ABSTRACT

Careful monitoring of both physiological and biochemical parameters of rice and soil water regime under water stress conditions is required for management of water stress in paddy field. The diffuse reflectance spectroscopy (DRS) approach is shown to have potential to monitor both crop and soil attributes. In this study, the DRS approach was evaluated for estimating both soil and crop attributes using chemometric models from spectral reflectance of rice canopy grown under controlled water stress conditions. Five different chemometric modeling approaches such as partial-least-squares regression (PLSR), support vector regression (SVR), random forest regression (RFR), locally-weighted PLSR ($PLSR_{LW}$), and PLSR with feature selection ($PLSR_{FS}$)) approaches were evaluated. These approaches were tested on crop and soil water stress parameters using four datasets: 1) 600 leaf area index (LAI) values, 2) 480 canopy water content (CWC) values, 3) 780 whole soil water potential (SWP) values measured over the water stress period, and 4) 72 terminal SWP values measured just before the water stress was broken. All these parameters and the spectral reflectance data were collected from an experimental field trial conducted over two rice growing seasons (December to May of 2014-15 and 2015-16). For the crop water stress parameters such as LAI and CWC, $PLSR_{LW}$ performed with a coefficient of determination (R^2) of 0.77 and 0.66 with root mean squared residual (RMSR) of 0.85 m^2 m^{-2} and 96.25 g m^{-2}, respectively. For the SWP, SVR approach yielded the best performance with the R^2 values of 0.71 and 0.55 for the calibration and validation datasets, respectively. Observed RMSR values for the predicted SWPs were in the range of -7 to -19 kPa. A new spectral water stress index was also developed using the reflectance values at 745 nm and 2002 nm, which showed strong correlation with relative water contents and electrolyte leakage. This new approach is rapid and non-invasive and may be used for estimating LAI, CWC and SWP over large areas.

Keywords: Diffuse reflectance spectroscopy; Soil water potential, Leaf area index, Canopy water content; Partial-least-squares regression; Locally-weighted partial-least-squares regression; Spectral vegetation indices