 invasive agricultural species classified by Institute of Environment and sustainable Development in Agriculture, CAAS (IEDA) [4]. It distributes in Liaoning, Inner Mongolia, Jilin, Fujian, Taiwan, Guangdong, Hong Kong, southern Guangxi and Yunnan provinces of China and has became a harmful weed in peanuts, corn, orchards and other farmlands [5, 6]. *C. pauciflorus* has strong adaption to environment. The seeds have a high germination rate and could germinate once the condition becomes suitable. Once introduced to the ranch, abandoned lands or roadside, it would expanded rapidly while the growth of other plants were restrained by its interference and within a few years *C. pauciflorus* can become the dominant species of the community [7, 8]. This study aimed to investigate the photosynthetic characteristics of *C. pauciflorus* and to further explore the relationship between its invasion mechanism and the environmental factors. The knowledge obtained may have important implications for better evaluation and effectively control of this species.

MATERIALS AND METHODS

General Situation of Experimental Field: The experiment was carried out in the Institute of Sandy Lands Improvement and Use of Liaoning in Zhangwu (42°07'-42°51'N, 121°53'-122°58'E), Liaoning province, China in which is the border of Liaoning and Inner Mongolia, northeast of Liaoning Province and south of Korqin sandy land. The landscape mainly takes the form of hills in the north and plains in the center and south in the region. The climate in the region is temperate. The average annual temperature is 7.2°C and the annual precipitation is 510 mm. Rainfall normally occurs during the period July to August and there are many windy days. With adequate lighting the temperature difference between day and night is high.

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Determination Methods: During July 6, 2010, at the stage of vegetative growth of *C. pauciflorus* populations, 3 leaves per plant were selected randomly, Pn, Gs, Tr, PAR were detected every hour from 8 am to 5 pm with CIRAS-1 portable photosynthesis system in full sunny day of July 6th, 2010. The average values were used to make a curve of daily photosynthesis change and photosynthesis-light intensity response. The LSP, LCP and AQY of the species were calculated out.

RESULTS

Diurnal Variation of the Photosynthesis of *C. Pauciflorus*

Diurnal Variation of Net Photosynthetic Rate (Pn): The curve of net photosynthetic rate of *C. pauciflorus* showed a double-peak type. In the morning the increase of effective radiated light caused net photosynthetic rate to rise gradually until 11 am. Later, the rate decreased and reached the minimum -0.01 μmol / (m^2•s) at noon showing a midday depression. Afterwards the rate increased and reached the maximum 2.14 μmol / (m^2•s) at 2 pm, then gradually decreased to 0 at 5 pm (Fig.1).

Diurnal Variation of Stomatal Conductance (Gs): The type of *C. pauciflorus* stomatal conductance was a double-peak. The maximum value was 0.167 mol/(m^2•s) at 3 pm and the minimum was 0.025 mol/(m^2•s) at noon, indicating that *C. pauciflorus* has strong capacity to regulate stomatal aperture.(Fig.2).

Diurnal Variation of Transpiration Rate (Tr): Changing tendency of transpiration rate was similar to that of net photosynthetic reaching the maximum 4.94 mmol/(m^2•s) at 2 pm. Changing tendency of transpiration rate changes, net photosynthetic rate and stomatal conductance were similar to each other (Fig.3). This might be because the plant could adjust the stomatal aperture, according to their situation and environment change. In this way, it could maintain normal physiological activities of plants and accomplish maximum fixation of CO_2 and minimum loss of water [9].

Diurnal Variation of Photosynthetic Active Radiation (PAR): Diurnal available radiation of photosynthesis increased smoothly in the morning until it reached its peak value 1704 μmol/(m^2•s) at 2 pm and decreased rapidly after 3 am (Fig.4).

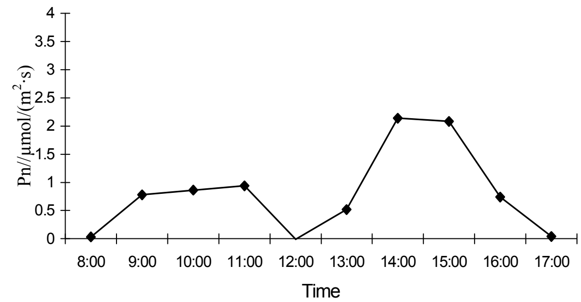

Fig. 1: Diurnal Pn of the leaves of *C. pauciflorus*

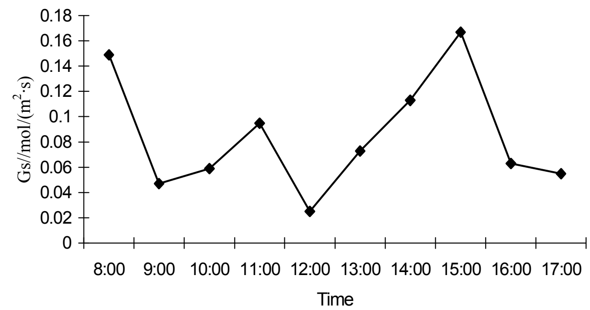

Fig. 2: Diurnal Gs of the leaves of *C. pauciflorus*

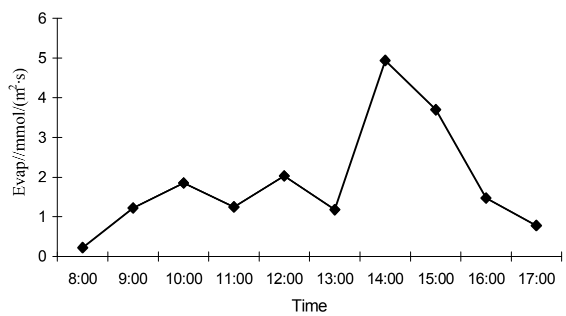

Fig. 3: Diurnal Tr of the leaves of *C. pauciflorus*

Photosynthesis-luminous Intensity Response Curves of *C. Pauciflorus*

Light Compensation Point and Light Saturation Point (LCP and LSP): Without change of other conditions, the net photosynthetic rate changed as PAR intensity changed. The results were made into two light response curves. When PAR was 0 ~ 200 μmol/(m^2•s), net photosynthetic rate continued to rise with the increase of PAR. When the net photosynthetic rate was 0 μmol/(m^2•s), the PAR was 20.68 μmol/(m^2•s) and also was the LCP of *C. pauciflorus*. When the PAR was above 200 μmol/(m^2•s), the net photosynthetic rate increased slowly. When PAR was 1500 μmol/(m^2•s), net photosynthetic rate was maximum. Net photosynthetic rate decreased later (Fig.5). From the results, we can see that *C. pauciflorus*

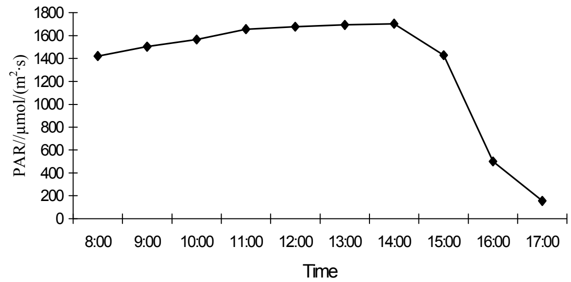

Fig. 4: Diurnal PAR of the leaves of *C. pauciflorus*

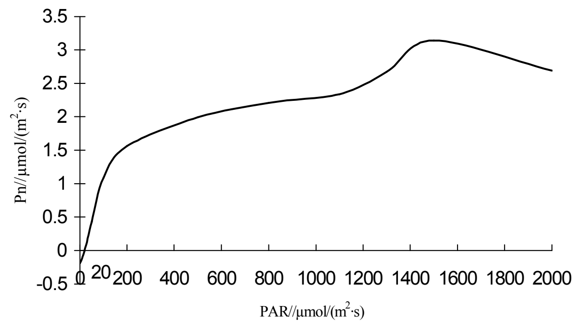

Fig. 5: Light responses of the leaves of *C. pauciflorus*

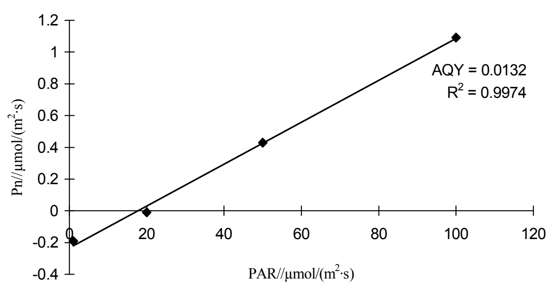

Fig. 6: Apparent quantum yield of the leaves of *C. pauciflorus*

was a typical sun plant with a high LSP. Photosynthetic rate and transpiration rate of Tribulus grass were decreased as light intensity decreased and the maximum net photosynthetic rate was 3.14 μmol/(m^2•s).

Apparent Quantum Efficiency (AQY): AQY of plants reflects the ability to use the light[9,10]. In a low light condition, light intensity was the main factor to control photosynthesis, so at this time the **AQY** was the slope of Photosynthesis-luminous intensity curve. The larger was the slope of the curve, the stronger was the ability of plants using light of low intensity [11-14]. **AQY of** *C. pauciflorus* was 0.0132 mol/mol, lower than the range of common plants (0.03 ~ 0.05 mol / mol) [10], which suggested that *C. pauciflorus* was at a low level of adaptation to poor light.

DISCUSSION

The curves of daily variation of Pn and Gs of *C. pauciflorus* showed double-peak types, indicating that there was a photosynthetic midday depression of this species. The mechanism of reducing water evaporation and regulating stomatal aperture increased its drought-resisting ability.

The LCP of *C. pauciflorus* was 20.68 μmol/(m^2•s) with LSP 1500 μmol/(m^2•s) and Pn 1.63 μmol/(m^2•s), which indicated that *C. pauciflorus* was an adaptable species and had high photosynthetic efficiency and strong ability of invasion, whereas the AQY of *C. pauciflorus* was only 0.0132, which meaned low efficiency of AQY [15, 16]. Our results indicated that it was sun plant and of poor tolerance of shade. This might be helpful for further exploring the invading mechanism of *C. pauciflorus* and also provide theoretical basis for the selection of alternative plants.

Study on the Photosynthetic Characteristics of *C. pauciflorus* Benth still needs more research on the saturation and compensation point of CO_2 because they are helpful to understand the mechanisms of invasion and competition and be useful to provide the basis for preventing and controlling *C. pauciflorus* species.

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