Effects of Simulated Acid Rain on Histology, Water Status and Growth of *Pinus densiflora*

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인공산성빗물이 소나무의 조직, 수분수지 및 생장에 미치는 영향
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ABSTRACT

To clarify the effects of acid precipitates on histological damage, water status, and growth of *Pinus densiflora* green house experiment applying simulated acid rain was carried out.

Contact angle of water droplet on needles of *P. densiflora* seedlings treated with simulated acid rain of different pHs decreased with the increase of acidity and the amount of simulated acid rain. The lower pH of simulated acid rain was, the more rapid transpiration was. Leaf water potential after water withdrawal was also reduced rapidly in proportion to acidity of simulated acid rain. Height growth of *P. densiflora* seedlings treated with simulated acid rain of pH 2 decreased, while growth of seedlings treated with that of pH 3 and 4 increased comparing with that treated with normal rain of pH 5.6. pH of cultivated soil in pH 2 plot was acidified with the amount of simulated acid rain applied but that in pH 3 and 4 plots did not show any directional change. From those results, it could be interpreted that decrease of height growth in pH 2 plot was originated from multiple effects of water deficit from rapid transpiration and soil acidification. On the other hand, increase of height growth in pH 3 and 4 plots would be originated from the supply of N and S included in simulated acid rain.

*Key words*: *Pinus densiflora*, Histological damage, Water status, Simulated acid rain, Soil acidification.

INTRODUCTION

Forest decline syndromes have increased dramatically throughout the world since early 1980s (Krause *et al.* 1986, Nilsson and Duinker 1987). Hypotheses postulating several causes as causal factor of forest decline have been suggested (Freedman 1986, Smith 1990). Major cause of forest decline was not clearly known yet, but acid precipitates has been thought as one of important causal factor of forest decline (Zottle *et al.* 1989, Ulrich 1990). Especially plants with cuticle damaged by acid precipitates are affected in their resistance against water stress during drought

In an investigation on *P. densiflora* grown in the Metropolitan area of Seoul epicuticular degradation on needle leaves, rapid transpiration of needles and growth inhibition of annual ring were reported (Lee et al. 1998). Also structural change, such as retrogression of succession might be induced by decline in vitality of *P. densiflora* and functional one like soil acidification were investigated in that area (Lee 1996, Lee et al. 1998). Soil acidification and histological damage of needle leaves would be caused by continuous falling of acid precipitates. On the other hand, growth inhibition and decline in vitality of *P. densiflora* were suspected to the water deficit by 1) rapid transpiration through epicuticular injury by acid precipitates, and 2) deterioration of water absorption capacity through growth inhibition or abnormal distribution of fine roots in acidic soil (Rhyu 1994, Lee 1997).

The purpose of the present study is to prove experimentally the results obtained in field investigation (Lee et al. 1998). Simulated acid rain (Lee and Weber 1979, Riding and Percy 1985, Rinall et al. 1986, Rhyu and Kim 1993a,b, 1994c,d) and acid fog (Mengel et al. 1989, Kim and Um 1996) have been generally applied in experimental studies assumed environmental conditions associated with forest decline. Acids in precipitates cause injury on leaf surface of plants (Evans et al. 1977, Mengel et al. 1989) and acidification of soil. It is believed that damage of epicuticular layer originated from those acid precipitates should have an influence on the holding of water and the growth of plants. Thus the present study focused on the questions as to whether the water holding capacity and the height growth of *Pinus densiflora* seedlings would be affected after they had received a treatment with simulated acid rain. During the experiment, contact angle, transpiration, water potential, height growth, and pH of cultivated soil were, therefore, measured.

**METHODS**

Simulated acid rain was prepared by mixing H$_2$SO$_4$ and HNO$_3$ in a 3:1 equivalent ratio to the distilled water. pH of simulated acid rain was adjusted into 2, 3 and 4. Normal rain of pH 5.6 was adjusted by dissolving CO$_2$ in distilled water. Each treatment plot consisted of 5 replicates with 9 seedlings per pot. Seeds of *P. densiflora* were obtained from Forest Genetics Korean Institute for Breeding of trees. Current year seedlings were used as sample plants. Cultivation of sample plants was continued for 2 months in the greenhouse experiment. Simulated acid rain was sprayed everyday by 50 ml during cultivation. Contact angle of water droplet dropped by microsyringe on the needle leaf was measured by graduator installed in dissecting microscope (Boyce and Berlyn 1988). Amount of water used to measure contact angle was 1 µl. Cuticular transpiration was determined by measuring the water loss that occurred from excised shoots in incubator condition of 25°C (Mengel et al. 1989). Shoots were sampled from 5 seedlings. Shoot was cut off just below cotyledons and cut surface was immediately covered with parafilm to prevent water loss from this surface. Shoots were weighed with a chemical balance and loss of weight was regarded as water loss. Water potential was determined by Shkadakov method (Barrs 1968).

Height of seedlings was determined by the length from the soil surface to apical part of seedling. Soil pH was analysed at 1 week interval for 6 weeks from the 4th week after treatment of simulated acid rain. Surface soil in the cultivation pot was used as sample soil. pH was measured by pH meter after shaking soil mixed with distilled water by ratio of 1:5 for 1 hour.