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Soil CO_2 dynamics in flood irrigated arid agricultural fields: temporal variability of abiotic and biotic CO_2 production and transport

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Arid soils have complex carbon dynamics, with both abiotic and biotic processes contributing to the production and release of CO_2. Abiotic carbon processes in arid environments consist of pedogenic carbonate formation, releasing abiotic CO_2 while biotic processes are related to CO_2 generation from plant and microbial respiration. Transforming arid land into agricultural land significantly alters carbon dynamics, modifying both abiotic processes by accelerating pedogenic carbonate formation and biotic processes by stimulating growth of crops. To know whether irrigation transforms land from a carbon source or sink, it is necessary to understand how both abiotic and biotic carbon processes evolve as agricultural fields are flood irrigated. Here we use soil CO_2 carbon isotopic composition to assess the source of CO_2 generated in an arid agricultural setting, a flood irrigated pecan orchard. Daily soil-gas samples were collected from multiple depths from approximately one week after irrigation to the end of the irrigation cycle and analyzed for pCO_2 and carbon isotopic ratios. The high-resolution sampling allows us to calculate the flux of CO_2 to the soil surface based on pCO_2 gradients, to determine how much of the flux can be attributed to abiotic vs. biotic processes, and to assess rates of these processes as a function of irrigation cycles, seasons, soil texture and sources of irrigation water. During the collection period, the soil CO_2 concentration generally decreases through time, while the $\delta^{13}C$ (‰) generally increases through time. The decreasing concentration leads to a decreased flux to the surface and decreased production of CO_2 later in the irrigation cycle. However, the isotopically enriched CO_2 indicates a higher contribution of abiotic CO_2 to the soil CO_2 pool, relative to the respiration of isotopically depleted organic carbon. Therefore, while the flux decreases through time, the relative importance of abiotic processes contributing to the CO_2 flux increases. The abiotic flux of CO_2 that results from pedogenic carbonate formation serves as a source of CO_2 to the atmosphere. Further investigation of this site will determine the annual flux of CO_2 to understand how arid agriculture impacts dryland carbon cycles, greenhouse gas dynamics, and regional agricultural sustainability.