Is natural defense capacity correlated to stem dry mass allocation in loblolly pine?

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Introduction

Phenolic compounds are a source of natural defense requiring C fixed by photosynthesis, and defense against insects and disease will be greater for loblolly pine families that produce abundant phenolics. C allocation to phenolics is affected by interaction among whole-crown C fixation and dry mass allocation pattern (Figure 1). Moreover, C allocation pattern and level of natural phenolic defense in plants is controlled, in part, by genotype (Danielson et al. 2011, Li et al. 1991, Stovall et al. 2013, Witzell and Martin 2008). It may be possible to predict the relative magnitude of natural phenolic defense among genetic sources of loblolly pine by knowledge of heritable dry mass allocation pattern.

Hypothesis- *There is a predictable relationship between C allocation pattern and natural phenolic defense among genetic sources of loblolly pine.*

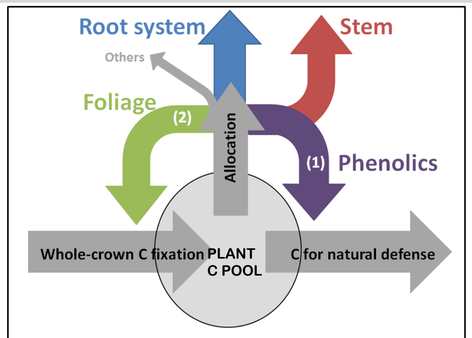

Figure 1. C for natural defense is controlled by whole-crown C fixation and dry mass allocation pattern, and is favored by C allocation to phenolics (1) and conditions that favor foliage production (2).

Greenhouse study methodology

- 20 seedlings of 15 loblolly pine families from past deployments by Arborgen, Weyerhauser, Plum Creek, and Rayonier.
- Seedlings established in a RCB split plot design with 10 blocks, family as a main effect, and N nutrition as a subplot effect.
- Potted seedlings were grown by normal cultural methods in a greenhouse for 28 weeks.
- Measurements were RCD, TH, R:S, and dry masses and fractions of foliage, stem plus branches, and root system.
- Stem total phenolic concentration (**TP**) was measured by a modification of the phosphomolybdic-phosphotungstic acid method.

Greenhouse study results

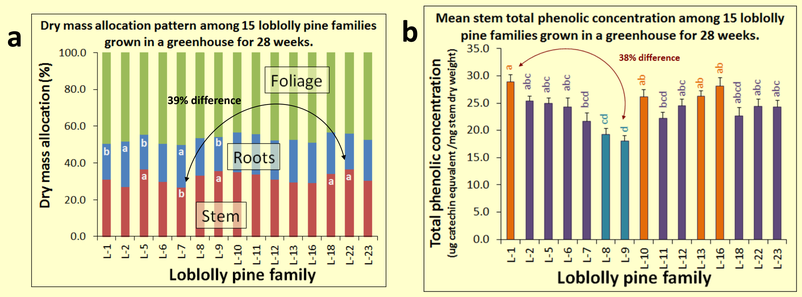

Figure 2. Dry mass allocation to the stem and root system (**a**) and stem TP (**b**) differed among loblolly pine families. ***Perhaps, genetic effects on C allocation pattern indirectly affect phenolic defense capacity.***

Table 1. The relationship between stem TP and seedling total dry weight was significant for 40% of the families. ***Because "leaves grow trees", photosynthetic capacity and thus, leaf area may have a controlling influence over phenolic defense.***

Family	*Pr > F*	R^2	*r*
L-7	0.0016	0.4542	0.6739
L-9	0.0044	0.3709	0.6090
L-12	0.0001	0.6438	0.8024
L-13	0.0065	0.3607	0.6006
L-16	0.0001	0.6915	0.8316
L-18	0.0091	0.3743	0.6118

Hypothesis- *Among genetic sources of loblolly pine, those with a high stem dry mass allocation produce less natural phenolic defense than those with a low stem dry mass allocation.*

Field study methodology

- Three blocks of eight 0.06 ha plots on a complex of very fine sandy loam and loamy fine sand.
- Two plots per block planted with four sources of elite loblolly pine in 2005.

No.	Genetic family	Seed source	Reproduction	Growth rate	Crown shape	Nutrient demand
1	NCC 7-56	Eastern	Open-pollinated	Rapid	Compact	Low
2	LA 8-103	Eastern	Open-pollinated	Rapid	Wide	High
3	MW 9	Eastern	Clone	Rapid	Wide	High
4	MW 93	Eastern	Clone	Rapid	Compact	Low

- One tree per plot in August 2009 destructively harvested and allometric equations between height, diameter, and the dry mass of the stem, branches, and foliage created; and above-ground dry mass allocation pattern of the average tree per plot estimated.
- In January 2015, total phenolic concentration (TP) of sunlit, 2014, 1st-flush foliage determined for two trees per plot by a modification of the phosphomolybdic-phosphotungstic acid method.
- Means of dry mass of, and its allocation to foliage, stem, and branches, and foliar TP assessed by RCB ANOVA.

Field study results

Dry mass and allocation of 4 elite loblolly pine sources at age 5 years

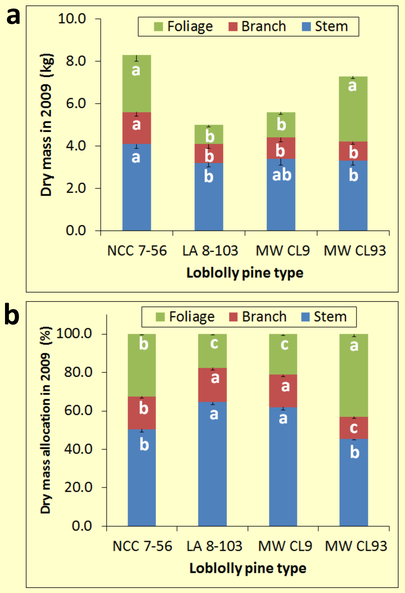

Figure 5. Stem, branch and foliage dry mass (**a**) and allocation (**b**) were distinctly different among the four sources of loblolly pine.

Relationship between stem TP and dry mass allocation

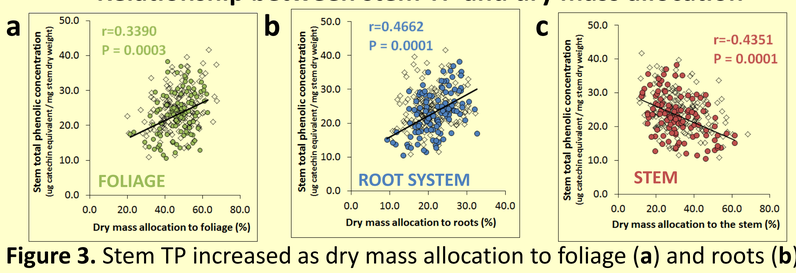

Figure 3. Stem TP increased as dry mass allocation to foliage (**a**) and roots (**b**) increased, and decreased as dry mass allocation to the stem (**c**) increased. Solid symbols are families L-7, L-9, L-12, L-13, L-16, and L-18. Open symbols are the remaining families.

Positive correlation between stem TP and foliage dry mass allocation suggests that foliage production supports the C demand of phenolic defense (Aspinwall et al. 2011).

Negative correlation between stem TP and stem dry mass allocation suggests that the stem competes with phenolic defense for C.

Effect of stem allocation and foliage mass on stem TP

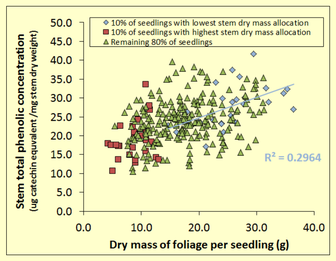

Figure 4. ***Accelerated foliage growth appears to benefit stem TP when dry mass allocation to the stem is low.***

For loblolly pine families exhibiting distinct dry mass allocation patterns, it may be possible to predict natural phenolic defense capacity.

It is proposed that high phenolic defense capacity would occur in families with moderate to low dry mass allocation to the stem, while poor phenolic defense capacity would occur in families with high dry mass allocation to the stem.

Phenolic concentration of 4 elite loblolly pine sources at age 10 years

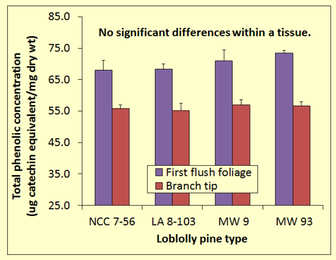

Figure 6. Total phenolic concentration did not differ by loblolly pine source at age 10 years.

Our goal was to determine if natural phenolic defense differs among loblolly pine sources with high and low dry mass allocation to the stem.

The TP of 1st flush foliage and branch tip tissues did not differ by loblolly pine source at age 10 years.

By age 10 years, light-limited C fixation by closing crowns may have interfered with the amount of C supplied to natural phenolic defense.

This notion is supported by Figure 7 showing a negative relationship between TP and total above-ground tree dry mass, and contradicts our greenhouse study results (Table 1).

Foliage total phenolic concentration and aboveground biomass

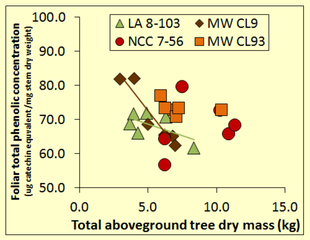

Figure 7. A negative relationship existed between TP (age 10 years) and tree size (age 5 years) for four sources of elite loblolly pine.

Conclusion- *Further assessments of phenolic defense and C allocation pattern in stands of known genotype where light is not limiting could aid the deployment of loblolly pine sources having a high natural defense capacity on sites where insect attack and disease risks are high.*

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