

An in-situ experiment on Maple saplings

The sap extracted from Sugar Maple trees, is used to produce maple syrup. There are many conflicting theories and an absence of experimental evidence, regarding the mechanisms involved in maple sap exudation. However the unique cellular structure of maple trees, the presence of sucrose within vessel sap, and repeated freeze-thaw events are thought to be the main contributing factors. With the in-situ CT capabilities of the IMBL, the effects of freeze-thaw events on live maple saplings can be visualised and measured. This creates a better understanding of Maple sap exudation and will greatly inform the controversy surrounding this topic.

The Research & Outcomes

Maple syrup is produced by concentrating the sap of Sugar Maples. Sap exudation occurs when trees develop elevated stem pressures such that sap will flow readily out of any opening made in the tree. Sugar Maples are unique in that they produce large quantities of sap in the springtime months after an extensive cold period. For this reason, the current Maple Syrup industry is geographically restricted to regions of long, cold winters (i.e. north-eastern North America). However, there is evidence to suggest that sugar maples can produce sap in milder climates, such as New Zealand.

The mechanism driving the production of Sugar Maple sap is linked to the unique structure of Maple trees, continuous freeze-thaw events that occur during the springtime months, the presence of sucrose within vessels sap. Research suggests that when maple trees experience freezing temperatures, gas-filled fibres within the tree fill with ice crystals. These ice crystals compress the gas within the fibres resulting in elevated stem pressures. Furthermore, as water in the sap freezes to produce ice crystals, the sugar remains behind producing a highly concentrated solution in the vessels. Osmotic pressure



then drives further uptake of water from the roots.

After a rapid growth in the 1990s 80% of the world's Maple syrup is produced in the province of Quebec, Canada. The industry is worth about \$360 million (USD). Understanding the biology of Maple sap exudation might allow other regions such as parts of New Zealand, to join in production and supply.

The Canterbury University research team have induced realistic freeze-thaw cycles in saplings allowing the processes within the tree stem to occur as they would in nature. Simultaneously acquiring 3D visualisations using IMBL under controlled freeze-thaw cycles has allowed a continued study of the physiological changes that occur, resulting in a greater understanding of the mechanisms that drive sap flow.

Benefits & Impacts

New Zealand has a much milder climate than that of north-eastern North America. This research will enhance and extend existing exudation models to enable accurate prediction of sap yields under NZ's milder climatic conditions. These synchrotron experiments will help to de-risk the establishment of a NZ maple syrup industry. Creating an opportunity for a new domestic industry producing a high-value export product.

<https://www.canterbury.ac.nz/bic/news/2019/uc-researchers-working-towards-a-new-zealand-maple-syrup-industry.html>