COMPARISON OF SHORTLEAF X LOBLOLLY PINE F1 HYBRID PHYSIOLOGY AND MORPHOLOGY TO PARENT OPEN-POLLINATED OFFSPRING

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Hybrids between shortleaf pine (*Pinus echinata* Mill.) and loblolly pine (*Pinus taeda* L.) previously were more frequent in drought and fire prone areas west of the Mississippi River (Hare and Switzer 1969; Edwards-Burke and Hamerick 1995; Tauer et al. 2007; Raja et al. 1997; Stewart et al. 2011 unpublished). However, recent evidence indicates that hybrids have been increasing at an alarming rate since the 1950's throughout the southeastern US (Stewart et al. 2011 unpublished). The goal of this study was to compare the physiology and morphology of artificial hybrids to those of the parent populations to determine whether shortleaf pine x loblolly pine hybrids might inherit useful traits from their parent species that have allowed them to thrive and increase in abundance over the past 60 years.

Materials and Methods

We examined several morphological and physiological characteristics of shortleaf pine (six families), loblolly pine (six families), and their hybrid seedlings (12 crosses) originating from the Western Gulf region. Seedlings were grown in a raised-bed nursery in Goldsby, Oklahoma in four replications of densely stocked family plots (114 seeds per 0.7 x 0.9 m plot) and in four replications of single tree plots spaced at 0.3 m x 0.3 m. During the dormant season following the first growing season, subsets of seedlings from the density plots were top-clipped and subsequent sprouting was monitored along with basal stem crooking (a fire adaptation of shortleaf pine). During the second growing season, morphological measurements on intact seedlings from the single tree plots included height, ground line diameter (GLD), needle characteristics (needle length, needle radius, needles per fascicle, fascicle sheath length, and specific leaf area). Physiological measurements on intact seedlings from the single tree plots focused on leaf-level variables, including net photosynthesis, stomatal conductance, intercellular CO_2 concentration (C_i), transpiration, ^{13}C isotope discrimination (δ^{13}_{CVPDB}%), and foliar nitrogen concentration. Gas exchange measurements were taken with a Li-Cor 6400 (Lincoln, NE) infrared gas analyzer with an attached cuvette that controlled irradiance, temperature, CO_2 concentration, and water vapor. Measurements were taken four times over the second growing season, and data was analyzed using Proc Mixed for differences between genotype.

Results and Discussion

Shortleaf pine had the highest number of sprouts per stump (17.9 sprouts), followed by hybrid pine (15.3 sprouts), and loblolly pine had the lowest number of sprouts per stump (7.8 sprouts) ($p < 0.0001$). After the sprouting study, each stump was removed and checked for the basal crook fire adaptation typically unique in shortleaf pine: the lower stem crooks and lays parallel to the ground, pulling the dormant bud cluster (present in both loblolly and shortleaf pine) down to ground level, keeping it better insulated from fire (Mattoon 1915). Stumps with basal crooks that ran parallel to the ground were considered ‘strong’ and functional crooks. Stumps that had only a slight bend were considered ‘weak’ and non-functional crooks. Shortleaf pine expressed higher strong crooking (42.6%) than both hybrids (6.4%) and loblolly pine (1.8%), which were not significantly different ($p < 0.0001$). Shortleaf pine is known to develop 100% strong crooking under normal field conditions within two to three months , but overly dense and shaded populations such as those in the nursery beds can delay crooking for several years (Stone and Stone 1954, Little and Somes 1956).

At the end of the second growing season, loblolly pine (105 cm) and the hybrids (105 cm) both were significantly taller than shortleaf pine (90 cm). Final GLD were similar for loblolly pine (31.8 mm) and the hybrid pine (33.0 mm) and larger than shortleaf pine (22.4 mm) ($p < 0.0001$).

Needle characteristics measured throughout the growing season on the first and second flushes indicated hybrids were intermediate between the two parent species, with loblolly pine having larger, thicker, longer, and more needles per fascicle than shortleaf pine. This is confirmed by several other shortleaf pine x loblolly pine hybrid studies (Mergen et al. 1965, Little and Righter 1965, Hicks 1973), but their use in hybrid identification should be limited due to large variation in genetic and environmental influences (Stewart et al. 2011 unpublished).

For leaf-level physiology measurements, there were no significant differences in any traits among species with the exception of C_i, ^{13}C isotope discrimination, and foliar nitrogen concentration. Loblolly pine had significantly higher C_i than shortleaf and the hybrid ($p = 0.01$), suggesting that it had a lower instantaneous water use efficiency (WUE; carbon gain per water loss). Although instantaneous WUE showed hybrids similar to shortleaf pine, the $\delta^{13}C$ discrimination indicted that the hybrid and loblolly pine had similar WUE that were lower than shortleaf pine ($p = 0.03$). These results confirm that shortleaf pine has a greater WUE than loblolly pine, and that the hybrid pine has similar or greater WUE than loblolly pine.

Loblolly pine x shortleaf pine hybrids grew fast like loblolly pine, possessed greater short-term WUE like shortleaf pine, and sprouted vigorously like shortleaf pine. This combination of positive traits exhibited by the hybrid seedlings may help explain why hybridization has increased over the last 60 years. Because shortleaf pine does not confer the basal crook fire adaptation to the hybrid, it is possible that fire suppression further enables the establishment of hybrids more readily than in the past.

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