Lipid and fatty acid changes linked to abscission in two contrasting genotypes of balsam fir needles postharvest

Gaye MacDonald, Rajasekaran R Lada, Claude D Caldwell, Chubuike Undenigwe, Dalhousie University, NS,CA

Introduction

Balsam fir constitutes about 99% of the total natural Christmas tree market in Atlantic Canada. Postharvest needle abscission remains a major challenge for the industry. Although some progress has been made in some hormonal and biophysical linkages to postharvest needle retention, we still do not know the nature and dynamics of changes in lipids and fatty acids postharvest. Thus, the objective of this experiment was to monitor changes in lipids and fatty acids after roots were detached and to determine their relationship to postharvest abscission in two contrasting genotypes of balsam fir.

Methods

Five balsam fir branches were collected from two known genotypes (AB-NSD-124 and AB-NRD-005) from a clonal orchard in Debert, NS in September. These branches were frozen in liquid nitrogen and stored at -80̊C for lipid extraction. More branches were cut from each genotype and placed in deionized water in the lab (Fig.1). Branches were monitored until peak needle abscission occurred. Response variables measured every two days were needle loss (NL), and average daily water use (ADWU). Membrane injury (MII), and stress index (fluorescence) were measured initially and once every 7 days. Needles were frozen and stored at -80̊C. Lipids were extracted in the lab and sent to Kansas Lipidomic Reseach Center for polar lipid and fatty acid analysis.

Figure 1. Experimental set-up

Statistical Methods

Repeated measures SAS® 9.3. ANOVA, Tukey's Multiple Means Comparison, Correlation, and Multiple Regression Minitab®17.

Results

Needle Loss and Water Usage

Abscission in AB-NSD-124 began around day 49, whereas in AB-NSD-005 it began on day 21 (Fig. 2). ADWU decreased by 83 and 77%, respectively by day 42.

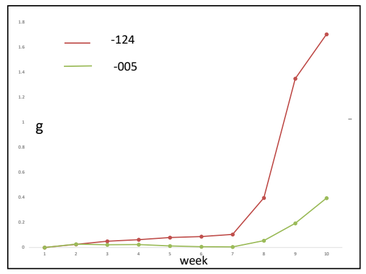


Figure 2. Cumulative needle loss for needles of root detached hydrated balsam fir over a 10 week period postharvest.

Stress Index (Fluorescence) and MII

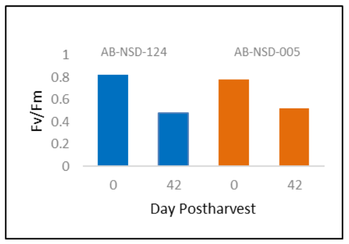


Figure 3. Stress index decrease postharvest in two genotypes.

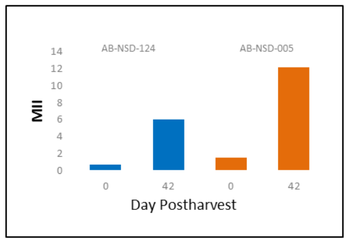


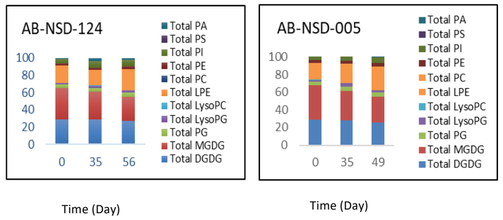
Figure 4. MII decrease postharvest in two genotypes.

Results

There was a significant interaction between day and genotype (p =.003). By day 63, there was 4x needle loss in AB-NSD-005 as in AB-NSD-124. NL in AB-NSD-005 was best predicted by increasing MII and decreasing capacitance (R^2 = 75.9%), whereas in AB-NSD-124 was best predicted by decline in fluorescence (R^2 = 75.6%; Figs. 3,4).

Lipid Classes

In fresh balsam fir needles of genotypes -124 vs -005, the most plentiful lipid class was MGDG composing 32.5% and 36%, respectively of total polar lipids, followed by DGDG composing 24.6% and 25.2%, respectively. The marked change that occurred in both genotypes was a significant decrease in MGDG percentage, and the MGDG:DGDG ratio. This resulted in and increase in the percentage of PC (Figs. 5,6).



Figures 5, 6: Percent of each lipid class in needles of 2 genotypes of root detached hydrated balsam fir. AB-NSD-124 (left) and AB-NSD-005 (right)

Fatty Acids

The most abundant fatty acids in fresh needles of balsam fir in both genotypes were 18:3n3 (17.5%), 18:2cis (16.5%), 18:1 cis (12%), and 16:0 (11.5%). There was a significant interaction between Day x Genotype in 18:3n3. Both genotypes decreased significantly, but NS-NRD-124 showed decrease later postharvest than NS-NRD-005 suggesting that maintaining long chain unsaturated fatty acids could be protecting the membranes of the high abscission resistant genotype for longer (Fig. 7). Total Δ-5UPIFA contributed 17.5%, with a significant decrease in 5,9 18:2 and 5,9,12 18:4 and an increase in 5,11,14 20:3 in both genotypes postharvest.

Results

In both clones, NL was inversely related to decreasing peroxidation index (PI) and double bond index (DBI), also linoleoyl-desaturase ratio (LDR) in AB-NSD-124 (R^2 = 62 %, 58% respectively; Figs. 8,9.10).

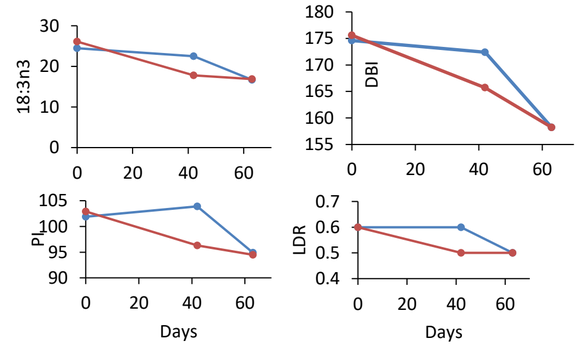


Figure 7, 8, 9, 10: 183n3, DBI, PI, and LDR over time in two diverse genotypes. Red represents AB-NRD-005, and blue AB-NRD-124.

Conclusions

- AB-NRD-124 is more resistant to abscission than AB-NRD-005
- NL in AB-NRD-124 is predicted by lowering stress index (fluorescence), where as in AB-NRD-005, NL is best predicted by membrane injury and capacitance.
- There is a decrease in MGDG in both genotypes by approximately 10% postharvest.
- There was a significant decrease in 18:3n3 in both genotypes, however 18:3n3 remained consistent in the more highly resistant genotype (AB-NRD-124) for longer.
- In both clones NL was inversely related to decreasing peroxidation index (PI) and double bond index (DBI), also linoleoyl-desaturase ratio (LDR) in AB-NRD-005.

postharvest