GROWTH AND BIOMASS ALLOCATION OF GRAFTED LOBLOLLY PINE SEEDLINGS FROM DIVERSE FAMILIES FOLLOWING FERTILIZATION

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INTRODUCTION

Both leaves and roots provide resources essential for carbon gain in trees, yet the leaves are the site of assimilation and allocation of carbon-based compounds. Hence, processes occurring in the leaves are generally considered to be paramount in determining growth of plant organs such as roots, stems and leaves. Less clear is the relative importance of processes occurring in the roots upon tree growth and biomass allocation. By grafting genotypes of different growth patterns, effects of rootstocks versus scions may be assessed.

In forestry, most studies of grafted rootstock effects on tree productivity have been conducted in tree seed orchards. For several reasons, it is argued that these studies do not ideally facilitate a genetic assessment of root system effects. For instance, plant material for rootstocks tends to be developmentally more juvenile and genotypically more variable than the scion clones of measured traits. Even so, studies have shown that rootstocks can alter aboveground traits in conifers (Jayawickrama et al. 1991). Rootstocks may influence physiological properties such as foliar nutrients (Schmidtling 1991) or morphological traits such as patterns of biomass allocation. We adopted a novel grafting approach which may better assess rootstock effects on growth and biomass allocation of pine tree seedlings.

METHODS

In this field experiment, ten open-pollinated families of loblolly pine *(Pinus taeda* L.) from two diverse provenances were used, five from a mesic ecotype (Atlantic Coastal Plain – ACP) and five from a xeric ecotype (Lost Pines Texas – LPT). Twelve-week-old seedlings were grafted reciprocally to facilitate distinction of scion-rootstock effects. Normal (non-grafted) seedlings, as well as self-grafted ones, were included as controls. In January 1998, the containerized seedlings were planted on a sandy, infertile site in a split-plot layout. Half of the plots were fertilized with a granular mixture of N,P,K plus micronutrients. In November and December 1998, one-third (600) of the seedlings were harvested and separated into leaves, stems, and roots.

Allometric analysis was used to quantify proportional changes in biomass allocation between the two nutrient regimes. Since proportional allocation of biomass to an organ may be related to total plant size, the full linear model was adjusted for total plant biomass. Analysis of variance procedures were used to test for significant effects on organ biomass due to nutrient treatments or provenances.

RESULTS

Effects of fertilization on cumulative height and biomass allocation were large after one growing season. Overall, fertilized trees of the mesic (ACP) provenance averaged 80 cm. in height, whereas the xeric (LPT) provenance averaged 73 cm. Unfertilized trees of mesic and xeric origins averaged 56 and 54 cm. in height, respectively. Comparable ranking in height of these same provenances has been documented to 4 years of age on an adjacent site (McKeand et al. 1999).

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Biomass accumulation differed between the two provenances mainly in the fertilized plots. When not fertilized, the provenances differed only in their allocation to roots. Since genotypic effects were evident mainly in the fertilized treatment, all of the following results pertain to the fertilized trees. Seedlings of the mesic provenance exhibited greater biomass in aboveground components, along with their superiority in height. This finding concurs with a separate experiment featuring the same provenances (Grissom et al. 1999). Allocation to branches of mesic-source trees increased markedly with seedling size, suggesting that mass allocation to this component may be important at an early age. Branch mass was the only component which differed markedly between provenances as a function of total seedling size.

The grafting operation was highly successful, but as expected, some hindrance of overall growth was evident. Grafted trees were, on average, 7% shorter than non-grafted trees. For total height, scion effects corresponded to those of non-grafted genotypes, and rootstock effects were minimal. Grafting was associated with reduced total biomass, but not with any changes in biomass allocation to organs. Grafting effects on biomass were not assessed at the family level, since sample sizes were inadequate at that level. At the provenance level, both scion and rootstock effects on biomass allocation were most evident when the xeric source was used as its counterpart (rootstock or scion). Scions had their most prominent effect on foliar mass. The mesic scion was associated with greater root mass, even when coupled with the xeric rootstock (Figure 1).

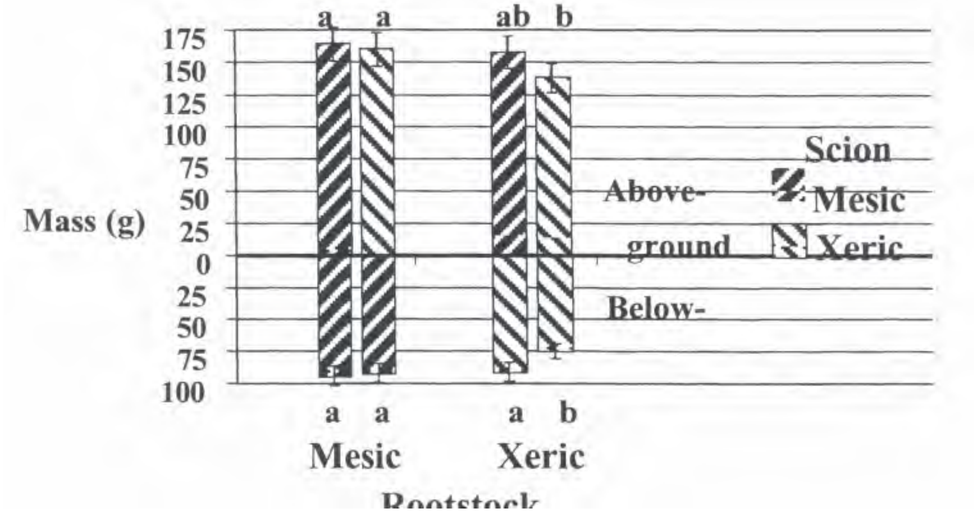

Figure 1. Dry matter (g) in aboveground and belowground components of grafted loblolly pine seedlings, after one year of growth in fertilized field plots. Different letters (a or b) above bars denote significant difference in above- or below-ground biomass at 0.05 level.

When fertilized, rootstocks altered allocation to aboveground biomass (Figure 1), most prominently to branches and stems. In particular, the mesic rootstock was associated with greater mass in aboveground components, regardless of scion genotype. It can be inferred from this finding that the mesic rootstock responds to fertilization by increasing dry matter production throughout the plant, including aboveground parts. Allocation to branches, further building structure for carbon acquisition, may be an important characteristic of mesic sources, as noted earlier. It appears that the mesic rootstock exerts a large effect on growth at the whole-plant level when given sufficient soil resources.

CONCLUSION

These results suggest that in fertile soil, internal (genetic) factors of tree roots can substantially influence allocation of mass to aboveground parts, especially to branches. The contrasting growth habits of these two provenances probably contributed greatly to the observed outcome. Since soil nutrition is an important external factor, the mechanism by which roots exert their influence likely involves uptake or metabolism of mineral nutrients.

More importantly, the degree of control that a plant organ exerts upon whole-plant growth may depend heavily on the genotypic make-up of that organ. In the fertilized treatment of this experiment, it appears that the mesic genotypes exert heavy influence on growth, whether they function as scion or rootstock.

The study will be extended through the 1999 growing season to further evaluate treatment effects on growth and biomass allocation. During this time, intensive ecophysiological study of selected families will be conducted to elucidate possible controlling mechanisms of observed growth effects.

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