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Development of automated sensors to track pH changes elicited by iron deficiency in hydroponic cultures

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Iron (Fe) is an essential nutrient for plant growth, and plants are the main source of Fe for humans and livestock. The World Health Organization estimates that Fe deficiency affects 30% of the world's population and is considered the most prevalent nutritional deficiency around the globe. Thus, understanding the molecular mechanisms that plants use to accumulate Fe will allow the development of biofortified crops for better human nutrition. Despite recent and significant advances in our understanding of how plants respond to Fe deficiency, the molecular and physiological mechanisms behind Fe deficiency are still poorly understood. This is due in part to the static nature of how our field currently assesses Fe deficiency responses. For instance, plants are known to acidify the root environment to make Fe more available but currently, data describing the timing and progression of this acidification is lacking. To solve this issue, we developed an automated pH tracking system to monitor pH changes in hydroponic systems. As a proof of concept, we tracked the acidification of media on maize plants grown over a week with and without Fe. We also compared the accuracy and consistency of two different sensors, PASCO's ready-to-use Wireless pH Sensor and DFRobot's DIY open-source Gravity pH Meter Pro. Overall, the PASCO sensors showed more consistent readings and required minimal software and hardware setup. DFRobot sensors on the other hand showed much more variance in their readings and required a microcontroller, a Raspberry Pi, and self-written software to read and analyze the values. However, the open-source capacity allows more possibilities for future development, such as real-time data uploads. Further experiments will focus on optimizing the sensitivity of both systems to provide an informed data-driven comparison of each sensor brand.