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Stručni članak

Extraction of Diseases and Insect Pests for Tobacco Based on Hyperspectral Remote Sensing

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ABSTRACT. To study the feasibility of monitoring the diseases and insect pests in tobacco using hyperspectral remote sensing, leaf spectrum of tobacco infected with diseases and insect pests at different severity levels was measured by using ASD hand-held spectroradiometers. The reflectance data was transformed by the method of the first differential coefficient. Meanwhile, the correlation between severity levels and spectral data was analyzed. The results suggested that the wavelength bands between 631 nm and 638 nm, 696 nm and 733 nm as well as 864 nm were selected out as sensitive bands region to the severity levels. The leaf spectral reflectance decreased due to the damage of diseases and insect pests. Moreover, the spectrum of tobacco leaf infected diseases and insect pests moved to the direction of long wave. This research is the basis to monitor the diseases and insect pests in tobacco, and it has a practical significance for applying remote sensing monitoring and determining the appropriate control time.

Keywords: tobacco, diseases and insect pests, hyperspectral, reflectance.

1. Preface

Tobacco is the important economic crops in China. It is one of the crops which suffering the most types and the heaviest diseases. Tobacco diseases and insect pests are one of the main limiting factors during producing tobacco, so the main problem is to control tobacco diseases and insect pests. Therefore, it'll have vital significance to reduce loss due to tobacco diseases and insect pests if people can know its situation timely and objectively, then can take effective measures to avoid.

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In comparison to conventional remote sensing, hyperspectral remote sensing has the advantage of more bands, higher resolution, strong continuity, and so on. It can get the continuous spectrum, the resolution of those spectrum can reach nanometers. Meanwhile, it can detect different target compounds with little spectral differences. Therefore, hyperspectral remote sensing has a good extensive application prospect, especially on the hand of monitoring the diseases and insect pests for vegetation. The researchers can monitor diseases by analyzing the changes of vegetation spectrum.

At present, scholars at home and abroad has made a lot of research on the study about spectrum features for many crops infected different diseases and insect pests. Riedell and Blackmer (1999) selected sensitive bands region to the damage of wheat aphid by comparing the spectrum features between the healthy leaves and the leaves infected wheat aphid. Malthus and Madeira (1993) monitor the severity levels by transforming the reflectance data of the healthy soybeans and the ones infected with diseases by the method of the first differential coefficient. Shu-wen et al. (2002) studied rice spectrum features at green, red and near infrared regions by measuring and analyzing rice canopy reflectance and differential spectrum with 4 levels of rice leaf blast. Minghua et al. (2003) studied the feasibility of monitoring potato late blight using hyperspectral remote sensing. Muyi et al. (2003) analyzed the correlation between the DI and the spectral data, established some inversion models for monitoring winter wheat stripe rust and provided theoretic foundation to further monitor winter wheat stripe rust at large scale using airborne and airspace remote sensing data. But, the papers on monitoring tobacco diseases and insect pests using remote sensing has few. In order to provide a theoretical basis to monitor tobacco diseases and insect pests using hyperspectrum remote sensing, the research analyzed the spectrum differences between the tobacco leaf which is healthy and damaged with diseases and insect pests.

2. Materials and Methods of Research

2.1. Experimental Design

The study area is located in Fei Xian tobacco field in Shandong province. The geographical position is 35°10’35”N, 117°40’18”E. Zhongyan 100 is the tobacco variety as experimental variety. The planting density in the study area is 120×55 cm and the supply of water and fertilizer is rational. The diseases and insect pests generates spontaneously. The study divided the severity levels into 4 degrees: healthy (without diseases and insect pests, that the lesion area on the leaf is 0%); gentle (the lesion area on the leaf is less than 10%); moderate (the lesion area on the leaf is between 10%–20%); severe (the lesion area on the leaf is more than 20%). The instrument is ASD Hand-held Spectro radiometers, whose wave band is 325–1075 nm, sampling interval is 1.4 nm, spectral resolution is 3 nm, the amount of output waveband is 751 (data interval is 1 nm) and field angle is 25°.

2.2. Spectral Measurement

The data was collected 10:00–14:00 Beijing Time in a sunny day using ASD Hand-held Spectro radiometers in the tobacco growth period. The instrument was corrected with a standard whiteboard every time in order to reduce errors. Three tobaccos in the same status was selected in a group, every tobacco was measured three times and ten spectrum was collected every time, then the average of these data was taken for the tobacco. The probe was 10cm from the leaves vertically.

2.3. Data Processing

Using the spectral processing software ViewSpec Pro 6.0 to analyze the data collected, and transformed the reflectance data with the method of the first differential coefficient. The formula for calculation is as follows:

$$R'(\lambda) = [R(\lambda + 1) - R(\lambda)]/\Delta\lambda, \quad (1)$$

where $R'(\lambda)$ is the first derivative in the band λ; $\Delta\lambda$ is the interval between the band $(\lambda + 1)$ and λ, it is 10 nm in the study.

Then input the original and the transformed data into Excel. To analyze the correlation between severity levels and spectral data, and draw diagram.

3. Analysis of Results

3.1. The Spectral Character Analyses for Tobacco Diseases and Insect Pests

When tobacco is infected with diseases and insect pests, the leaf spectrum of tobacco has a little differences at different severity levels. As shown in Fig. 1.

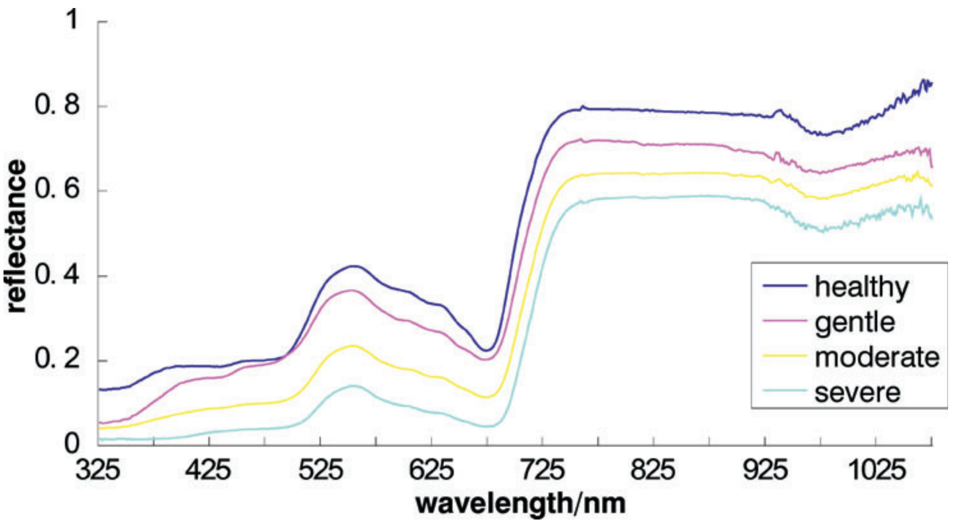

Fig. 1. *Spectra of tobacco diseases and insect pests at different severity.*

In Fig. 1, the trend of four spectrum curve is almost the same: There is a reflectance peak and valley in the visible region. Meanwhile, the spectrum reflectance decreased as the severity of diseases and insect pests increased. In Fig. 1, compared to the healthy tobacco, the reflectance of the severe one decreased from 0.424 to 0.141 in waveband 525–600 nm, from 0.798 to 0.586 in waveband 700–800 nm.

3.2. The first derivative spectral data of tobacco leaves

Usually, the primitive spectral data is not regarded as interpretation mark due to many inevitable personal error, system error, and so on.

It can not only eliminate the interference of partial background and noise, but also determine the position for the inflection point, the wavelength of max and min. The greatest change of the first derivative spectral lies in red region. Red edge generates because of the absorption at red band and the reflection at near-infrared waveband. The feature of red edge is usually described by means of red edge slope and red edge position that is the wavelength where the reflectance of the first derivative spectral is the maximum.

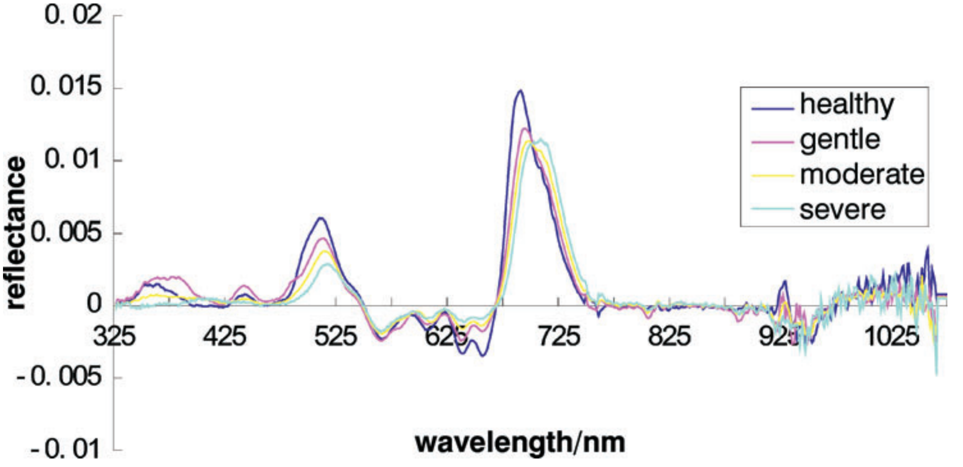

Fig. 2. *The curve of the first derivative spectral data with different severity.*

In Fig. 2, the data of the first derivative spectral decreased as the severity of diseases and insect pests grew. Furthermore, the spectrum of leaves infected diseases and insect pests move to the direction of long wave compared to the healthy one in Fig. 2. The maximum of the healthy spectral data is 0.0148, the corresponding wave (that is red edge) is 691 nm. While the maximum of the severe one is 0.0115, the corresponding wave (red edge) is 709 nm. The red edge position moves 18 nm to right.

3.3. The Extraction of sensitive bands for tobacco diseases and insect pests

According to Fig. 1 and Fig. 2, spectrum features of tobacco leaves infected with diseases and insect pests in different severity is different. Therefore, the correlation between severity levels and spectral data was analyzed, and the diagram of correlation was drawn for Fig. 3 and Fig. 4.

In Fig. 3, the correlation between primitive reflectance and the severity levels is negative. The absolute of correlation coefficient is from 0.93 to 1.00, that the correlation is not obvious. The wavelength bands 377–397 nm, 588–644 nm, 690–901 nm were selected out as sensitive bands region to the severity levels.

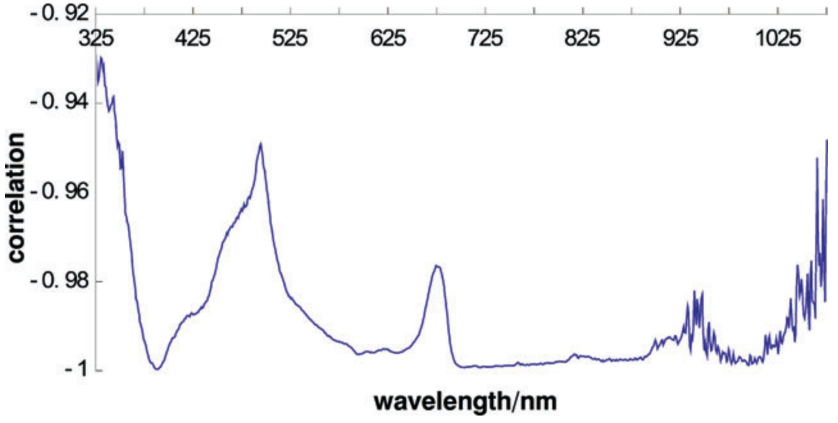

Fig. 3. *Correlation coefficients between the primitive spectral data and the severity levels of diseases and insect pests.*

In Fig. 4, the primitive spectral data of tobacco leaf was transformed by the method of the first differential coefficient. Meanwhile, the correlation coefficients

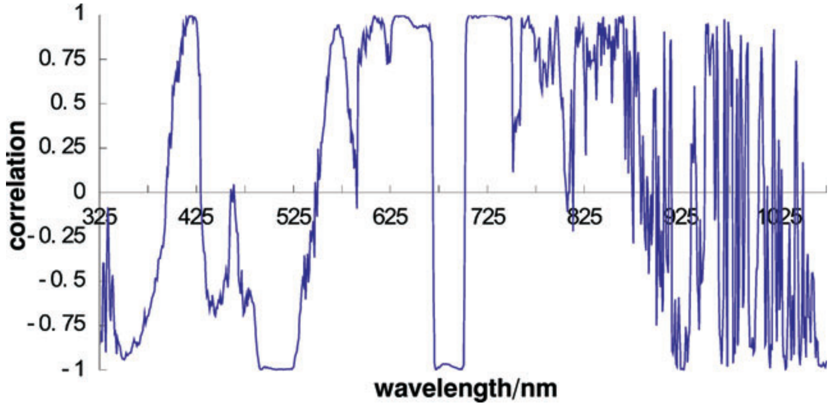

Fig. 4. *Correlation coefficients between the first derivative spectral data and the severity levels of diseases and insect pests.*

were higher. Furthermore, the wavelength bands 491–523 nm, 631–638 nm, 696–733 nm, and the individual bands of 420 nm and 864 nm were selected out as sensitive bands region to the severity levels.

According to Fig. 3 and Fig. 4, the position of the highest correlation coefficients is a little different. So, the wavelength bands 631–638 nm, 696–733 nm and the individual band of 864 nm were selected out as sensitive bands region to the severity levels.

4. Conclusion and Discussion

The spectrum features can change when tobaccos are infected with disease and insect pests: Spectral reflectance was down at green and near infrared band; the spectrum move to the direction of long wave. The reason may be that the internal structure of tobacco leaf is damaged by diseases and insect pests. Then spectrum features change. Thus it provides a possibility to monitor tobacco diseases and insect pests with remote sensing.

Comparing the correlation coefficients between the primitive spectral data and the severity levels to the one between first derivative spectral data and the severity levels, the rang of the correlation coefficients between the first derivative spectral data and the severity levels is wide, while the rang of the correlation coefficients between the primitive spectral data and the severity levels is narrow. It is shown that the transformation of the first derivative is helpful to improve the correlation between the spectral data and the severity. Also, it can make the sensitive bands easier to be selected.

The study analyzed leaf spectrum of tobacco infected with diseases and insect pests at different severity levels with hyperspectral technology based on Ground Remote Sensing Platform. Meanwhile, the correlation between severity levels and spectral data was analyzed and the sensitive bands were selected out. It is the basis to tobacco monitor diseases and insect pests and determine the appropriate control time with hyperspectral remote sensing. On the other hand, the kinds of the diseases and insect pests wasn't considered in the study, and it should be taken into consideration in the next research.

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Izdvajanje bolesti i insekata štetočina na duhanu na temelju hiperspektralnog daljinskog istraživanja

SAŽETAK. U svrhu proučavanja izvodljivosti praćenja bolesti i insekata štetočina u duhanu koristeći hiperspektralno daljinsko istraživanje, površina lista duhana zaraženog bolestima i insektima štetočinama na različitima razinama jačine mjerena je koristeći ručne ASD spektroradiometre. Podaci refleksije transformirani su metodom prvog diferencijalnog koeficijenta. U međuvremenu je analizirana korelacija između razina jačine i spektralnih podataka. Rezultati upućuju na to da su područja valnih duljina između 631 nm i 638 nm, 696 nm i 733 nm, kao i 864 nm bila izdvojena kao senzitivno područje u odnosu na razine jačine. Spektralna refleksija lista smanjila se zbog oštećenja nastalih uslijed bolesti i insekata štetočina. Osim toga, spektar lista duhana zaraženog bolestima i insektima štetočinama pomaknuo se u smjeru dugog vala. To istraživanje je temelj za praćenje bolesti i insekata štetočina u duhanu, te ima praktični značaj u primjeni daljinskog istraživanja za potrebe praćenja i određivanja odgovarajućeg vremena kontrole.

Ključne riječi: duhan, bolesti i insekti štetočine, hiperspektralno, refleksija.

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