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Classification of high-throughput phenotyping data for differentiation among nutrient deficiency in common bean

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The development of automated, image-based, high-throughput plant phenotyping enabled the simultaneous measurement of many plant traits. Big and complex phenotypic datasets require advanced statistical methods which enable the extraction of the most valuable traits when combined with other measurements, interpretation, and understanding of their (eco)physiological background. Nutrient deficiency in plants causes specific symptoms that can be easily detected by multispectral imaging, 3D scanning, and chlorophyll fluorescence measurements. Screening of numerous image-based phenotypic traits of common bean plants grown in nutrient-deficient solutions was conducted to optimize phenotyping and select the most valuable phenotypic traits related to the specific nutrient deficit. Discriminant analysis was used to compare the efficiency of groups of traits obtained by high-throughput phenotyping techniques (chlorophyll fluorescence, multispectral traits, and morphological traits) in discrimination between nutrients [nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), and iron (Fe)] at early and prolonged deficiency. Furthermore, a recursive partitioning analysis was used to select variables within each group of traits that show the highest accuracy for assigning plants to the respective nutrient deficit treatment. Using the entire set of measured traits, the highest classification success by discriminant function was achieved using multispectral traits. In the subsequent measurements, chlorophyll fluorescence and multispectral traits achieved comparably high classification success. Recursive partitioning analysis was able to intrinsically identify variables within each group of traits and their threshold values that best separate the observations from different nutrient deficiency groups. Again, the highest success in assigning plants into their respective groups was achieved based on selected multispectral traits. Selected chlorophyll fluorescence traits also showed high accuracy for assigning plants into control, Fe, Mg, and P deficit but could not correctly