RESEARCH ON NUTRITION AND QUALITY DETECTION TECHNOLOGY OF SOIL, LEAF AND FRUIT OF CITRUS BASED ON AND DIGITAL IMAGE SPECTROSCOPIC TECHNIQUES

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ABSTRACT

The diagnosis technique of real-time lossless crop nutrition is the foundation and conditions for the precise, effective fertilization, cultivation and management, and so on. Currently, the diagnosis of crop nutrition mainly relies on the routine chemical analysis of laboratory. Due to the complicated procedure, time-consuming, high cost and high professional technique requirement, it can hardly meet the need of precise variable fertilization technology. Spectrum technology is the technology of real-time and non-destructive testing, and its development has rapidly promoted in recent years. Therefore, it is widely adopted in many fields, such as Chinese medicine chemical analysis, on-line quality control, while less adopted in real-time diagnosis of field crop research and progressed slowly. In order to explore the diagnostic technology based on spectrum and digital image of soil and leaf nutrient and fruit quality of citrus and provide evidence for the development of real-time, accurate, and non-destructive citrus nutrition, we have carried out real-time detection technology research in citrus orchard based on the visible-near infrared spectroscopy and digital image detection of the soil-leaf nutrient elements contents and fruit quality.

Keywords: Three Gorges Reservoir Area; Citrus; Nutrient and Quality; Spectroscopy and Digital Image Techniques; Detection

METHODS AND CONCLUSIONS

(1) The relationship between the spectrum characteristics and nitrogen content of soils in citrus orchard of the Three Gorges Reservoir Area was studied by analyzing the visible near-infrared spectrum. The collected soil samples were made of 20 mesh and 60 mesh dry weight, leaves samples made of powder samples. The results showed that the soil reflectivity increased lineally as the wavelength increases across the visible spectrum and reached a stable plateau in the short wavelength near-infrared region (780-1750 nm) without much fluctuation. In the long wavelength near-infrared region (1750-2400 nm) the reflectivity of the soils was higher with higher fluctuation. There were three strong absorbance peaks around 1416, 1913 and 2209 nm, respectively in the long wavelength infrared region. Soil available nitrogen content and total nitrogen content were positively correlated with soil light reflectivity but negatively correlated with catoptrics-spectrum values reciprocal logarithm. At 541 nm of visible light region, a high positive correlation was found between the available nitrogen content and the first derivative of the soil reflective spectrum with a correlation coefficient of +0.605 and the best fitting equation was y=2E+09x^2-3E+06x+890.49, where R^2 =0.5, and x is the first derivative of the soil reflective spectrum. At 1909 nm of the near-infrared long wavelength region, the correlation between the total nitrogen content and the reciprocal-log values of the reflective spectrum of the soils was the best with a correlation coefficient of -0.612, and the best fitting equation was y=1.3721x^2–2.1075x+0.8592, where R^2=0.4, and x is the reciprocal values of the log reflective spectrum of the soils (Fig. 1).

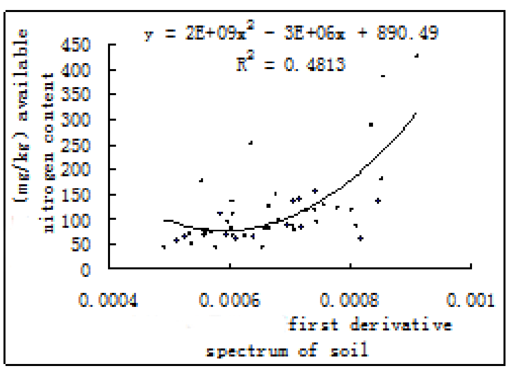

Fig.1 The fitting model of the available nitrogen and first derivative spectrum (541 nm)

(2) Visible/near-infrared spectroscopy (Vis/NIRS) appears as a prominent technique for non-destructive evaluation. In this research, the potential of using

the Vis/NIRS was investigated for measuring the nitrogen content in Peng'an 100 Jincheng orange leaves, and the relationship was established between non-destructive VNIRS measurement and the nitrogen content in Peng'an 100 Jincheng orange leaves. Intact Peng'an 100 Jincheng orange leaves were measured by reflectance VNIR in 350-1075 nm range. The data set as the reflectance VNIR was analyzed in order to build the best prediction model for these characteristic, using several spectral pretreatments such as First Derivatives Spectrum (FDS), Second Derivatives Spectrum (SDS) and Reciprocal Logarithm Spectrum (Log(1/R)) with Standardization of Variables (SNV) techniques. The results showed the reflectance spectrums of leaves presented downward trend within 350-700 nm and upward trend within 750-1075 nm with the increasing of the nitrogen fertilizer in potted plant of Peng'an 100 Jincheng orange (*Citrus sinensis* L. Osbeck) on trifoliate (*Poncirous trifoliata*) rootstock. The model for the nitrogen content in Peng'an 100 Jincheng orange leaves prediction using FDS with SNV spectral pretreatments showed an excellent prediction performance. This non-destructive, fast and accuracy technology can be used in citrus industry that would be beneficial to predict the plant nutrition (Fig. 2).

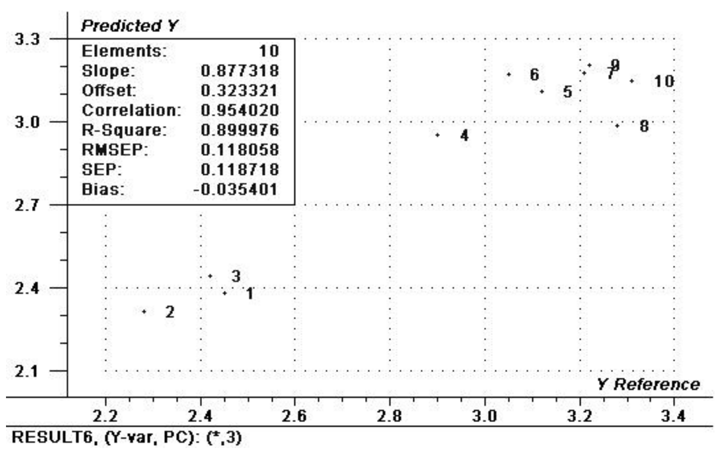

Fig.2 The relationship between predictive and true values in summer shoot leaves of Peng'an 100 Jincheng

(3) Field experiments were conducted to assess the potassium content of Citrus sinensis (L)cv. peng'an 100 Jincheng orange leaves by using VIS/NIRS spectral method. Before calibration, principal component analysis (PCA) and partial least square (PLS) techniques were applied in data pre-processing. The order of leaf reflective spectrum intensity is $K_3 > K_0 > K_1 > K_2 > K_4$ in the visible

near-infrared range of 400-1000 nm, where the K fertilizer usage of K_0, K_1, K_2, K_3, K_4 treatments are 0 g, 30 g, 75 g, 90 g, 120 g(k_2O/strain/year) respectively. The calibration models of potassium content were built and applying PLS and internal cross-validation test method, through processing the reflectance spectrum, the first derivatives, the second derivatives and the reciprocal logarithm spectrum of peng'an 100 jincheng leaves using multiplicative scatter correction(MSC). The results showed that the model of the second derivatives calibration of reflectance spectrum had the best ability of predicting，the highest correlation coefficient, the smallest root mean square error of predicating (RMSEP) and the smallest absolute bias with 0.82, 0.0038 and -2.34E-05, respectively. The second derivatives of reflectance spectrum can predict the potassium content in peng'an 100 jincheng leaves. And 477-515nm, 541-588nm, 632-669 nm, 701-718 nm and 754-794 nm were the characteristics of wavelengths of second derivatives of reflectance spectrum predicting potassium content of peng'an 100 Jincheng in summer shoot leaves(Fig. 3）.

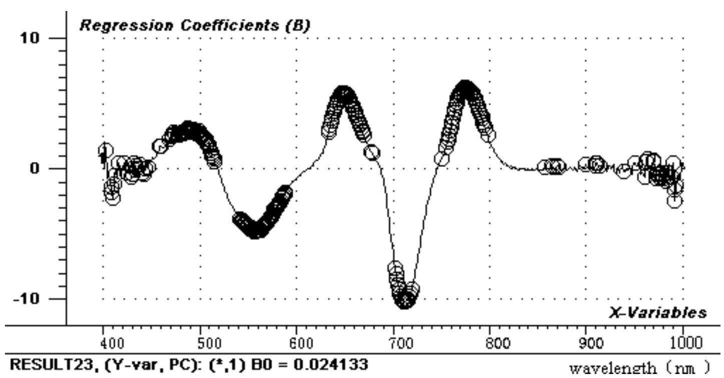

Fig.3 The regression coefficients of the potassium content and the second derivatives spectrum in summer shoot leaf of peng'an 100 jincheng（Note:'○'significant x-variables）

(4) Take Olinda valencia orange leaves dry powder-like as sample, using such method combing chemical analysis with technology of visible near-infrared spectroscopy (Vis/NIRS), through the treatment process of second deviate spectrum of samples of the original spectrum and denoising(Noise), meanwhile, using method of partial least squares(PLS) and cross-validation to establish math model of Zn concentration which applies band combination composited by 400-500 nm and 1201-1300 nm of characteristic wavelength band. By this method, it will be well-predicted and stable. The coefficient of establishing

models is 0.9975, while the coefficient of correlation coefficient of prediction is 0.9920. The root mean square error of prediction (RMSEP) of cross-validation is 0.5868. Therefore, the means using visible near-infrared spectroscopy (Vis/NIRS) and the methods of cross-validation and PLS to establish the spectral correction model reflecting the Zn content in leaves and characteristic wavelength bands, can detect the Zn content in citrus leaves quantitatively and quickly(Fig. 4).

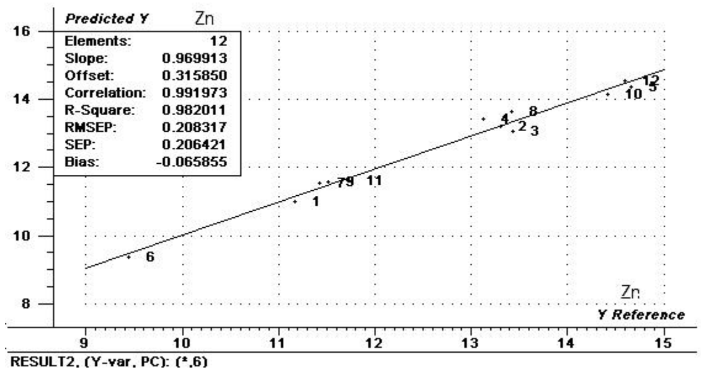

Fig.4 Predicted results of PLS models for Zn content of Olinda orange leaves

(5) The color characteristic parameters of the images of Peng'an 100 Jincheng's leaves captured with simple digital camera were acquired by the Photoshop software. Then the relationships between the characteristic color parameter processed by the mathematic transforming and normalization processed and the SPAD value of the Jincheng 100 leaves were analyzed, and the regression model were established. The results showed that the color characteristic parameter R/B, R/(G+B), B-R, (B-R)/(B+R), chromaticity coordinate r and r-b are presented a significant non-linear relativity. The SPAD value predicting model of peng'an 100 jincheng orange leaves were established by the color characteristic parameter R/(G+B) and the normalized coordinates r are $SPAD=-1077.936[R/(G+B)]^2+823.594[R/(G+B)]-74.432$ ($R^2=0.840$) and $SPAD=-7883.574r^2+4715.912r-628.263$ ($R^2=0.841$), separately. The errors of prediction are relatively minimum (2.12%) (Fig.5). Therefore, the color characteristic parameter R/(G+B) and chromaticity coordinate r are able to regard as best prediction index of Jincheng leaves's SPAD values based on computer visual. (Note: r=R/(R+G+B), g=G/(R+G+B), b= B/(R+G+B)).

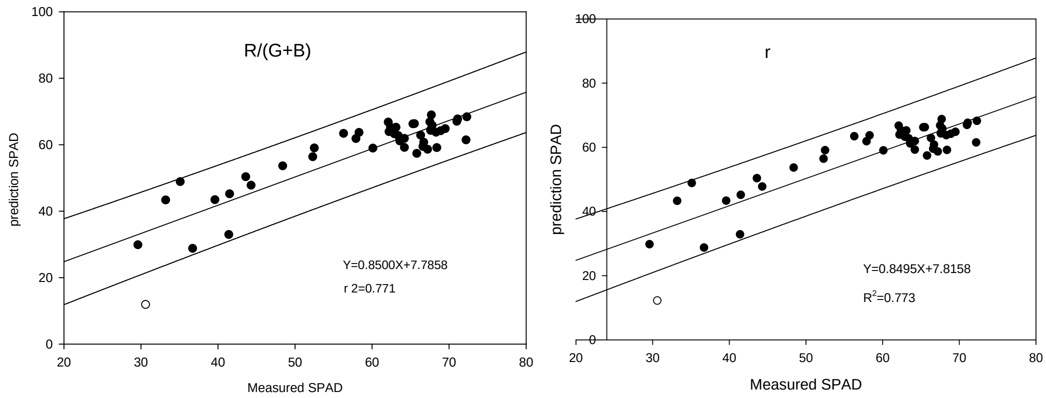

Fig.5 Test of regression models for peng'an 100 jincheng leaves SPAD value content and color characteristic parameters

(6) Research on the detection model of soluble solids content of Ponkan (Citrus reticulata Blanco cv. Taiwan Ponkan) fruit by using computer vision technology and chemical analysis methods. Study on the correlation of R, G, B color channel image parameter information captured by MS3100 multi-spectral camera and the citrus fruits soluble solids content using chemical analysis in laboratory on different periods of collecting Ponkan samples. The experiment shows a good correlation existed in the five-image-color-parameters of R, G-R, B-R, G/R and (G-R)/(G+R) value and SSC, and with average correlation coefficient 0.83 of monitoring model. The validation results of monitoring model reveals the effective prediction model should be created by the image color parameter values of B-R and fruit SSC, whose determinational coefficient (R^2) is 0.651(Fig.6). The image color parameters of B-R is the best in the monitoring of fruit SSC by comprehensive comparisons. The monitoring model is a quadratic equation and $SSC=-0.0001(B-R)^2-0.0219(B-R)+9.601$. The neural network model can accommodate more related bands to participate the estimation of citrus SSC, and the correlation coefficient between the measured and predicted values is higher than the other models, while the root mean square error (RMSE) is lower than other models, indicated that it is feasible to detection citrus fruit SSC using computer graphics technology .

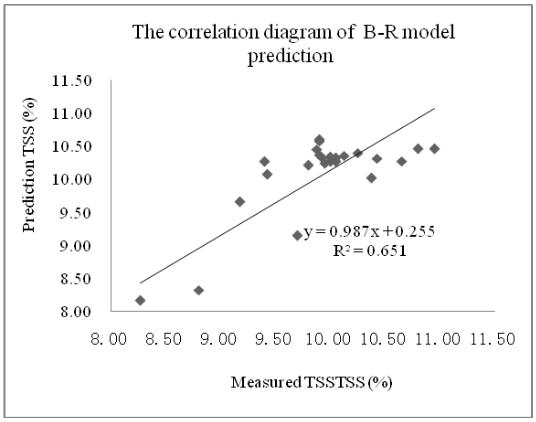

Fig.6 The relevant diagram of measured and prediction of Ponkan fruit SSC(Represent testing sample)

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