

Impact of summer conditions of growth (drought, defoliation, shade) on freezing tolerance of trees

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Introduction: Low temperature represents one of the most important environmental constraints limiting plant productivity and the distribution. The freezing tolerance of most perennial plants increases from fall to winter to prevent injury under winter conditions. This phenomenon is referred to as hardening or cold acclimation. For freezing tolerance, winter starch mobilization resulting in sucrose increase was an essential step on the way to cold hardiness (fig. 1). The efficiency hardening may change with the summer conditions of growth. (e.g., Late July defoliation: fig. 2).

Materials :

3 species of tree are experimented : Walnut (W), Maple (M) and Beech (B).

Growth conditions (fig. 3):

- **Drought:** Water deficit was induced by stop irrigation (W only).
- **Shade:** Tree were covered with a shading net allowing approximately 33% of incident PAR (W, M & B).
- **Defoliation:** see fig. 2

Methods :

LT50: 3 freeze-controlled chamber (-5°C, -10°C and -15°C) were designed to hold twig segments by a circulator bath (Ministat Huber -25°C to +120°C) with external Pt 100 into the chamber, with a steady rate of cooling and thawing of 5°C h⁻¹. Before thawing, the segment was maintained during 1h to -5, -10 and -15°C respectively. Copper-constantan thermocouples were used to measure stem and air temperature. Temperature were recorded with data logger as one-minute averages and averaged at five minute intervals. After conditioning, segments were used for estimating frost hardiness with an electrolyte leakage conductivity method (LT50: ie, subzero temperature causing 50% mortality: based on the methods of Wisniewski and Ashworth, 1985; Zhang and Willison, 1986).

Gelista™: Measurement were made on excised 1-year old twigs. The same freeze-controlled chamber were utilized. Stem diameter variations were monitored with LVDT device (models DF 2.5 and DF 5, Solartron Metrology, Massy, France) allowing sensitive measurements (+/-1µm) of diameter variation throughout the experimentation. Temperature and stem diameter fluctuations were recorded with data logger as one-minute averages and averaged at five minute intervals.

In addition segment of twigs were frozen in liquid nitrogen, lyophilized, and their dry weight measured. Soluble sugars were then extracted from the stems with hot ethanol/water (80/20, v/v), and purified on ion-exchange resins (Bio-rad AG 1-X8 in the carbonate form, Dowex 50W in the H+ form), as described by Moing and Gaudillère (1992). Using a spectrophotometer at 340 nm, sucrose, glucose and fructose contents were determined after enzymatic assays (Boehringer, 1984)

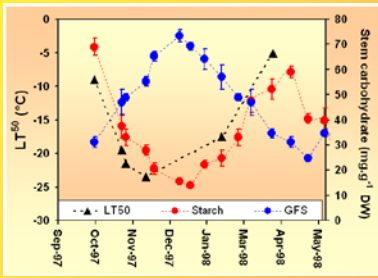


Fig. 1: Evolution of freezing tolerance and stem carbohydrate during winter

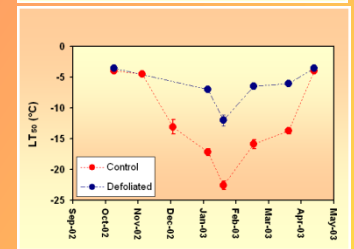
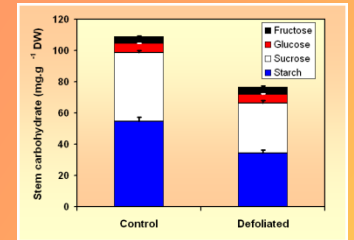


Fig. 2 : Late defoliation (July):

- Defoliated tree ⇒ Stem carbohydrate ↓ (30%)
- Defoliated tree ⇒ 100 % mortality after freeze -10 °C

Drought

Defoliation

Shade

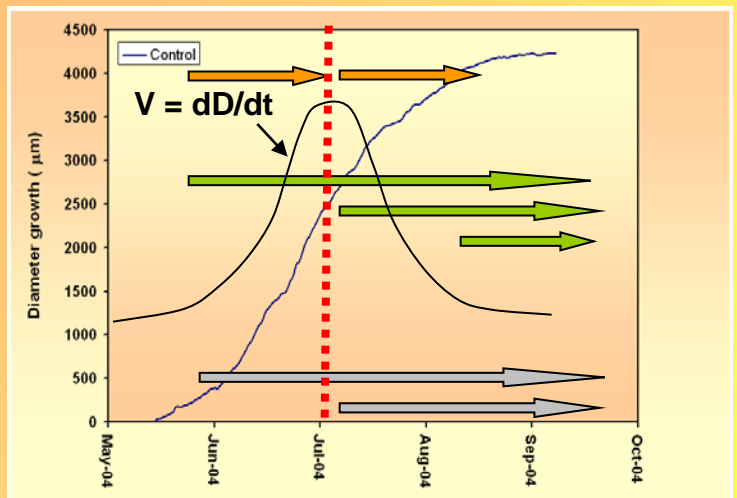


Fig. 3 : Schematization of different treatments (abiotic stress) during summer period

Conclusion: The aim of this study is to characterize the freezing resistance and cold hardiness of different tissues and organs in relation to their carbohydrate status as induced by contrasted summer conditions of growth.