RES-FOR HIGHLIGHT #7a

June 2020

Genetic variation in stomatal sensitivity to atmospheric drought & water use efficiency in lodgepole pine & white spruce progeny trial trees

Overview

We examined genetic variation in two drought resistance traits: 1) stomatal sensitivity to atmospheric drought; and 2) water use efficiency in field progeny trials of the Region C lodgepole pine (Pl) & Region D1 white spruce (Sw) tree improvement programs.

Goals & Objectives

1. A key plant response to drought is to close their stomata to prevent mortality caused by losing too much water. Our **first goal** was to compare families in their stomata sensitivity through measuring stomatal conductance (g_s, how fast water is lost on a per area 'leaf' basis) to atmospheric drought measured as vapor pressure deficit (VPD, a metric that combines air temperature and humidity).
2. The closure of stomata comes with a cost of reduction in photosynthesis. Intrinsic water use efficiency, indicated by measuring the stable carbon isotope ratio ($\delta^{13}C$), captures how many carbon molecules a plant uses for a given amount of water lost, and thus has been used as a selection target in breeding for drought resistant crop varieties. Crop breeders realized that focusing on $\delta^{13}C$ *per se* could result in varieties that had low g_s and low growth rate; Ideally, one should select for genotypes with a high $\delta^{13}C$ ratio driven by a high carboxylation capacity, i.e., the ability to achieve greater photosynthesis at a given g_s. Our **second goal** was to compare families in their $\delta^{13}C$ ratio and to test if there was a positive genetic correlation between $\delta^{13}C$ and foliar nitrogen content (N_{area}), a surrogate for carboxylation capacity.
3. Our **third goal** was to test if genetic values of stomatal sensitivity and $\delta^{13}C$ of the families were correlated with climate conditions at the mothers' location of origin.

Methods

We measured g_s under naturally varying ambient VPD in 40 Pl families and 34 Sw families in two field progeny trials (one trial per species), and measured N_{area} and $\delta^{13}C$ in a subset of the families that: a) covered the entire range of height breeding values of the trees; and b) were also tested in a greenhouse trial (Highlight Sheet #7b).

Results

1. The Pl families showed significant variation in g_s (but not in stomatal sensitivity to VPD), which was negatively correlated with $\delta^{13}C$ (Fig. 1). This result suggests that the genetic variation in $\delta^{13}C$ among Pl families was primarily driven by g_s.
2. In both species, progenies with higher N_{area} showed higher $\delta^{13}C$, but the two traits showed no positive genetic correlation. This result suggests that N_{area} was not a major driver for genetic variation in $\delta^{13}C$, but it might be possible to boost water use efficiency through manipulating environmental factors such as planting at more fertile sites, that could increase N_{area}**.**
3. The Sw families showed significant variation in $\delta^{13}C$ and in stomatal sensitivity to VPD. The families of mothers that originated from drier, warmer habitats had more sensitive stomata and higher water use efficiency (Fig. 2). No such climate- trait correlations were found among the Pl families.

Conclusions

We found significant genetic variation in δ^{13}C, and positive phenotypic correlations between δ^{13}C and foliar nitrogen content (N_{area}) in both species. In addition, we found warmer, drier habitats were occupied by Sw individuals with higher water use efficiency and more sensitive stomatal responses to atmospheric drought.

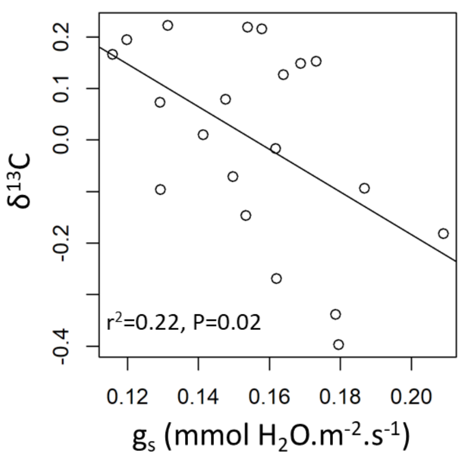
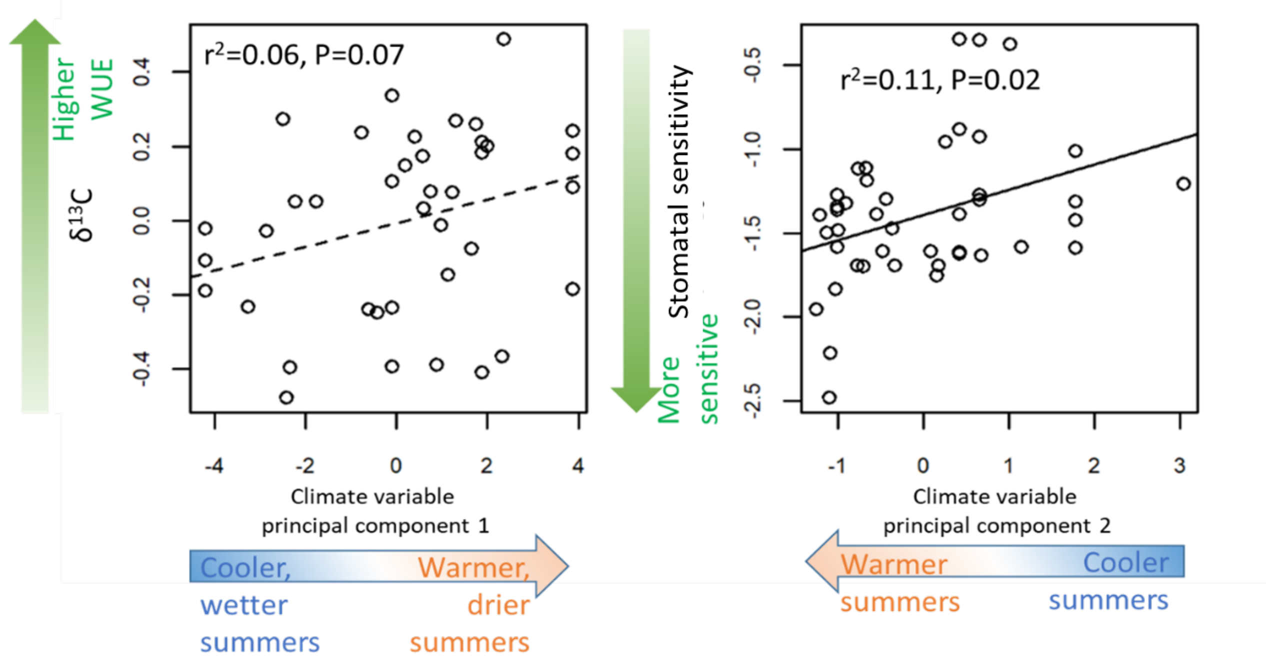


Fig. 1 Breeding values of δ^{13}C (centered around 0) and g_s of the Pl families. Solid line is the regression line.

Fig. 2 Principle component analysis of breeding values of δ^{13}C (left) and stomatal sensitivity (slope of g_s against VPD) vs. climate conditions (right) at the mothers' location of origin. Dash and solid lines are the regression lines.



For more information on the RES-FOR project please contact:
Barb Thomas: bthomas@ualberta.ca or Stacy Bergheim: sberghei@ualberta.ca
For more information on this highlight sheet please contact:
xwei6@ualberta.ca or bthomas@ualberta.ca

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