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Novel methods for measuring drought stress of crops in the field

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There is currently no available method for land managers to directly and non-destructively measure the water status of plants in the field. Water status of a plant effects plant growth and function and contributes to end-of-season crop yield. We have developed wearable, minimally invasive microneedle sensors that can be precisely placed in leaves of crops, to be used as electrodes for electrical impedance spectroscopy (EIS). EIS measures the passive electrical properties (magnitude and phase shift of impedance) of the leaf. EIS can be used to model biologic tissue as an electrical circuit, where ions in the intra- and extracellular fluid are describes as resistors and the cell membrane is modeled as a capacitor.

Our previous work has demonstrated that the magnitude of impedance varies with water availability and can be used to monitor drought stress. In this study, we aim to further our understanding of how phase shift of impedance correlates to tissue damage caused by drought stress. Because EIS models the cell membrane as a capacitor, we predict that changes in phase angle correspond to cell membrane damage. To continue studying EIS as an indicator of plant health, data loggers with microneedle electrodes were deployed in a field of *Sorghum bicolor* at the New Mexico State Agricultural Science Center in Los Lunas, New Mexico. Two genotypes of *S. bicolor* were divided into two study groups, one receiving normal irrigation and one receiving half the irrigation. The plant-based EIS data was collected throughout the growing season. Initial results demonstrate that we can collect continuous data directly from plants in the field. Impedance signals mirror expected diurnal cycles from previous lab-based studies. Initial results indicate that phase shift of impedance changes gradually as a leaf progresses through senescence (programmed tissue aging and death) and that phase shift of impedance changes rapidly when a leaf's vascular system is damaged (inhibiting the ability of the leaf to maintain hydration). These initial results indicate that microneedle EIS monitoring of phase angle of impedance may provide land managers with a method to directly monitor plants for drought damage, while distinguishing from typical plant aging.