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学 位 論 文 要 旨

氏名:　　今 田　 省 吾

題目: Studies on growth characteristics of *Populus alba* under different water table depths and salinity levels

[異なる地下水位および土壌塩分条件下におけるｳﾗｼﾞﾛﾊｺﾔﾅｷﾞの生育特性に関する研究]

Soil salinization is one of the major factors of desertification. The spread of soil salinity has resulted in large reductions in plant productivity worldwide. To combat soil salinization and ameliorate salinized soils, various scientific methods were used. A biological method using native deep-rooted perennial plants has drawn attention because of low initial investment and sustainability. In this method, the plantation of perennial plants, particularly woody plants, is expected to lower shallow water tables which resulted in soil salinization through water uptake by deep and extensive root systems. However, there is some evidence that some plants may also increase levels of soil salts, so it is necessary to select appropriate species. In order to select the species, the growth characteristics in regions where selected species would be planted needs to be understood. Saline environments are generally characterized by shallow groundwater tables and large amounts of salts in the soil. Then, for successful amelioration, the response of a species under water table depth and soil salinity conditions should be examined. Furthermore, changes in the soil after planting the species in saline environments also need to be evaluated. In this study, I first determined the effects of three constant water-table depths (45, 30, and 15-cm depths from soil surface) and a fluctuating water table regime (fluctuating between 45- and 30-cm depths) on the fine-root growth and whole-plant biomass of 1-year-old rooted *Populus alba* cuttings. Fine-root growth varied with water-table depth and soil water profiles in all the treatments: fine roots were scarce in the soil layers below the water tables because of soil O_2 depletion and proliferated in the layer just above water table because conditions were favourable for exploiting water. The allometric approach demonstrated that total biomass and root length in each treatment were positively correlated and the relationship did not differ significantly among treatments, suggesting an important role of fine roots in controlling whole-plant growth under different levels of soil water availability. I also examined the relationship among different growth components at the whole-plant level. Both net assimilation rate and leaf area ratio correlated with relative growth rate (RGR). While leaf mass ratio (LMR) and specific leaf area positively correlated with RGR,

and the stronger correlation was found in the LMR. The variation in LMR was mainly attributed to variation in root biomass allocation. The root biomass allocation strongly and negatively correlated with the proportion of fine-root biomass not only at whole root system level but at each soil depth layer. These results suggest that such root growth responses may relate to whole-plant growth along a soil moisture gradient. To examine, in detail, the growth and mortality of fine roots of *P. alba* in fluctuating water tables, I exposed the *P. alb* cuttings to a constant water-table depth (45-cm) and two fluctuating water-table depth conditions (fluctuating between 45- to 30-cm and between 45- to 15-cm). Fine-root biomass was similar among the treatments, while the proportion of fine-root necromass increased in the fluctuating water-table depth treatments. Despite the increase in gross fine-root mass, the water-table fluctuations did not influence the whole-plant growth and biomass allocation among the plant parts. These results suggest that the increase in gross fine-root mass would be an important mechanism of *P. alba* in adapting to fluctuating water tables. Finally, I investigated the effects of saline irrigation on the growth, Na partitioning, and Na dynamics of the cuttings. The plants were grown in lysimeters and were watered with either field water (control) or solutions containing either 2000 or 5000 mg L^{-1} of a mixture of NaCl and $CaCl_2$ (low- and high-salt treatments, respectively). The cuttings in the low-salt treatment exhibited growth similar to that of the control after 1 year of treatment. In the low-salt treatment the addition of Na to the soil by irrigation for 1 year (1831 kg ha^{-1}) was similar to the levels of Na that accumulated naturally in saline soils in *Populus deltoides* forests. But, the addition of Na to the soil in the high-salt treatment (4568 kg ha^{-1}) caused a significant growth reduction and 20% mortality for the plants. Strong Na partitioning was observed in the roots (about 90%) in the control and low-salt treatment, suggesting that this is an important salt tolerance mechanism in *P. alba*. The Na accumulated in the biomass after 1 year in the low-salt treatment was about 88% of the total uptake, resulting from low rate of return to the soil. However, the percentage of Na added to the soil taken up by the cuttings was very low (2% in the low-salt treatment), suggesting that this tree can not reduce salt concentration in soil through its ability to accumulate salts in the body. My findings suggest that *P. alba* would grow well under shallow and fluctuating groundwater tables, and can tolerate soil salinity which found in the natural forests in saline environments. In addition, the results of Na dynamics indicate that *P. alba* may have little risk of increasing levels of soil salts after planting this species in saline soils since the tree can accumulate a high proportion of Na in the biomass. Thus, *P. alba* can be a good candidate for afforestation in saline soils where the tree can tolerate salinity levels and expected to lower water tables through water uptake by the root systems.