EFFECTS OF LIGHT ACCLIMATION ON PHOTOSYNTHESIS, GROWTH, AND BIOMASS ALLOCATION IN AMERICAN CHESTNUT SEEDLINGS

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Poster Summary

American chestnut [*Castanea dentate* (Marshall) Borkh.] was a widely distributed tree species in the Eastern U.S., comprising an estimated 25 percent of native eastern hardwood forests. Chestnut blight eradicated American chestnut from the forest canopy by the 1950s, and now it only persists as understory sprouts. However, blight-resistant hybrids with approximately 94 percent American chestnut genetic inheritance are scheduled to be available in 2007. Given the economic and ecological importance of the species prior to the blight, great interest and support for the reintroduction is expected. Successful reintroduction will ultimately depend on a viable silvicultural system. However, little is known about the silvics of American chestnut. The objective of this experiment was to investigate light acclimation of American chestnut seedlings growing under a wide range of light conditions.

METHODS

Pure American chestnut seeds were germinated and grown under well-watered conditions for 1 week. Ten seedlings were randomly assigned into each of 4 light treatments (100, 32, 12, and 4 percent of full sunlight) in a rainout shelter. Seedling height and root collar diameter were measured twice a month beginning on June 7, 2004. On August 2, 2004, all seedlings were destructively sampled and oven-dry mass of root, stem, and leaf, as well as specific leaf area were determined. After 2, 4, and 6 weeks of acclimation under each light treatment, net photosynthesis, leaf stomatal conductance, and transpiration rate were measured using a portable steady state gas-exchange system (CIRAS-I, PP Systems). In addition, the 10 seedlings growing under full sunlight were also used to determine the light response curve, based on which light compensation, light saturation, and maximum photosynthesis rate were determined. Analysis of variance followed by Bonferroni's multiple comparison was used to test the difference in diameter, height, biomass, biomass allocation, and physiological variables.

RESULTS AND DISCUSSION

Maximum photosynthesis, light compensation, and light saturation were determined as 9.08, 29.5, and 203.50 μmol m^{-2} s^{-1}, respectively. When measured under their acclimated light environment, both net photosynthesis and water use efficiency significantly increased with the light level. Mortality due to light limitation was not found even in the 4 percent light, suggesting that American chestnut would survive when planted in the understory of a closed canopy forest. Height did not increase significantly in 4 percent light, while diameter significantly increased under all light levels. By not growing tall under light limitation, American chestnut decreased its height to diameter ratio, thus increasing light use efficiency. Differences in diameter and height were detected 15 days into the experiment and onward. At end of the experiment, seedling growth was significantly affected by light treatment, with the highest growth found in 100 percent light and the lowest growth found in 4 percent light. Root to shoot ratio was lower under 4 percent and 12 percent compared to 32 percent and 100 percent light treatments. Specific leaf area significantly decreased with light levels, with 100 percent < 32 percent = 12 percent > 4 percent. Smaller root to shoot ratio and greater specific leaf area indicated a high efficiency to capture light under shade conditions. Regardless of light level, American chestnut invests > 70 percent of its total biomass to above-ground growth. This allocation pattern is comparable to tulip poplar, red maple, and black gum but different from white oak and mockernut hickory, species that allocate < 35 percent to the aboveground.

CONCLUSIONS

American chestnut quickly adapted to light limitation by changing its biomass allocation along the light gradient. The morphological and physiological acclimation to low light suggests that American chestnut is shade tolerant. Based on its shade-tolerance and strong response to canopy release, an underplanting-and-release or gap-phase regeneration approach would be feasible, and a clearcut-and-planting approach may not be necessary when reintroducing American chestnut back to its native range.

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