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Tree diversity enhances leaf water status and soil moisture during dry periods: Evidence from IDENT-Ethiopia

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Abstract

Soil moisture critically limits forest growth and restoration success in drylands. While tree diversity enhances ecosystem functioning and productivity, its effects on plant and soil moisture status have not been explored in tropical dry forest. This study examined how tree diversity influences leaf water and soil moisture status during dry period using a six-year-old IDENT- Ethiopia tree diversity experiment. The experiment includes 270 plots across six blocks, with varying species richness (1, 2 and 4) and functional diversity (low, medium and high) in mixtures, established with nine native tree species.

Data on leaf water content (LWC) and volumetric soil water content (VWC) were collected and calculated, and midday leaf water potential (LWP) was measured to assess leaf and soil water status across a species-diversity gradient during the dry period. Relative LWC was estimated from 6,440 leaves, and midday LWP of 2,866 leaves were measured using a pressure bomb. VWC was estimated from 264 soil water samples. Relative LWC and VWC data were analyzed using Generalized Linear Mixed-Effects Models with a logit link, and LWP with a log link.

Our results showed that four-species mixtures significantly increased relative LWC compared with two-species mixtures ($p < 0.001$), while LWP was significantly reduced in the four-species mixtures ($p = 0.002$). Relative LWC in four-species mixtures (71.8 %) was higher than in two- species mixtures (69.1 %), demonstrating improved leaf water status. Midday LWP in four-species mixtures (−2.44 MPa) was higher than in two-species mixtures (-2.55 MPa), indicating that trees in four-species mixtures experienced less water stress. Soil moisture analysis partially supported these patterns, with four-species mixtures showing a 6 % higher likelihood of increased VWC compared with two-species mixtures.

In conclusion, greater species richness underpins plant–soil water regulation. Higher mixtures improved leaf water status, increased soil moisture, and reduced water stress, highlighting that higher mixtures were better hydrated and more resilient than less species-rich mixtures during dry period. These advantages likely stem from complementary rooting, where different tree species access water from distinct soil layers, and from hydraulic lift by deep-rooted trees that draw water from deeper horizons and rehydrate upper soil layers for shallow-rooted species.

Keywords: Leaf water potential, mixed-species, plant water relations, relative leaf water content, soil moisture content

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