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| **Title:** | Determination of Leaf Nitrogen Concentrations Using Electrical Impedance Spectroscopy in Multiple Crops | | | |
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| **Abstract:** |  |
| In this work, crop leaf nitrogen concentration (LNC) is predicted by leaf impedance measurements made by electrical impedance spectroscopy (EIS). This method uses portable equipment and is noninvasive, as are other available nondestructive methods, such as hyperspectral imaging, near-infrared spectroscopy, and soil-plant analyses development (SPAD). An EVAL-AD5933EBZ evaluation board is used to measure the impedances of four different crop leaves, i.e., canola, wheat, soybeans, and corn, in the frequency range of 5 to 15 kHz. Multiple linear regression using the least square method is employed to obtain a correlation between leaf nitrogen concentrations and leaf impedances. A strong correlation is found between nitrogen concentrations and measured impedances for multiple features using EIS. The results are obtained by PrimaXL Data Analysis ToolPak and validated by analysis of variance (ANOVA) tests. Optimized regression models are determined by selecting features using the backward elimination method. After a comparative analysis among the four different crops, the best multiple regression results are found for canola with an overall correlation coefficient (*R*) of 0.99, a coefficient of determination (*R*2) of 0.98, and root mean square (RMSE) of 0.54% in the frequency range of 8.7–12 kHz. The performance of EIS is also compared with an available SPAD reading which is moderately correlated with LNC. A high correlation coefficient of 0.94, a coefficient of determination of 0.89, and RMSE of 1.12% are obtained using EIS, whereas a maximum correlation coefficient of 0.72, a coefficient of determination of 0.53, and RMSE of 1.52% are obtained using SPAD for the same number of combined observations. The proposed multiple linear regression models based on EIS measurements sensitive to LNC can be used on a very local scale to develop a simple, rapid, inexpensive, and effective instrument for determining the leaf nitrogen concentrations in crops. | |