

研究论文

黑杨无性系间长期水分利用效率差异的生理基础

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摘要 试验于2003年6月10日至8月20日在温室中进行, 采用完全随机区组设计, 4个水分处理(充分供水、轻度胁迫、中度胁迫、重度胁迫), 6次重复。各水分处理严格控制浇水间隔: 充分供水, 每2d浇水1次; 轻度胁迫, 每3d浇水1次; 中度胁迫, 每4d浇水1次; 重度胁迫, 每5d浇水1次。每次浇水的量相同, 500ml。试验材料为美洲黑杨杂交无性系, 父本为哈佛杨(*Populus deltoides* Bartr. Cl. 'Harvard'), 母本为山海关杨(*Populus deltoides* Bartr. CV. 'Shanhaiguanensis'), 共10个无性系, 编号为J1~J10。以当前优良品系108杨(*Populus euramericana* CV. '114/69')和中林46杨(*Populus deltoides* Bartr. CV. 'Zhonglin 46')为对照, 编号为CK₁、CK₂。测定了12个无性系间长期水分利用效率(WUE_L)、光合参数(净光合速率Pn、蒸腾速率Tr、气孔导度Gs、瞬时水分利用效率WUE_i、最大净光合速率Pmax、光饱和点LSP、羧化效率Ce)及气孔特征参数(气孔频度、气孔大小、上/下表皮气孔数目比)、根冠比的差异, 并深入分析了光合参数与WUE_L、气孔特征参数与WUE_L、根冠比与WUE_L及光合参数之间的相互关系。结果表明: 无性系间WUE_L存在差异, 这种差异随水分胁迫的加剧而更加显著。无性系间WUE_L的差异在4个水分处理下表现出一致性, 即WUE_L最优的都是J2, 其次为J₆、J₇、J₈、J₉。高WUE_L的J2等无性系其气孔频度、气孔大小、Gs、Tr、Pn和根冠比在所有无性系中都处于适中的位置。它们的上/下表皮气孔数目比大, P_{max}、LSP、Ce明显优于对照。Pmax高、LSP高、Ce大, 表明高WUE_L的J2等无性系光合能力强。Gs、Tr、Pn适中, 表明J2等无性系在保证具有高WUE_i的同时能保持较强的光合能力。根冠比适中, 表明J2等无性系的光合产物在根、冠之间分配合理, 能有充足的根系分布保证水分的供应, 同时又有较多的光合产物积累在地上部分。气孔特征参数的差异是导致无性系间光合能力和WUE_i差异, 并最终导致WUE_L差异的一个主要因子。气孔频度和气孔大小适中的无性系, 其Gs、Tr、Pn适中, WUE_i较高; 上/下表皮气孔数目比大的无性系则具有较强的光合能力。无性系间WUE_L的差异是一系列具有差异的生理参数共同作用的结果, 高WUE_L的无性系通常光合能力强、WUE_i高、根冠比适中。今后工作中选育高WUE的无性系时, 除需关注单个生理参数的突出作用外, 更应关注生理参数的协同作用。

关键词 黑杨; 无性系; 长期水分利用效率(WUE_L); 光合参数; 气孔特征参数; 根冠比

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Physiological foundation for the differences of long-term water use efficiency among *Populus deltoides* clones

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Abstract In this study, an experiment was carried out in accordance with the randomized complete blocks design. There are six replications in greenhouse between June 10th and August 20th in 2003. Four water treatments were designed. They were well-watered condition, slight water str

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ess, moderate water stress and severe water stress. The irrigation intervals were strictly controlled. Under well-watered treatment, the seeding of the tested clones was irrigated every two days. For the others, the irrigation intervals were every three days, every four days and every five days respectively. However, the volumes of irrigated water were same every time, i.e. 500ml. The 10 tested clones were derived from a cross between the female *Populus deltoides* Bartr. CV. 'Shanhaiguanensis' and the male *Populus deltoides* Bartr. CI. 'Harvard', which were named J1~J10. CK₁ and CK₂ were *Populus euramericana* CV. '114/69' and *Populus deltoides* Barter CV. 'Zhonglin 46', which perform well currently. The following physiological parameters were examined, the long term water use efficiency (WUEL), photosynthetic parameters (net photosynthetic rate (P_n), transpiration rate (Tr), stomatal conductance (G_s), instantaneous water use efficiency (WUE_i), maximum photosynthetic rate (P_{max}), light saturation point (LSP), carboxylic efficiency (C_e)), stomatal properties (stomatal frequency, stomatal size, superior/inferior ratio) and root/shoot ratio. The comparison of physiological parameters among different clones was studied under different water treatments. The interrelations between WUEL and photosynthetic parameters, stomatal properties, root/shoot ratio were analyzed. The results showed that the WUEL differences were obvious among tested clones, and the differences became greater along with the severer water stress. The WUEL differences of the tested clones under 4 water treatments were consistent. The best clone was J2, and J6, J7, J8, J9 were quite good. Some physiological parameters, such as stomatal frequency, stomatal size, G_s , Tr , P_n and root/shoot ratio of J₂ et al were moderate, while the superior/inferior ratio, P_{max} , LSP , C_e of J₂ et al were higher than other clones. Higher P_{max} , LSP , C_e implied that J₂ et al had strong photosynthetic capacity. Moderate G_s , Tr , P_n revealed that J₂ et al not only had relatively higher WUE_i but also had relatively strong photosynthetic capacity. Moderate root/shoot ratio indicated that the photosynthetic products distribution was reasonable among root and shoot, which resulted to enough root to ensuring water supply and at the same time more photosynthetic products run up to canopy. The stomatal differences among tested clones might be a key factor which accounting for the photosynthetic capacity differences and WUE_i differences, which ultimately induced to WUEL differences. The clones with moderate stomatal frequency and stomatal size had suitable G_s , Tr , P_n , and relatively higher WUE_i . The clones with large superior/inferior ratio had strong photosynthetic capacity. The WUEL differences among tested clones were induced by a series of physiological parameters, and higher WUEL clones often had strong photosynthetic capacity, a comparatively higher WUE_i , and a satisfied root/shoot ratio. For selecting higher WUE clones in breeding program, the co-operation of several physiological parameters should be concerned more than the effect of a single physiological parameter.

Key words [Populus deltoides](#) _ [clones](#) _ [long-term](#) [water](#) [use](#) [efficiency](#) ([WUEL](#)) _ [photosynthetic](#) [parameters](#) _ [stoma](#) [properties](#) _ [root/shoot](#) [ratio](#)

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