

## ARBORICULTURAL ABSTRACTS

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### INDUCTION OF GENES FOR THE STRESS PROTEINS PR-10 AND PAL IN RELATION TO GROWTH, VISIBLE INJURIES AND STOMATAL CONDUCTANCE IN BIRCH (*BETULA PENDULA*) CLONES EXPOSED TO OZONE AND/OR DROUGHT

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Well-watered (WW) or drought-stressed (DS) saplings of ozone-sensitive and ozone-tolerant (less sensitive) birch (*Betula pendula* Roth) clones were exposed for 43 days to 0 nl<sup>-1</sup> or 100 nl<sup>-1</sup> ozone. Relative growth rates of leaves, stem, and roots, leaf discoloration, stomatal conductance, and induction of genes encoding stress-related proteins PR-10, PAL, and a LEA-group protein BP8 were determined. In general, both ozone and drought stress, singly and in combination, increased transcript levels of PR-10 in both clones. This was related to lower induction of PAL (except in older leaves of the tolerant clone) and to increased proportions of visibly injured and yellowed leaves in ozone-exposed plants. The clones differed in their stomatal conductance and growth responses. In the less sensitive clone 2, ozone did not affect growth rates, but high stomatal conductance was observed in WW ozone-exposed plants. The more sensitive clone 5 showed, on the contrary, reduced growth rates and low stomatal conductance in WW ozone plants. Interestingly, clone 2 was sensitive to drought stress alone, whereas clone 5 was highly sensitive to ozone and drought stress experienced together. The results show that appearance of visible injuries (necrotic flecks) and enhanced yellowing of leaves coincided with the induction of genes for stress proteins PR-10 and PAL. The short-term growth responses, however, seemed to be separate processes. Additionally, stomatal conductance was related to leaf injuries and growth rates in a complicated manner, emphasizing the complex nature of ozone sensitivity/tolerance mechanisms in birch. (*New Phytol.* 1998. 138:295–305)

### RESPONSES OF LEAF PROCESSES IN A SENSITIVE BIRCH (*BETULA PENDULA* ROTH) CLONE TO OZONE COMBINED WITH DROUGHT

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Saplings of an ozone sensitive clone of birch (*Betula pendula* Roth, KL-5-M) were well-watered or exposed to mild drought-stress combined with ambient or elevated (1.5 × the ambient) ozone for 11 weeks in open-field conditions in central Finland. Stomatal response, visible injury, chlorophyll and nutrient content, and changes in cellular anatomy and plant growth were studied. Drought stress alone, in ambient ozone, reduced stomatal density and stomatal conductance. Drought stress and ozone effects were additive, reducing total leaf number, foliage area and starch formation in mesophyll cells. Drought stress and ozone effects were additive, increasing the N concentrations in the leaves, the thickness of the upper epidermal cell wall, the number of pectinaceous projections of mesophyll cell walls, and the vascular tannin-like depositions and phenolic droplets, regarded as signs of activated stress defense mechanisms. The increase in specific foliage mass, cytoplasmic lipids (younger leaves), and a condensed appearance of the upper epidermal mucilaginous layer were caused by both drought and ozone, but were not additive. The results show that combined drought stress contributed to birch responses to 1.5 × current ambient ozone concentrations, corresponding to critical-level ozone exposure. The only beneficial effect of drought stress was the slight reduction of visible leaf symptoms induced by ozone in autumnal leaves. (*Ann. Bot.* 1998. 82:49–59)

#### HETEROGENEOUS SELECTIVE PRESSURES ON EGG-HATCHING TIME AND THE MAINTENANCE OF ITS GENETIC VARIANCE IN A TETRANEURA GALL-FORMING APHID

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The performance of gall-forming aphids is largely dependent on the timing of egg hatch relative to host budburst. This study examined the mode of natural selection acting on egg-hatching time and the extent of its genetic variance in a *Tetraneura* aphid. The budburst time of the primary host of the aphid varied greatly among individual trees. Egg hatch on a host tree was often asynchronous with host budburst.

Transplant experiments indicated that egg-hatching time was subject to heterogeneous selective pressures in heterogeneous host environments. Hatching time was compared between half-sib families. Small nymphs in a half-sib family tended to hatch later, and this resulted in large within-family variance in hatching time. Small nymphs that hatched late were likely to be selected out during the galling process. Thus, these nymphs may be produced not as bet-hedging but due to material effects. When such maladapted nymphs were not included in analysis, a significant amount of additive genetic variance was detected in hatching time. Heterogeneous selection, coupled with density-dependent regulation of population on respective host trees, probably maintains additive genetic variance in this trait. (*Ecol. Entomol.* 1998. 23:229–237)

#### COMPARISON OF PHOTOSYNTHETIC RESPONSES TO MANGANESE TOXICITY OF DECIDUOUS BROAD-LEAVED TREES IN NORTHERN JAPAN

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The effects of manganese (Mn) toxicity on photosynthesis of 4 tree species in northern Japan representing different successional traits were examined. The 4 species are: *Betula ermanii* (Be) and *Alnus hirsuta* (Ah) representing two early successional species, *Ulmus davidiana* var. *japonica* (Ud) as the mid-successional species, and *Acer mono* (Am) as the late successional species. Seedlings were grown hydroponically in a solution containing nutrients and Mn of 4 concentrations (1, 10, 50, 100 mg/L) for 50 days. Gas exchange

measurements indicate that in all species. Mn accumulation in leaves resulted in the decline of light-saturated net photosynthetic rate at ambient CO<sub>2</sub> pressure (35 Pa, Pn<sub>amb</sub>) and at saturating (5%) CO<sub>2</sub> pressure (Pn<sub>sat</sub>), and of carboxylation efficiency but has little effect on the maximum efficiency of photochemistry. Sensitivity to elevated levels of Mn differed among species where the decline of Pn<sub>amb</sub> was much more modest in the 2 early successional species of Be and Ah than the mid- and late successional species of Ud and Am. The same trends were observed in both Pn<sub>sat</sub> and carboxylation efficiency. Based on these results, we suggest that early successional species (*Betula ermanii* and *Alnus hirsuta*) have greater tolerance for excess Mn in leaves than mid- and late successional species. (*Environ. Pollut.* 1997. 97(1–2):113–118)

#### NUTRITION AND THE OZONE SENSITIVITY OF BIRCH (BETULA PENDULA)

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Cuttings of a single birch clone (*Betula pendula*) were grown in field fumigation chambers throughout the growing season in either filtered air (control) or 90/40 nl O<sub>3</sub>/L (day/night), both regimes being split into high and low nutrient supply. High nutrition was neither advantageous for maintaining the photosynthetic capacity and life span of the leaves nor for limiting the productive loss of the whole plant under O<sub>3</sub> stress relative to low-fertilized (LF) plants. However, nutrition determined, through carbon allocation and leaf turn-over, the way plants coped with O<sub>3</sub> impact. High leaf turn-over under O<sub>3</sub> stress related the carbon gain of high-fertilized (HF) plants to the photosynthesis of newly formed, intact leaves, although the foliage area remained reduced (shedding of O<sub>3</sub>-injured leaves, inhibited branching). In contrast, the low leaf turn-over of LF plants reflected the maintenance of the O<sub>3</sub>-injured leaves, causing high respiratory costs in the whole-plant carbon balance and a root/shoot biomass ratio as low as in the HF plants. Within the root system, the carbon allocation was determined by nutrition rather than ozone, whereas the water-use efficiency of the whole-plant carbon increment was lowered by ozone in both nutrient regimes. The relationship between biomass production and nutrient levels in the whole plant was hardly affected by ozone, with only the range of

interaction being narrowed. Conditions requiring the maintenance of foliage rather than favoring the replacement of O<sub>3</sub>-injured leaves may render trees more susceptible to shifts in the carbon allocation. (Trees 1997. 12:11–20)

EXPLORATORY STUDY OF THE RELATIONSHIPS BETWEEN TREE GROWTH, SITE CONDITIONS, AND MAINTENANCE PRACTICES IN STREET PLANTINGS OF *FRAXINUS PENNSYLVANICA* MARSHALL OF LA PLATA CITY, ARGENTINA

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The purpose of this paper was to study the size and vigor of green ash (*Fraxinus pennsylvatica* Marshall) planted in sidewalks of La Plata City, Argentina, in relation to site conditions and maintenance practices. Samples studied ( $n_{(A)} = 254$ ,  $n_{(B)} = 256$ ) were even-aged. For each tree, the following variables were considered: diameter at breast height (DBH), total height

(Ht), vigor, root pruning (RootP), sidewalk breakages (SidBk), sidewalk exposure (NW/SE), tree-pit surface (PitS), urban morphology, or residential character (UrbMo) and soils (Soil). Chi-squared was calculated as a test of independence and as an indicator of the degree of association between variables. DBH and Ht averages were similar among samples; in both cases DBH and Ht were significantly associated with each other, the same as tree size and SidBk. The larger sidewalk breakages were registered for taller and thicker individuals. Associations were also found among size and vigor of trees, root pruning, and both microhabitat (NW/SE, PitS) and mesohabitat characteristics (UrbMo, Soil). The latter 2 factors should both be considered when designing sampling regimes since they were influential in the differing outcomes revealed in this study. Incidence of SidBk and RootP found in samples studied indicated that root space requirements for green ash in street plantings in the city need to be reconsidered. (Arboric. J. 1997. 21:305–315)