THE EFFECT OF DROUGHT ON LOBLOLLY PINE (*PINUS TAEDA*) PHOTOSYNTHESIS AND WHETHER THINNING OR GENETIC ENTRY CAN IMPROVE PLANTATION DROUGHT RESILIENCE

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EXTENDED ABSTRACT

Loblolly pine (*Pinus taeda*) is an essential economic timber species that brings in billions of dollars to the economy of Southeastern States; however, climate projections predict a warmer and more droughty climate over the next century (Ahmadalipour and others 2017, McNulty and others 2019, Oswalt and others 2019). Plantation managers must adopt new practices to maintain timber production despite these future adverse conditions. Two main methods are proposed to ameliorate drought stress in timber plantations: Reducing plantation density through thinning and planting drought-resistant genotypes. During the 2011 extreme drought in Texas, Klockow and others (2020) observed that loblolly plantations exhibited superior survival rates to natural stands and attributed those survival rates to the lower tree density.

For decades foresters have analyzed growth differences among loblolly pine genotypes and seed sources. Seed sources from the Atlantic Coastal Plain (ACP) exhibit superior growth rates and form, but loblolly pine seedlings from the Western Gulf Region (WGR) are thought to be more drought-resistant (Schmidtling 2001). While ACP seed sources are preferred by landowners due to their superior productivity, future drought conditions may incentivize the planting of WGR seed sources. This study set out to understand whether thinning could ameliorate loblolly pine tree drought stress and if there was genotypic variation in drought resistance.

A loblolly pine plantation was established in Homer, LA in 2005 at the LSU AgCenter Hill Farm Research Station. Three genotypes of loblolly pine were planted: (LA) an open-pollinated Louisiana family commonly recommended for landowners in North Central Louisiana, (756) an open-pollinated North Carolina family from the Atlantic Coastal Plain, and (93) a clonally propagated variety based on the rooted cuttings of a robust 756 individual. Additional site details and genotypic information can be found in Blazier and others (2018). Half of the trees were thinned in 2018 to create thinned (561 trees ha^{-1}) and non-thinned (1122 trees ha^{-1}) treatments. Beginning in 2019, half of the plots were

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trenched 1 m deep, and plastic was lined in the trenches to restrict lateral flow of water in soil. Precipitation exclusion shelters were built around each drought plot to cause complete water exclusion, which was fully initiated on June 5, 2020. All possible combinations of genotype, thinning, and drought treatments were replicated three times for a total of 36 experimental units.

Photosynthetic measurements were recorded during each season to understand seasonal variation in photosynthesis and drought resistance. A LiCor 6400 XT (LiCor Inc., Lincoln, NE, USA) was utilized to measure photosynthesis. Foliage was destructively measured by removing branches from the trees. Two flushes from each branch were measured when present. Curve fitting software was utilized to convert field data into P_{gmax} and R_d for analysis (Lobo and others 2013).

Repeated measures analysis of variance (ANOVA) was conducted in SAS (SAS Institute, Inc., Cary, NC) using PROC GLIMMIX which incorporates fixed and random effects to compare P_{gmax} and R_d between treatments. Genotype, thinning, and drought and their interactions were included in the model as fixed effects, while date and its interactions with fixed effects were random effects. An alpha level of 0.10 was utilized to account for the inherent variation in photosynthesis among needles in a large tree canopy (Tang and others 1999). Each flush generation (F18, F19, F20) was analyzed separately. Flush 2018 did not have date or drought incorporated into the statistical model because it was only measured on one date prior to water exclusion.

Following initiation of drought simulation on June 5, 2020, treatment differences in volumetric soil water content (VWC) did not manifest until August 3, 2020 (fig. 1). A large increase in VWC occurred in non-drought plots following Hurricane Laura on August 27, 2020. Despite the site experiencing a massive amount of precipitation from the hurricane, water exclusion shelters were able to prevent soil water recharge in drought plots.

Strong date effects were observed in this study (table 1). Leaf photosynthesis and dark respiration were greatest during the summer and lowest during the dormant season. Photosynthetic analysis observed significant differences in P_{gmax} and R_d among the genotypes. In the F18 flush, LA and 756 genotypes had significantly greater P_{gmax} than the clonal 93 genotype (P=0.09). Genotypic differences were maintained during the F19 flush, with LA having significantly greater P_{gmax} than clonal 93 (P=0.09). No genotypic differences in P_{gmax} were observed in the F20 flush (P>0.1).

Significant genotypic differences in R_d were also observed among the genotypes. In F18, 756 and LA exhibited significantly greater R_d than 93 (P=0.09). In F20, 93 exhibited significantly greater R_d than LA, while 756 was not significantly different than either genotype. No significant differences were observed in the F19 flush.

No significant drought or thinning effects were observed during the study, but there was a marginally nonsignificant trend for non-drought plots to exhibit greater P_{gmax} than drought plots during the F20 flush (P=0.12).

This study demonstrated clear genotypic differences in P_{gmax} and R_d among eastern and western loblolly pine genotypes. While significant photosynthetic differences in drought treatments were not observed, the marginally non-significant trend indicates that photosynthetic differences may develop as differences in soil moisture increase. While the 2011 southeastern drought caused extreme drought conditions for 11 months, plantation loblolly pine only experienced 10 percent increased mortality (Klockow and others 2020). That trend suggests that loblolly pines are considerably drought-resistant and that more time is needed in this experiment for drought effects to manifest.

Table 1—Statistical analysis (ANOVA F-Tests) test of fixed effects of maximum gross photosynthesis (P_{gmax}) and dark respiration (R_d) in F20, F19, and F18 foliage

		P_{gmax}		R_d	
	Fixed Effects	df	*P*	df	*P*
F20	Genotype	2	0.3014	2	**0.0146**
	Drought	1	0.1184	1	0.1763
	Thin	1	0.9383	1	0.8781
	Date	3	**<0.0001**	3	**<0.0001**
	Genotype x Drought	2	0.7417	2	0.9120
	Genotype x Thin	2	0.7945	2	0.2842
	Thin x Drought	1	0.8202	1	0.3452
	Genotype x Drought x Date	6	0.3397	6	0.7476
F19	Genotype	2	**0.0862**	2	0.7080
	Drought	1	0.5808	1	0.9225
	Thin	1	0.6963	1	0.1718
	Date	5	**<0.0001**	5	**<0.0001**
	Genotype x Drought	10	0.3580	10	0.3339
	Genotype x Thin	2	0.4830	2	0.4434
	Thin x Drought	1	0.7697	1	0.1775
	Genotype x Drought x Date	6	0.7711	6	0.7418
F18	Genotype	2	**0.0926**	2	**0.0516**
	Drought	—	—	—	—
	Thin	1	0.8934	1	0.1637
	Date	—	—	—	—
	Genotype x Drought	—	—	—	—
	Genotype x Thin	2	0.9294	2	0.5827
	Thin x Drought	—	—	—	—
	Genotype x Drought x Date	—	—	—	—

Em dash (—) indicates that drought and date effects were not analyzed in F18.

Degrees of freedom (df) and probability of a greater F (P) are provided for each variable and flush. F20 and F19 foliage were measured over multiple dates and analyzed with a repeated measures ANOVA. F18 developed prior to drought initiation, and values only represent a single measurement period. Significant *P* values ($\alpha \leq 0.10$) are bolded while marginally nonsignificant values are italicized.

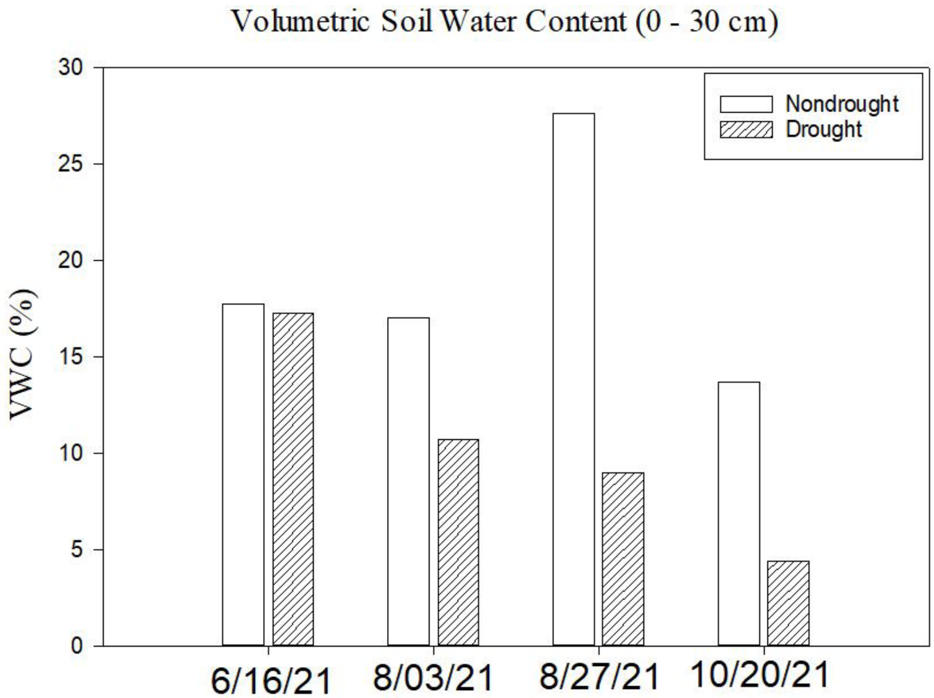

Figure 1—Volumetric Soil Water Content (VWC) (0 - 30 cm) of drought and nondrought plots following drought initiation on June 5, 2020.

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