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Ecotypic variation of xylem embolism, phenological traits, growth parameters and allozyme characteristics in *Fagus sylvatica*

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Summary

1. Variation in late-winter xylem embolism, phenological traits, growth parameters, xylem anatomy and allozyme characteristics were examined in four populations of European beech (*Fagus sylvatica*) from different geographical origins in Italy.
2. Ultrasonic acoustic emissions from plant stems were measured during winter. Late-winter xylem embolism was quantified before budburst. The timing of budburst was recorded and plant growth parameters were monitored during the spring. The dimension and density of xylem conduits were measured. The genetic variability was investigated using isoenzymes as genetical markers.
3. Significant differences between populations in the rate of acoustic emissions, late-winter embolism, phenological traits and spring growth parameters were observed. Xylem embolism was higher in populations that displayed a higher rate of acoustic emissions during winter. The most embolized population displayed later budburst and slower growth in the spring. No significant differences in xylem anatomy were found.
4. Six out of 10 isoenzymatic loci showed significantly different allele frequencies between populations, but no clear association was found between the genetic variation and the variation of the other traits investigated.

Key-words: Budburst, freezing, genetic variation, growth, hydraulic conductivity
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Introduction

There is increasing evidence that cavitation and xylem embolism are widespread phenomena in plants (Tyree & Sperry 1989). Two conditions are recognized as being primarily responsible for the formation of xylem embolism: water stress and freezing. Water stress is thought to act through the increase of xylem tension, which may cause the aspiration of air through the inter-vessel pit membranes from previously embolized or mechanically damaged xylem conduits (Sperry & Tyree 1988). Freezing of xylem sap is thought to cause the formation of bubbles, as a result of the lower solubility of gas in ice. If large enough, these bubbles may nucleate cavitation at thawing (Hammel 1967; Sucoff 1969; Robson, McHardy & Petty 1988).

Recent studies suggest that freezing-induced embolism may be a widespread and physiologically relevant condition in woody plants. In deciduous tree species it has been observed that more than 50% and, in some cases, up to 100% of the hydraulic conductivity is lost by late winter (Sperry, Donnelly & Tyree 1988a; Sperry, Tyree & Donnelly 1988; Cochard & Tyree 1990; Wang, Ives & Lechowicz 1992).

By reducing water transport efficiency, xylem embolism may restrict the water supply to leaves and predispose plants to water stress. Further consequences may include impaired gaseous exchange and reduced annual growth. Therefore, the vulnerability of xylem to embolism may be critical for the survival of a tree in a given habitat and may hold one key to the understanding of the vegetational response to climatic change.

Data on the intraspecific variation of xylem embolism in woody species are scarce. This is necessary if the ecological and evolutionary significance of cavitation and xylem embolism are to be evaluated.

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Abstract

1. Variation in late-winter xylem embolism, phenological traits, growth parameters, xylem anatomy and allozyme characteristics were examined in four populations of European beech (Fagus sylvatica) from different geographical origins in Italy. 2. Ultrasonic acoustic emissions from plant stems were measured during winter. Late-winter xylem embolism was quantified before budburst. The timing of budburst was recorded and plant growth parameters were monitored during the spring. The dimension and density of xylem conduits were measured. The genetic variability was investigated using isoenzymes as genetical markers. 3. Significant differences between populations in the rate of acoustic emissions, late-winter embolism, phenological traits and spring growth parameters were observed. Xylem embolism was higher in populations that displayed a higher rate of acoustic emissions during winter. The most embolized population displayed later budburst and slower growth in the spring. No significant differences in xylem anatomy were found. 4. Six out of 10 isoenzymatic loci showed significantly different allele frequencies between populations, but no clear association was found between the genetic variation and the variation of the other traits investigated.