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Tree size as a proxy of texture and soil salinity in a pecan orchard: exploring the spatial variability and dominant controls on carbon fluxes in managed dryland critical zone

MICHELLE QUIROZ[1], AIMEE GARCIA[1], VALERIA MOLINA[1], ORLANDO RAMIREZ-VALLE[1], MANNY SOSA[1], VIRIDIANA ORONA[1], GALEN KAIP[1], DIANE DOSER[1], MARK ENGLE[2], HUGO GUTIERREZ[1], ANTHONY DARROUZET-NARDI[1], LIN MA[3] AND **LIXIN JIN**[4]

[1]University of Texas at El Paso
[2]The University of Texas at El Paso
[3]University of Texas et El Paso
[4]University of Texas, El Paso

Presenting Author: ljin2@utep.edu

Agriculture in drylands requires intensive irrigation, making these managed critical zone systems hydrologically, geochemically and biologically dynamic. The conversion of natural drylands to managed agricultural fields also modifies organic and inorganic carbon cycling. Indeed, irrigation water supports growth of crops, modifying the biological cycles, and ecosystem-atmosphere CO_2 exchange. With intensive evaporation and reduced leaching, irrigation leads to salt accumulation in soils, affecting the soil quality and productivity. In this process calcite forms as a secondary phase, releasing inorganic CO_2. This study focuses on a pecan orchard in Tornillo, Texas, along the Rio Grande valley where soils are developed on floodplain sediments. We combined environmental geophysical, biological, geochemical and isotopic tools, as well as sensors and remote sensing, to investigate how the soil texture serves as the master variable to spatially control variability of soil moisture dynamics, redox conditions, salt buildup, tree size, crop yields, calcite accumulation and CO_2 emission. The surveys acquired by EM31 and EM38 ground conductivity meters showed that soil texture varied laterally and with depth within the orchard. Higher conductivity levels, a proxy for clay-dominant soils, correlated with smaller tree sizes (diameter at breast height), higher soil salinity, periodically reducing conditions, and higher soil moisture and more evaporative water loss. Results showed that in soils with finer particles, water infiltration was reduced, thus increasing evaporation rates, and resulting in excess salt accumulations that stunt tree growth. It is also possible that clayey soils limit root growth and thus primary productivity. This study demonstrated tree size data as a valid proxy for soil texture, and salt buildup in an irrigated agricultural field, providing insight into the strong links among irrigation, soil salinity, tree growth, calcite formation and CO_2 release, and provided tools to quantify different fluxes across landscapes from pedon, to orchard, and regional scales.