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Photosynthetic characteristics of linze jujube in conditions of high temperature and irradiation

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Abstract

Linze jujube (*Zizyphus jujuba* Mill. var. *inermis* (Bunge) Rehd.) is a unique native selection with high-quality fruits. Photosynthetic capacity was evaluated under high temperature and irradiation using CO_2 exchange and chlorophyll fluorescence parameters. The diurnal course of net photosynthetic rate (P_n) was bimodal. The first peak occurred around 10:00 from late June to August. The second peak occurred around 17:00 during late June to late July with high temperature and intense sunlight, but around 16:00 in late August with lower temperature and irradiation. A clear midday depression of P_n lasted from 12:00 to 16:00 from late June to late July, but it was less clear in late August. The light compensation point and light saturation point of P_n were 28 and 1000 μmol m^{-2} s^{-1}, respectively, and the CO_2 compensation point and CO_2 saturation point of P_n were 64.3 and 677.5 μmol mol^{-1}, respectively in late July. Under the conditions of high temperature ($T_a > 40$ °C) and irradiation (PFD $>$ 2000 μmol mol^{-1}), photochemical efficiency of PS II (F_v/F_m) changed little between 0.78 and 0.84 all day, without photochemical damage. It was concluded that under the conditions of high temperature and irradiation, the midday reduction of P_n

Abbreviations: P_n, net photosynthetic rate; PPFD, photosynthetic photon flux density; G_s, stomatal conductance; PFD, photon flux density; VPD, vapor pressure deficit; RH, air relative humidity; T_l, leaf temperature; T_a, air temperature; C_i, intercellular CO_2 concentration; F_v/F_m, photochemical efficiency of PS II; F_o, original fluorescence; F_m, maximum fluorescence

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should be mainly attributed to stomatal conductance, which mainly resulted from the increase in vapor pressure deficit.

Keywords: High temperature and irradiation; Photosynthesis; Photochemical efficiency of PS II; Jujube; Oasis

1. Introduction

Jujube (*Zizyphus jujuba* Mill. var. *inermis* (Bunge) Rehd.) is native from China and has a cultivation history of over 2500 years (Wang and Qu, 1987), consequently forming a number of endemic varieties with unique characteristics. Linze jujube grows endemically in arid northwest China and in the Linze Oasis of Gansu Province. It has adapted to high temperature, irradiance and dry atmospheric environment. Compared with other more than 20 jujube accessions, linze jujube had higher fruitset and was richer in Vitamin C content (averaged 579.3 mg Vc per 100 g flesh of fresh fruit) (Chen, 1993). Linze jujube has low water consumption and can grow and fruit normally in the oases with a mean annual precipitation of only 116.8 mm, as long as 450 mm of irrigation water per year is supplied (Su et al., 2002b).

As shown in the comparative study of desert oasis plants species (Su, 2003), the stable carbon isotope ratio ($\delta^{13}C$) in the leaves of linze jujube was −26.6‰, while that of desert plants *Caragana korshinskii*, *Nitraria sphaerocarpa* and *Hedysarum scoparium* was −25.8‰, −25.8‰ and −26.4‰, respectively, with no significant difference ($P = 0.01$) among them. Foliar $\delta^{13}C$ values can reflect water use efficiency associated with plant photosynthetic and transpiration (Lajtha and Michener, 1994). Farquhar et al. (1989) believed that foliar $\delta^{13}C$ value could be used to indicate the long-term water use efficiency of plants and to a certain extent $\delta^{13}C$ value was positively correlated with water use efficiency (Farquhar and Richards, 1984; Marshall and Zhang, 1994; Sun et al., 1996). It is thus evident that water use efficiency of linze jujube is similar to that of some desert plants.

The diurnal course of photosynthesis of many plants in temperate zone is often bimodal. Midday depression of photosynthetic rate seemed to be related with high irradiation (Matos et al., 1998). However, the changes in photosynthesis caused by high irradiation differ among species and temperatures regimes (Pastenes and Horton, 1996). The diurnal course of net photosynthetic rate of desert plants *C. korshinskii*, *N. sphaerocarpa* and *H. scoparium* is bimodal under high temperature and light. The decline in net photosynthetic rate of *C. korshinskii* and *H. scoparium* is mainly caused by non-stomatal factors (Su, 2003). Linze jujube, as a woody food crop, is considered to be fitted for a tree species of subordinate belt of shelterbelt networks, for intercropping with cereals, for planting around villages and houses, along roads and canals, etc. The summer climate of the linze jujube growing area is characterized by drought, high temperature and strong sunlight. However, no systematic study has been carried out on the photosynthetic and physiological characters of linze jujube. This study intends to probe into its CO_2 exchange characteristics in different stages and the changes in chlorophyll fluorescence parameters and thus to provide a primary basis for further clarifying the mechanism of its adaptation to the harsh environment in this region.