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应用两种近地可见光成像传感器估测棉花冠层叶片氮素状况

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Estimation of Canopy Leaf Nitrogen Status Using Imaging Spectrometer and Digital Camera in Cotton

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摘要 作物叶片含氮量是作物长势监测、产量及品质估测的重要依据，实时、无损地监测植株体内氮素营养状况有助于棉花氮肥的正确施用。本研究比较2种近地可见光传感器的光谱和颜色信息用于监测棉花氮素营养的能力，确定MSI200成像光谱仪和数码相机监测棉花冠层叶片氮含量最佳的波段、光谱指数和颜色参数并建立估测模型。结果表明，在可见光波段，冠层反射率随着冠层叶片氮素含量的增加而降低，且叶片含氮量的光谱敏感波段主要位于绿光和红光区域；与棉花冠层叶片含氮量的拟合效果最好的2种传感器的光谱指数为差值指数DI(R_{580}, R_{680})和G－R，而颜色参数则分别为b*和H，同一传感器以光谱指数的拟合效果优于颜色参数，不同传感器以MSI200数据的拟合效果优于数码相机；利用独立试验资料检验所建模型的估测性能表明，差值指数对棉花冠层叶片氮素的预测能力优于比值指数和归一化差值指数，DI(R_{580}, R_{680})和G－R所建模型的估测精度最高，分别为0.8131和0.7636。因此，利用数码相机和MSI200型成像光谱仪可以定量估测棉花冠层叶片氮素营养状况。

关键词： 棉花冠层 叶片含氮量 成像光谱仪 数码相机 光谱指数 颜色参数

Abstract: Leaf nitrogen content is an important index to evaluate and estimate crop growth status, yield and quality. Real-time and non-destructive measurement of nitrogen nutrition status of plants is useful for nitrogen fertilizer management in cotton (Gossypium hirsutum L.) production. The objectives of this study were to determine the relationships of ground-based canopy spectral reflectance, spectral index and color parameters obtained by using common digital camera (Olympus C-5060) and imaging spectrometer (MSI200), with canopy leaf nitrogen content, and to develop regression models for estimating leaf nitrogen content in cotton. The results showed that canopy spectral reflectance decreased with increasing leaf nitrogen content, and the bands sensitive to leaf nitrogen content occurred the green and red regions mainly. Furthermore, the models to retrieve canopy leaf nitrogen contents using DI (R_{580}, R_{680}) and G－R were most feasible with the maximum determination coefficients (R^2) and the minimum standard error (SE) for two visible sensors, respectively. Additional, b* (CIE 1976 L*a*b* color model) and H (HSI color model) were the optimum color parameters. On the whole, for the fitting effects, the spectral index was superior to color parameters for the same sensor, and MSI200 superior to digital camera. Then, the prediction performances of the spectral indices of digital camera were validated by using independent dataset. We found that difference indices DI (R_{580}, R_{680}) and G－R were the optimum indicators of canopy leaf nitrogen content with the highest predictive precision (0.8131 and 0.7636, respectively) and accuracy (1.0149 and 0.9661) and the lowest RMSE (2.3313 and 2.7406 mg g^{-1}, approximately 6.52% and 8.24% of the mean). Hence, canopy spectral parameters in visible region may provide an effective and feasible means of estimating canopy leaf nitrogen contents quantitatively in cotton field.

Keywords: Cotton canopy Leaf nitrogen content Imaging spectrometer Digital camera Spectral index Color parameter

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