Evaluating a Real-Time Soil Nitrate Sensor for Precision Nutrient Management and Groundwater Protection

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The agricultural use of nitrogen fertilizers is widely recognized as a major contributor to nonpoint source nitrate contamination of groundwater. Consequently, in many areas with intensive agriculture, domestic wells often exceed the U.S. Environmental Protection Agency's (EPA) maximum contaminant level (MCL) of 10 mg/L of nitrate-N in drinking water. Improving nitrogen use efficiency is increasingly challenging due to complex soil nitrogen dynamics and the limitations of traditional monitoring methods. To address this issue, we developed a novel real-time soil nitrate sensor that enables continuous monitoring. During the 2024 growing season, we deployed and evaluated this sensor in a 1-acre subsurface drip-irrigated processing tomato field alongside suction lysimeters. The nitrate sensor recorded daily measurements, while the suction lysimeters were used to extract soil pore water weekly for laboratory nitrate analysis. Preliminary results indicate that the real-time sensor detected nitrate concentration patterns similar to those measured by the lysimeters, while also capturing daily fluctuations missed by weekly measurements. We observed soil nitrate concentrations peak after fertigation and decline approximately two weeks later, demonstrating the sensor's ability to track rapid changes in nitrate availability. This approach enhances our ability to monitor soil nitrate at a finer scale and shows strong potential as a decision-support tool for precision nitrogen management.