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研究论文

铜毒对海州香薷（*Elsholtzia splendens*）不同种群光合作用和蒸腾作用的影响

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摘要 通过水培实验，对种子分别来自湖北省铜绿山、赤马山铜矿区和红安非矿区的海州香薷种群在铜胁迫下的光合作用和蒸腾作用进行了比较研究。结果发现，矿区两个种群在铜胁迫下的光合能力明显比非矿区种群强，尤其在高Cu(100μmol/M)处理更为显著：如铜绿山和赤马山叶片净光合速率分别为13.15μmol CO_2 m^{-2} s^{-1}和12.59μmolCO_2 m^{-2} s^{-1}，为红安种群(1.07μmol CO_2 m^{-2} s^{-1})的13倍；铜绿山和赤马山种群的光能利用效率分别为0.0221μmol CO_2 μmol^{-1}和0.0224μmol CO_2 μmol^{-1} photon，为红安种群(0.003μmolCO_2 μmol^{-1} photon)的7倍。表观量子产额在两个矿区种群中没有明显的变化，低Cu (5和20μmol/L)处理促进了矿区种群叶绿素（Chl a 和Chl b）含量的增加，而非矿区种群的这两个指标则随处理浓度的增加而迅速下降。来自矿区两个种群的蒸腾速率受铜的胁迫影响较小，而来自非矿区种群随处理浓度的加大而明显降低，其叶片的蒸腾速率在5、20μmol/L和100μmol/L浓度处理时迅速下降为对照的62.74%、50.96%和42.6%；水分利用效率在矿区两个种群中随处理水平的增大而提高，在100μmol/L处理时铜绿山和赤马山种群分别是对照的161.83%和130.41%，而非矿区种群随处理浓度的增加而急剧降低。另外，矿区两个种群的呼吸速率和气孔阻力随处理浓度的降低和升高的幅度明显比非矿区小。总之，在铜污染胁迫下，矿区种群保持的这种生理生态特性是其能在这种环境中正常生长定居的重要原因，是其长期进化的结果。

关键词 铜；海州香薷；光合作用；蒸腾作用

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Effects of copper toxicity on photosynthesis and transpiration of three *Elsholtzia splendens* Nakai ex F.Maekawa populations

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Abstract Three Elsholtzia splendens populations, one from an uncontaminated site (Hongan) and the other from two Cu mine sites (Tonglvshan and Chimashan), were studied in hydroponic experiments for the photosynthesis and transpiration under Cu treatment. The results showed that, under Cu stresses, the capacity of photosynthesis in the two populations from Cu mine sites was stronger than that in the non-polluted population. Under 100 μmol/L Cu treatment, the net photosynthesis rates of leaves in the populations from Tonglvshan and Chimashan were 13.15 μmol CO_2 m^{-2} $s^{-1}$and 12.59 μmol CO_2 m^{-2} s^{-1}, respectively, which were around 13 times higher than that in Hongan population (1.07 μmol CO_2 m^{-2} s^{-1}). Using efficiencies of light in the two Cu mine populations were 0.0221 and 0.0224 μmol CO2 μmol^{-1} photon, respectively, which were about 7 times higher than that in Hongan population (0.003 μmol CO_2 μmol^{-1} photon). It was found that t

here was no significant change in apparent quantum efficiency in the two mine populations and a si gnificant reduction in the non-polluted population under different Cu treatment. The chlorophyll (C hl a and Chl b) contents in the non-polluted population decreased significantly with the increase o f Cu concentration, while in the two mine populations, the chlorophyll (Chl a and Chl b) contents i ncreased with lower Cu treatment. Transpiration rates in the two mine populations were less influe nced by Cu treatment. However, the transpiration rate in Hongan population was significantly dec reased by the Cu treatment, which was 62.74%, 50.96% and 42.6% of the control under 5, 20 μ mol/L and 100 μmol/L Cu treatments, respectively. Using efficiency of water in two mine populati ons increased with the increase of Cu concentration. With 100 μmol/L Cu treatment, the using effi ciency of water in Tonglvshan and Chimashan populations was 161.83% and 130.41% of the co ntrol, respectively. In addition, it was also found that the decrease of dark respiration rate and th e increase of stomatic resistance in the two mine populations were smaller than that in the non-poll uted population. In conclusion, these eco-physiological characteristics might be important factors t hat cause the two copper mine populations grow normally in the Cu-contaminated soils, indicatin g that the two populations have developed into Cu-resistant populations.

Key words Cu _ *Elsholtzia splendens* _ photosynthesis _ transpiration

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