RES-FOR HIGHLIGHT #7b
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*Selecting for drought resistance based on physiological traits
in the Region C lodgepole pine breeding program*

Overview

Selection for drought resistance can be made based on drought resistance traits that indicate yield under drought. Choosing the appropriate traits involves considering the available genetic variation in the selected traits, the importance of the traits in determining yield under drought, and the cost of phenotyping.

Goals & Objectives

We conducted a greenhouse experiment on seedlings from selected lodgepole pine (Pl) families to examine the genetic variation in their physiological and growth trait responses influencing yield (stem dry mass) under a control (well-watered) and moderate (non-lethal) drought treatment.

Methods

1. We focused on 9 Pl families that represented the range in breeding values for height within the Region C breeding program in central Alberta.
2. We divided yield into four components as follows:
   Yield = *photosynthesis (A)* × *canopy area* × *coefficient* × *stem mass ratio*, and examined A, canopy area (using total needle dry mass as an estimate), and stem mass ratio. Coefficient is a quantity indicating the loss of photosynthetic products through processes such as dark respiration, which we did not measure in this study.
3. We also examined genetic variation in the response (reduction) of stomatal conductance (g_s) to the moderate drought treatment. A greater reduction in g_s can prevent cavitation - induce mortality and cause crown dieback under severe drought but might also reduce yield by decreasing photosynthesis under a more moderate drought.
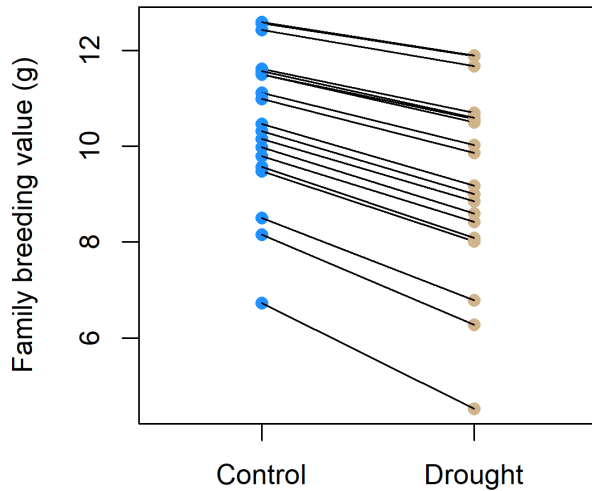
Results

1. A, g_s, needle dry mass, and yield, but not stem mass ratio, showed a significant reduction in measured values to the moderate drought treatment compared to the control treatment.
2. A, needle dry mass, yield, and stem mass ratio, and the reduction of g_s to the moderate drought treatment, all showed significant variation among families. The family ranking in needle dry mass, and yield showed little change between the control and the moderate drought treatment (Fig. 1).
3. Yield showed a strong and positive correlation with needle dry mass (Fig. 2), and a moderate and positive correlation with stem mass ratio among families. Due to a negative correlation between A and needle mass, yield showed an unexpected negative correlation with A.
4. We found no significant correlation between yield under drought and the reduction of g_s to the drought treatment among families. This suggests that selecting for a greater ability to avoid damage caused by severe drought, would not interfere with the selection for higher yield under moderate drought.

Conclusions

We found significant variation among the Region C Pl families in photosynthesis (A), needle dry mass, and stem mass ratio, which were all correlated with yield under moderate drought. In particular, needle dry mass showed a strong correlation with yield and can be estimated in adult trees using remote sensing methods at a relatively low cost.
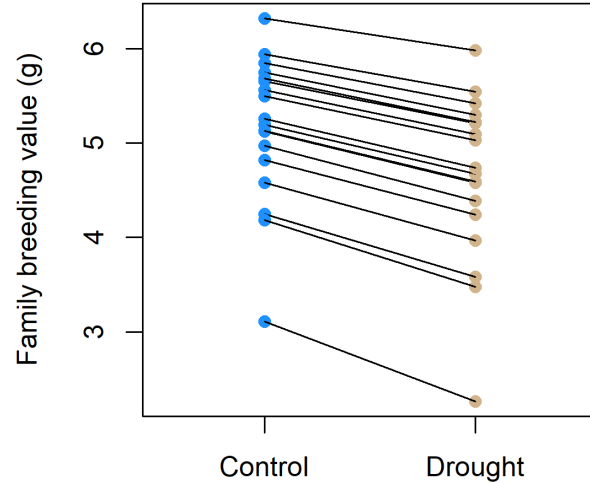
Needle dry mass

Stem dry mass

Fig. 1 Family breeding values of needle (left) and stem (right) dry mass. Each pair of blue and yellow dots connected with a line indicate the breeding values of a family under the control and moderate drought treatments. Note that the family ranking did not change between the control and drought treatments.
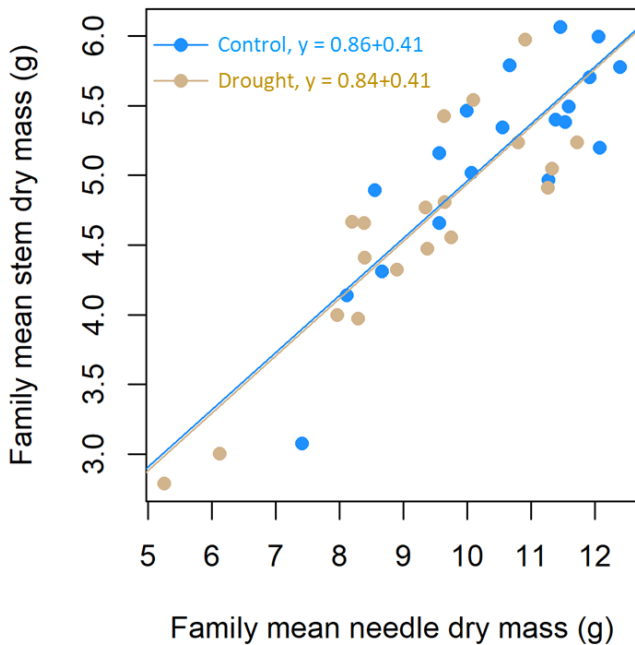

Fig. 2 Family mean stem and needle dry mass was strongly correlated with each other. The blue and yellow lines are the regression lines under the control and drought treatments, respectively. If similar correlations hold true in adults, then there is an opportunity to use canopy area as a proxy for wood production (yield). Dots indicate family means.

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