Variation in abiotic and biotic resistance within birch (Betula pendula) population
Background

European White Birch (*Betula pendula*)

- wide geographic range in Europe
- continuous distribution in N Europe
- efficient gene flow
  - prolific flowering
  - light pollen and seeds

large within population variation
What has been studied

Reproduction
- seed production
- germinability

Phenology
- bud burst
- flowering
- growth termination

Growth
- competitive ability
- photosynthesis

Secondary chemistry
- leaf
- shoot
- ontogeny

Biotic factors
- insects
- pathogenic fungi
- endophytes
- mammals

Abiotic factors
- Ozone
- UV-B
- CO2
- T

Leaf decomposition
Leaf nutrients
- nitrogen
- carbohydrates
- proteins
Flowering & seed production

Large variation in flowering, pollen and seed production and germination within birch population.
Bud burst observations

- 7 years series in mother trees, 4 years in field experiments
- large variation among genotypes
- some genotypes need lower heat sum to start their growth than others
- significant genotype x site interaction
Ozone resistance


Figure 1. Elevated-ozone induced visible foliar injuries counted (a) as proportion of leaves showing injuries at branch level for all clones, and (b) as number of spots at leaf level (per 0.25 mm² area) in clones 4, 6, 7, 17, 19, 20, 26 and 30, organized in s/r - increased, s/r - decreased and s/r - unaffected groups. Data is pooled over the two replicate ozone rings, ***p<0.001, **p<0.01, *p<0.05.

Summary:

S/r ratios increased plants (30% of the genotypes)
- Increased antioxidant capacity at the expense of proteins
- Compensated leaf production

S/r decreased plants (60% of the genotypes)
- Avoidance by stomatal closure=>reduced photosynthesis
- Small leaves
- Low cost antioxidants

S/r unaffected plants (12% of the genotypes)
- Highest constitutive amount of total phenolics
- Low cost antioxidants
- N allocation to leaves (Rubisco and chlorophyll)
- Stomatal closure
Ozone & frost resistance


Fig. 2 Bud break as percentage of open buds in relation to all buds on 26 March, 28 March and 3 April, 2002, in six *Betula pendula* genotypes. Values are means ± SD (n = 10). Bars: open, control plants; Closed, ozone plants. Multivariate ANOVA, P < 0.05; * = significant at 5% level.
Ozone & Frost resistance


Summary:

• There is large genetic variation within birch population in response to frost and ozone.

• Generally, birch seem to recover from acute frost occurrence efficiently through compensating leaf production, but co occurring ozone enhancement may disturb the recovery processes mechanistically through structural damage in photosynthetic tissue, especially in chloroplasts.

• Ozone delayed bud burst, but stimulated subsequent growth.

• Early bud burst predisposed to frost damage, whereas late bud burst increased the vulnerability to ozone.

• In combined ozone + frost treatment, freezing reduced visible ozone injuries, counteracted ozone-induced growth enhancement and stomatal changes, and exacerbated ozone-caused reduction in palisade cell, chloroplast and starch grain size.

Fig. 3 Percentage of ozone-injured leaves of total number of leaves in ozone and ozone + frost treated plants of six Betula pendula genotypes. Values are means ± SD (n = 10). Bars: closed, ozone plants; dotted, ozone + frost plants. Multivariate ANOVA, P < 0.05; * = significant at 5% level.
Insect resistance
Damage types counted from Parikkala and Kuikanniitty
• in total 20 insect species (some unidentified)

1. *Eriocrania* sp.
2. *Rhyncites betulae*
3. *Rheumaptera hastata*
4. ”Roll 1”, (family Pyralidae)
5. ”Hole pathway”
6. *Phyllonorycter* sp. (big)
7. *Phyllonorycter* sp. (big)
8. ”Mutant-leaf”
Insect resistance, field experiments

- large variation among clones in insect damage index
- 20 studied species; in 5 of them there were significant differences among clones
Insect resistance
Feeding experiments

Species-specific response in larval growth

From 11 relative growth rate (RGR) experiments:
- significant differences among clones
  - Rheumaptera hastata
  - Operophtera brumata
  - Agelastiga alni (2nd instar)
  - Dineura virididorsata
- non-significant differences among clones
  - Epirrita autumnata
  - Agelastiga alni (4th instar)
  - Cleora cinctaria (2003 and 2004)
  - Xestia baja

Choice experiments:

Agelastica alni beetles preferred same genotypes in two different years (2002 & 2004)
LAI-measurements, field experiments

Large variation among clones in their morphology

Clone 24

Clone 18
Insectiside treatment

Aphids

spraying insectiside

• in general treated trees grew 9 % more than non-treated trees
Secondary chemistry

Variation in compounds and compound groups

- 4 sites, 14 clones and 22 chemical compounds
- For 22 compounds, difference among clones
- For 10 compounds, difference among sites
- For 5 compounds, site x clone interaction

Secondary chemistry

Birch bark secondary chemistry and hare resistance


Fig 4 Palatability for different study clones. Palatability results are expressed as the number of eaten plantlets per clone.

Fig 5 Correlations between palatability and chemical concentration of total flavonoid aglycones and total triterpenoids.
• There is a large within population variation in all studied traits so far
• Effect of environment on chemical composition is evident
• Ecological trade-off mechanisms are complicated and are being studied in more details

taken together, our results suggest the high capacity of birch to adapt quickly to climate change

Research Group
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