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学 位 論 文 要 旨

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題目：Studies on the Physiological Mechanisms of Tolerance and Adaptability to Environmental Stresses and Survival Strategies in *Salicaceae* Species (ヤナギ科植物の環境ストレス耐性、適応性及び生存戦略に関する研究)

Soil salinization associated with water scarcity is an increasingly serious environmental problem, limiting plant growth worldwide in arid and semiarid regions. When growing under saline conditions, plants are usually subjected to three types of stress: water deficit, mineral toxicity, and disturbances in the absorption of mineral nutrients. As a result, morphology, anatomy, ultra-structure, and metabolism of plants growing under salt stress are adversely affected.

Flooding or waterlogging with seawater or freshwater also is a very important environmental stress worldwide and causes oxygen deficiency in rhizosphere. In northwestern China, many arid saline regions have high water tables; moreover, precipitation is concentrated in summer and so temporary waterlogging of soil commonly happens during the rainy periods. In this case, plants are subjected to both salinity and hypoxic stresses in roots. Therefore, it is necessary to study the growth and physiological reaction in plants subjected to the two stressors in these areas.

Populus is one of the main tree species grown in above-mentioned regions of China and plays important economic and environmental roles in many countries and regions. There has been little research into the salt tolerance and the interactive effects of salinity and oxygen deficiency in root system of *Populus alba* and *Populus nigra*. *Salix* spp. comprise one of the main tree types growing in the Mousu Desert in northwestern China and the physiological reactions to salt stress and salt tolerance of *Salix psammophila* and *Salix matsudana* have not been well researched.

In the thesis, growth, photosynthesis, and Na^{+}, K^{+}, Ca^{2+}, and Mg^{2+} distributions were investigated in 2-year-old hydroponically cultured *Populus alba* cuttings exposed to salt stresses (0, 0.85, 8.5, 17, or 85mM NaCl and 0, 50, 100, 150 or 200mM) for 4 weeks (chapter II), *Populus alba* and *Populus nigra* cuttings exposed to salt stress (0, 50, or 100 mM NaCl) for 4 or 6 weeks and to non-aeration stress for 1 or 3 weeks, followed by a 3-week aeration period (chapter III), and S*alix psammophila* and *Salix matsudana* cuttings exposed to salt stress (0, 25, 50, 75 or 100 mM) for 6 weeks in 2/5 Hoagland solution (chapter IV).

A NaCl concentration of around 150mM is close to the maximum that *P. alba* could tolerate, whereas *P. nigra* can only tolerate NaCl concentrations of less than 50 mM. Combined salinity and non-aeration inhibited height increase to a greater degree than either stress alone in both populous species. Simple salt stress (<100mM) did not affect diameter increase in *P. alba*, whereas combined high salinity (100 mM NaCl) and non-aeration inhibited the diameter increase. Growth and biomass accumulation were more sensitive to salt stress in *P. nigra* cuttings than in *P. alba*, although *P. alba* showed a more rapid decrease in photosynthesis in response to non-aeration stress. Ion distribution in the leaves and roots differed between species. *P. alba* was superior to *P. nigra* in terms of Na^+ exclusion capacity, such that most of the absorbed Na^+ was confined to the root system, with little reaching the leaves. The lower Na^+/K^+ ratio in leaves indicated that *P. alba* was more tolerant to salt stress than *P. nigra*.

S. matsudana exhibited highly depressed growth and biomass at NaCl concentrations of 50 mM or more, whereas *S. psammophila* was adversely affected only by the 100 mM NaCl treatment. Although *S. matsudana* exhibited higher photosynthesis under salt-free conditions, its photosynthesis levels were quick decreased under higher salt conditions compared to those of *S. psammophila*. In addition, ions distribution in the leaves and roots differed between species. *S. psammophila* adapted to salinity by avoiding salt uptake, such that most external Na^+ in the solution was excluded from the root system. Conversely, *S. matsudana* did so by tolerating salt uptake, such that most of the absorbed Na^+ was compartmentalized to the root system, with little reaching the leaves when the salt concentration was under a certain threshold (<100 mM NaCl). The lower Na^+/K^+ ratio in the leaves of *S. psammophila* indicated that it was more tolerant to salt stress than *S. matsudana*. As a result, *S. psammophila* may survive more easily and thus can be used more widely than *S. matsudana* in saline soils.