SMART Atlantic Balsam Christmas Tree Research Centre

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Effect of xylem-fed maple sap on balsam fir needle abscission and water loss in spring and autumn

Introduction

Balsam fir is the primary Christmas tree species in Atlantic Canada, but postharvest needle abscission poses a major challenge. Dehydration is a key factor contributing to abscission, but balsam fir will shed needles even under well hydrated conditions. It is proposed that root-detachment represents the first committed step towards abscission which may be triggered due to the lack of a certain unknown root-derived factor. The objective of this study is to supplement postharvest balsam fir branches with sap from a root-intact system and evaluate effects on postharvest needle abscission.

Methods

The experiment followed a completely randomized design with four factors: maple sap concentration, season of harvest, filtration of water supply, and autoclaving of water supply. Maple sap was diluted to 7 concentrations (0, 1, 10, 25, 50, 75, or 100%), branches were harvested in either spring or autumn, the water supply (including sap) was either filtered using reverse osmosis or not filtered at all, and the water supply (including sap) was either autoclaved or not. The experiment was considered a 7 x 2 x 2 x 2 factorial and was replicated 5 times, which required 280 branches.

Branches were evaluated for the length of time to begin abscission (NAC – needle abscission commencement), the length of time to complete abscission (NRD – needle retention duration), the length of time to reach the critical water uptake rate of 0.05 mL g^{-1} d^{-1}, and the length of time to reach ignition point (33% FW moisture content).

Results

Postharvest abscission

Filtration method had no effect on needle abscission in spring harvested branches, but NAC was delayed by 41% and NRD delayed by 72% in autumn harvested branches when supplied water that had not been filtered.

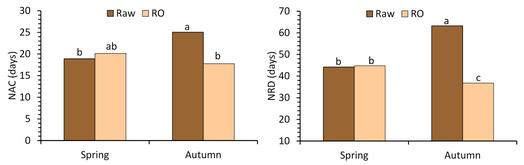

Fig. 1. Interaction effect between harvest season and filtration method on needle abscission commencement and needle retention duration.

Overall, any concentration of maple sap fed via xylem had an adverse effect on needle retention. As above, unfiltered sap tended to maintain better needle retention than RO filtered sap.

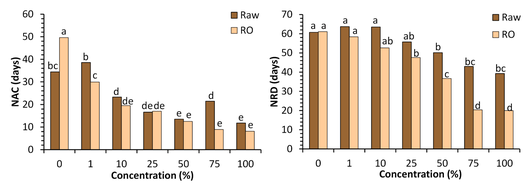

Fig. 2. Interaction between maple sap concentration and filtration method on needle abscission commencement and needle retention duration.

Abscission curves for balsam fir are typically logistic. A shift to the right is indicative of a positive treatment. Maple sap shifts the abscission curve strongly to the left.

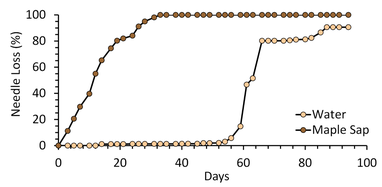

Fig. 3. Abscission curves of branches fed water only as compared to those fed pure maple sap.

Results

Water uptake and content

Previous studies identified 0.05 mL g^{-1} d^{-1} as a critical water uptake rate closely associated with postharvest abscission. Filtration method had no effect on the time to reach critical water uptake in spring, but it took 46% longer in autumn when maple sap was unfiltered. There was also an overall trend of higher maple sap concentrations accelerating abscission, though this was less pronounced when water supply was autoclaved.

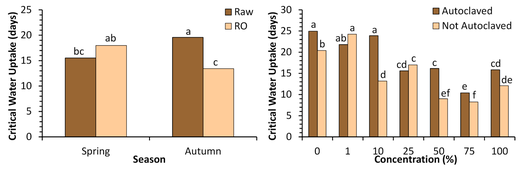

Fig. 4. Interaction between harvest season and filtration (left); interaction between maple sap concentration and autoclaving (right) on time to reach critical water uptake.

Balsam fir will ignite when exposed to a burning match once they reach 33% moisture content. The length of time to reach ignition point decreased as maple sap concentration increased, suggesting those branches dried out faster. There was no effect from filtration method in spring, but there was a significant decrease in autumn when maple sap underwent RO filtration.

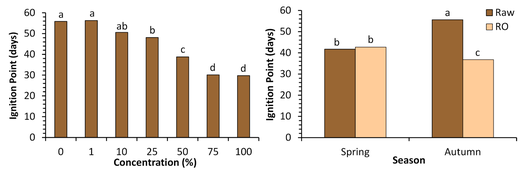

Fig. 5. Effect of maple sap on length of time to reach ignition point (left); interaction between harvest season and filtration method on length of time to reach ignition point (right).

Results

Hormone analysis of maple sap

ABA and its metabolites were found in all samples of maple sap (Table 1). Autoclaving made no difference in ABA concentrations, but the concentration of ABA and its metabolites was significantly lower in sap submitted to RO. The primary metabolite present in maple sap was PA at 163.0 ng g-1, but it was 95% lower in RO sap. There was an 80% decrease in ABA, 97% decrease in DPA, and 77% decrease in OH-ABA resulting from RO. In addition, t-ABA decreased from 3.6 ng g-1 to concentrations below the detectable limit after RO.

Table 1. Concentration of ABA and ABA metabolites in maple sap that is either unfiltered or has undergone RO filtration.

	Concentration (ng/g fresh sap weight)				
	c-ABA	DPA	PA	OH-ABA	t-ABA
Raw	18 ± 5	69 ± 23	163 ± 2	8 ± 2	4 ± 0
RO	4 ± 0	2 ± 3	8 ± 0	2 ± 3	ND
P	= 0.001	= 0.001	< 0.001	= 0.002	n/a

Conclusions

- Relatively low concentrations of ABA and ABA metabolites are present in maple sap, though most are removed during filtration.
- Even dilute concentrations of maple sap do not offer any benefit to postharvest balsam fir. Branches supplied maple sap tend to shed needles earlier, have lower water uptake rates, and dry out faster than branches provided water alone.
- RO filtration was generally not helpful. It had no effect on spring harvested branches and accelerated abscission in autumn harvested branches.
- There was some evidence that autoclaving water supplies could improve water uptake rates.