Autumn phenology integrated to frost hardness modelling of fruits trees

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Autumnal phenology integrated to frost hardiness modelling of walnut and apple trees

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Freezing events are among the first causes generating losses in fruit production, especially during autumn (early frosts) and spring (late frosts). As for most abiotic constraint, we can distinguish between two strategies of frost resistance for trees: avoidance and tolerance. Frost avoidance is triggered by the growth suspension during the so-called process of dormancy. Dormancy is released by successive chilling and forcing temperature while frost tolerance occurs in parallel and varies with temperature. Although both strategies are evidently related, we are missing a complete understanding of these processes with respect to freezing events, especially at the edge of the frost-exposed, period in autumn and spring.

We have selected varieties of walnut and apple trees, highly variable for phenology-related traits (budburst ranged over approx. 1.5 month) and winter maximum frost resistance. We put automatic and autonomous micro-dendrometers (PépiPIAF system) to monitor the responses to freezing events of those trees, measuring continuous micro-variations in branch diameter. Then, we compared those responses to different ecophysiological and phenological measurements such as leaf senescence (leaf colouring and shedding), dormancy assessment (one-node cuttings under forcing conditions) and frost resistance (electrolyte leakage method).

We observed that leaf transpiration (indicated by a small diameter shrinkage) lasted for approx. 5 days after the first freezing event (indicated by a large diameter shrinkage) until it felt down. Diameter analyses consequently allowed precisely dating the freezing events and obtaining the ice formation temperature in the studied tree.

Using the real date of leaf shedding on a physiological basis (end of transpiration) should improve the phenological models. These findings are crucial for accurate prediction of the length of the growing season for trees. Furthermore, actual ice formation will definitely improve frost risks assessment, using a more realistic approach.