Site Specific Nitrogen Management in Citrus Orchard to Minimize Nitrogen Pollution

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Site-specific agricultural management relies on identifying within-field spatial variability and is being used for variable rate input of resources. Precision agricultural management commonly attempts to integrate multiple datasets to determine management zones (MZs), homogenous units within the field, based on spatial characteristics of environmental and crop properties (i.e., terrain, soil, vegetation conditions). This study aims to develop a novel statistical multivariate spatial clustering approach to determine MZs for precision nitrogen fertilization in a citrus orchard along the growing season. Five variables were used to characterize spatial variability (i.e., N spectral index, crop water stress index (CWSI), tree height, elevation, and slope) within four plots based on a monthly thermal and multispectral high-resolution imagery acquired from an unmanned aerial vehicle (UAV). The UAV data was tested against leaf N samplings based on samples taken from 48 trees within the four craters plots, which were selected based on a stratified random design (SRD) model. A Support Vector Machines-Regression (SVM-R) model was applied to develop a prediction N spectral index for canopy N levels. The clustering model included the following components — spatial representation of the data based on Getis Ord Gi*. Then variable weights were assigned based on their relative contribution to principal component analysis. Fuzzy C-means algorithm was applied to the weighted spatial representation and was found to generate spatially continuous and homogeneous MZs with similar numbers of trees. In addition, we analyzed the temporal dynamics in the MZs and clustering patterns throughout the year, using information based on the monthly UAV imagery. Management of the sub-units, or plots, using spatial representation rather than the measured values, is suggested as a more suitable platform for agricultural practices. Future development of fertilization applications for individual trees will require adjusting the statistical approach to support tree-specific management. The proposed model composite is flexible and may be composed of different models and/or variables for developing optimal MZ delineation for specific plots.