

# DROUGHT TOLERANCE AND OSMOTIC ADJUSTMENT OF FOUR DECIDUOUS TREE SPECIES UNDER ALTERED PRECIPITATION: PRELIMINARY RESULTS<sup>1</sup>

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**ABSTRACT:** The degree and biochemical basis of drought tolerance and osmotic adjustment of dogwood (*Cornus florida* L.), white oak (*Quercus alba* L.), chestnut oak (*Quercus prinus* L.), and red maple (*Acer rubrum* L.) is being assessed in a mature hardwood forest using three hydrologic regimes: ambient, wet (+33% throughfall), and dry (-33% throughfall). Currently, leaf water potential, osmotic potential at saturation, and metabolite concentrations are determined monthly for trees under the three treatments. First year results show that within the dry treatment, dogwood demonstrated the highest osmotic potential at saturation (-1.2 MPa), indicating the greatest sensitivity to water stress. Increasing tolerance was evident in red maple (-1.4 MPa), white oak (-1.6 MPa), and chestnut oak (-1.9 MPa). In June, dogwood displayed a 0.12 MPa adjustment to drought, relative to the ambient control. In July, chestnut oak displayed a 0.18 MPa adjustment. This osmotic adjustment resulted primarily from fructose and glucose accumulation in dogwood, and shikimic acid and sucrose accumulation in chestnut oak.

## INTRODUCTION

The response of forests to increased occurrence of drought, associated with global climate change, will depend on the drought resistance capabilities of component species. Drought-tolerant tree species will be at a competitive advantage. The mechanisms of drought tolerance and osmotic adjustment are being assessed for four hardwood species in an upland oak forest. Osmotic adjustment results from the accumulation of solutes, allowing the individual to maintain turgor and growth under drought conditions. The major solutes typically include free amino acids, soluble carbohydrates, and inorganic ions. To investigate mechanisms of drought tolerance in a mature forest, a stand-level manipulation of hydrologic inputs to a hardwood forest has been implemented on Walker Branch Watershed in Oak Ridge, Tennessee. The Throughfall Displacement Experiment facility is designed to simulate chronic drier-than-normal and wetter-than-normal soil moisture conditions (ranging from 8% volumetric moisture content on the dry site to 27% on the wet site).

## METHODS

Leaves from overstory and understory tree species were sampled monthly during the growing season

<sup>1</sup>A poster presented for the Physiology Working Group at the SAF National Convention held at Anchorage, Alaska, on September 18-22, 1994.

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(six replicates of each species for each of the 3 treatments). At the time of sampling, leaves were either immediately frozen for later biochemical analyses or recut underwater to be rehydrated overnight for osmotic potential determination. Leaf water potentials were measured to give a preliminary estimate of the degree of water stress. Biochemical analyses were performed on species which displayed adjustment of osmotic potentials under drought conditions. Free amino acids were analyzed as *o*-phthalaldehyde (OPA) derivatives by reversed-phase (C<sub>18</sub>) high performance liquid chromatography. Soluble carbohydrates were analyzed by gas chromatography/mass spectrometry following trimethylsilyl derivatization. Inorganic ions were analyzed by inductively-coupled plasma and carbon-arc spark emission spectroscopy.

## RESULTS

First year results show that within the dry treatment, dogwood had the highest osmotic potential at saturation (-1.2 MPa). Decreasing values were observed for red maple (-1.4 MPa), white oak (-1.6 MPa), and chestnut oak (-1.9 MPa), indicating increasing drought tolerance. There were no significant differences in osmotic potential at saturation between overstory and understory red maple. In June, dogwood displayed a 0.12 MPa adjustment to drought, relative to the ambient control. In July, chestnut oak displayed a 0.18 MPa adjustment (Fig. 1). The other species studied did not display significant osmotic adjustment. Increases in solute concentrations were observed in leaves of dry treatment dogwoods and chestnut oaks. The solute accumulation in dogwood (May, 1994) is summarized in Table 1. Fructose, glucose, and catechin accounted for an adjustment of 359  $\mu$ mole/g dry weight in dogwood. Shikimic acid and sucrose were responsible for a 550  $\mu$ mole/g dry weight adjustment in chestnut oak (July, 1994).

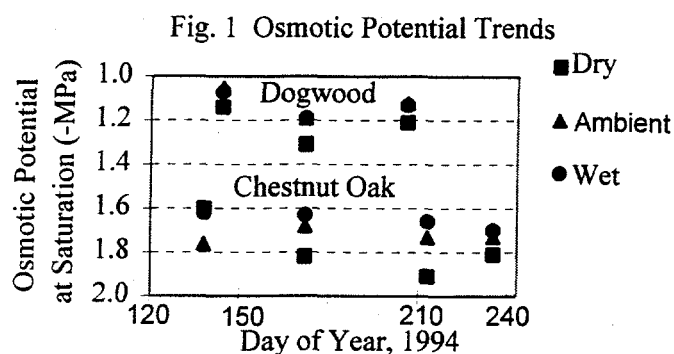


Table 1. Major solutes comprising the total accumulation in dry treatment dogwoods (May, 1994)

Accumulating Osmotica	% of Total Accumulation (relative to ambient)
<u>Carbohydrates</u>	
Fructose.....	28
Glucose.....	17
Catechin.....	15
Myo-inositol.....	7
<u>Inorganic Ions</u>	
Sodium.....	8

## CONCLUSIONS

First year results indicate that canopy position had no effect on the expression of osmotic potential in red maple, which did not display significant osmotic adjustment. We concluded that dogwood was the most sensitive to water-stress (highest osmotic potential at saturation); whereas chestnut oak was the most drought-tolerant. The role of free amino acids in solute accumulation was minimal in the species studied. In all cases, the contribution of free amino acids was <1% of the total solute pool. In dogwood, the solute pool was comprised mostly of inorganic ions (~60%), secondarily of soluble carbohydrates. In chestnut oak, the reverse was evident. In both species, soluble carbohydrates were the most important class of solutes in osmotic adjustment.

Research sponsored by the Program for Ecosystem Research, Office of Health and Environmental Research, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

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