Using hyperspectral imaging to quantify cadmium stress and predict uptake across different spinach genotypes

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Abstract

Cadmium (Cd) is a naturally occurring toxic heavy metal found in trace concentrations in most soils. However, some soils have high levels of Cd due to parent materials or anthropogenic factors such as industrial waste and legacy fertilizers contaminated with Cd. Complications arise when Cd bioaccumulates in soil and plant tissues with carcinogenic effects in humans such as kidney and skeletal dysfunction. Leafy greens including spinach and kale are especially susceptible to Cd accumulation due to high translocation of the metal into the edible leaf tissues of the crop. However, while high concentrations of Cd in soil are generally toxic to plants, unlike other plant stresses, Cd toxicity has no distinguishing visual features that indicate stress or uptake of the metal in the plant, making it difficult to determine if remediation strategies are effective. In this study, emergent plant sensing tools such as Hyperspectral Imaging (HSI) and red-green-blue (RGB) wavelengths were utilized as high-throughput screening techniques to quickly distinguish wavelengths reflected by spinach plants grown in Cd contaminated soil. Feature selection of the HSI and RGB bands were used to identify regions of interest that exhibited significant differences of Cd uptake within multiple spinach genotypes previously shown to vary in Cd uptake. Applications of these technologies provide nondestructive sampling of crops to identify wavelengths sensitive to Cd stress and uptake, with potential applications using machine learning to provide a framework to model these interactions, informing plant breeding programs, and ultimately reducing human health risks.

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