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Photosynthesis and transpiration of Chicory with different irrigation treatments in Beijing

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Introduction Water deficit usually influences photosynthesis, causing stunted growth and development, and further reduces yield of forage (Flexas et al. 2004). Knowledge gained from studying photosynthesis and transpiration of chicory at different irrigation levels is essential for growing plants in a water stressed area like Beijing.

Materials and methods The experimental site, with a mean temperature of 12.2 °C and an average annual precipitation of 518.3 mm, was located in Shunyi County in the northeast of Beijing. Chicory was seeded in spring at a rate of 12 kg/hm². The plot area with 3 replications was 5m×10m each, and the space between plots was 2 m. Buffer areas were covered by plastic film to prevent water infiltration. Three different irrigation treatments of 60 mm (CK, 600 m³/hm²), 40 mm (MS), and 20 mm (SS) water were applied for regrowth after 4 and 5 mowings in 2002 and in 2003, respectively. The diurnal changes of photosynthesis (Pn) and transpiration (Tr) of chicory were measured for the different treatments and different stages of leaf, bolting, and budding using CIRAS-1 Cassettes Photosynthesis System (PPS Co., Ltd., UK). On sunny days, four mature leaves of chicory in each plot were selected randomly to measure every 2 hours from 08:00 to 18:00 and to calculate the average Pn and Tr.

Results The diurnal change of leaf Pn showed the "S" shape with the first peak occurring at 10:00, the second at 14:00, and the trough at 12:00. The diurnal change of Tr was similar to Pn, but peaks and the trough were delayed by 1-2 hours compared with Pn. The average Pn and Tr changes (Table 1) showed soil water content had a great influence on photosynthesis and transpiration of chicory's leaves. A quadratic relationship existed between the Pn and Tr at the different soil water contents. CK: $P_n = -0.3365 \times Tr^2 + 8.4787 \times Tr - 34.453$ ($R^2 = 0.5563$, $P < 0.05$); MS: $P_n = -0.3287 \times Tr^2 + 7.8767 \times Tr - 30.757$ ($R^2 = 0.5415$, $P < 0.05$); SS: $P_n = -0.0414 \times Tr^2 + 1.7927 \times Tr - 3.8072$ ($R^2 = 0.4274$, $P < 0.05$), due to the effects of stomatal movement on both rates and the lag in response of transpiration (Gao 1999).

At low soil water levels, the stoma closed in order to decrease water loss from chicory's leaves. It appeared the response of chicory to the water shortage at the bolting stage and bud stage were more sensitive than that at the leaf stage. The results showed that a quadratic relationship existed between Pn and Tr, and it was essential if normal photosynthesis and transpiration were to occur, plants needed irrigation for regrowth after each harvest in Beijing.

Table 1 The Pn and Tr of chicory's leaves at different irrigation treatments.

treat- ments	leaf stage			bolting stage			bud stage			
	average	peak	trough	average	peak	trough	average	peak	trough	
Pn $\mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$	CK	17.93±1.03 ^a	28.12±0.74 ^a	19.15±0.81 ^a	12.83±1.62 ^a	21.60±1.25 ^a	12.96±1.49 ^a	14.07±1.11 ^a	25.80±0.75 ^a	14.58±0.84 ^a
	MS	15.17±0.88 ^a	26.57±0.63 ^a	15.93±0.67 ^b	10.90±1.56 ^a	19.73±1.14 ^a	11.55±1.35 ^a	11.64±0.92 ^b	23.33±0.67 ^a	10.72±0.62 ^b
	SS	7.51±0.43 ^b	18.05±0.36 ^b	5.68±0.38 ^c	6.30±1.04 ^b	15.24±0.88 ^b	5.65±0.96 ^b	6.51±0.33 ^c	16.55±0.33 ^b	5.15±0.30 ^c
Tr $\text{mmol H}_2\text{O} / (\text{m}^2 \cdot \text{s})$	CK	10.74±0.62 ^a	14.68±0.66 ^a	11.79±0.56 ^a	11.39±0.68 ^a	15.88±0.85 ^a	11.79±0.48 ^a	11.76±0.92 ^a	15.93±0.92 ^a	12.15±0.45 ^a
	MS	10.27±0.59 ^a	13.74±0.60 ^a	10.92±0.78 ^a	10.38±0.59 ^a	14.23±0.79 ^a	10.30±0.39 ^a	10.31±0.82 ^a	14.11±0.81 ^a	9.93±0.52 ^{ab}
	SS	5.73±0.33 ^b	8.64±0.40 ^b	5.38±0.35 ^b	7.01±0.44 ^b	10.38±0.50 ^b	7.01±0.70 ^b	7.72±0.60 ^b	11.03±0.64 ^b	7.34±0.20 ^b

Note: average-average of Pn from 08:00 to 18:00; peak-Pn of 10:00; trough-Pn of 12:00. average-average of Tr from 08:00 to 18:00; peak-Tr of 12:00; trough-Tr of 14:00. Different superscript letters in the same column indicate the significant difference at a $P < 0.05$ level.

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