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The effect of leaf area index on the spectral feature of winter wheat infected with stripe rust and its elimination

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ABSTRACT

Canopy spectral reflectance of winter wheat with stripe rust that was inoculated artificially at different LAI (Leaf Area Index) level was obtained. In this paper, the LAI was treated nine levels, and the spectral reflectance at nine levels was analyzed. It indicates that the spectral reflectance, which is up at red light region and is down at near infrared light region, is different significantly with LAI's change. Meanwhile, the first derivation of canopy spectral reflectance was analyzed, and the result shows that the difference is lowest around 680nm band. The correlation between the DI (Disease Incidence) and the first derivations of reflectance was analyzed, and the result shows excitedly that the correlation coefficient is highest above 0.98 around 680 nm band. Lastly, the study shows that the LAI's change has effect on the spectral feature of winter wheat with stripe rust, but the bands of around 680 nm were immune from the LAI's change, then the first derivation of spectral reflectance around 680nm band can be selected to model with DI.

KEYWORDS

Leaf area index; Stripe rust; Hyperspectral; Spectral feature; Disease incidence.

INTRODUCTION

It is well known that wheat is an important crop in China, particularly in North China. The damage, however, caused by the stripe rust disease, accounts for approximately 73~85% of the national gross production. With such a large production and serious damage ratio, an effective stripe rust of winter wheat monitoring tool is needed. As we know that stripe rust, which can cause yield and quality of the wheat to decrease heavily, is one of the most serious diseases on winter wheat on Agricultural production[1]. Many scholars have done detailed and in-depth research on the disease monitoring using the canopy spectral reflectance data at home and abroad[2-5].

The high spectral resolution and the high Geo-spatial resolution are the dominant characters for hyperspectral data, carrying the electromagnetic wave information of goal from visible light to thermal infrared, which has many advantages on detecting matter, compared with the traditional remotely sensed data. So, the hyperspectral remote sensing data is enough to analysis the sensitive spectral band position of the canopy reflectance spectral data of winter wheat infected with stripe rust, qualitatively and quantitatively. It is, therefore, significant to discuss the relationship between the DI of winter wheat stripe rust and the hyperspectral remotely sensed data. In this paper, through artificial inoculation of winter wheat stripe rust, influence of leaf area index (LAI) on canopy spectral curve has been quantitatively studied, meanwhile, the relationship between the canopy spectral and different leaf area index (LAI) under the same disease index (DI) has been analyzed.

MATERIAL AND METHODS

Experimental conditions

The experiment was conducted at the Research and Demonstration Basement of National Precision Agriculture, which located in Xiaotangshan town. The soil type is sandy loam, the nutrient content from 0-20cm of plough layer was as follows: the organic matter 1.45%, alkali-hydrolysis nitrogen 63.4mg/kg, available phosphorus 37.7mg/kg, rapidly available potassium 123.4mg/kg. Two kinds of tested variety have been used in this study, one of those was 98-100, namely tx1, which is general infected type by the stripe rust, and the other was XUZAO, namely tx2, which is susceptible variety infected by the stripe rust.

Acquisition of the DI data

The DI data was investigated in field at interval of 5 days after 20 days when the “98-100” was inoculated. And the disease severity ratings was classified nine levels, which was as follows: 0, 1, 10, 20, 30, 45, 60, 80, and 100, where those number represented 100 times of the ratio between the stripe rust patch area and the total leaf area. Then, the DI can be calculated from the formula:

$$DI=\frac{\sum(x\times f)}{n\times\sum f}\times 100$$

, where x is the level magnitude, e.g. 0 is 0, 1 is 1, and 100 is 8. f is the number of leaf with x level magnitude. n is the highest level magnitude, which is 8. For the specific directions of the method of inoculating and other information, the reference[1] can be referred.

Measurement of the hyperspectral data

We measured the canopy reflectance data of the winter wheat on the selected days with no visible cloud coverage and no strong wind at 10:30-14:00(Beijing local time) in order to minimize the solar effects using the portable spectroradiometer with 25°field of view, which was made in ASD of U.S.A, with the spectrum bands from 350-2500nm. The sensor was placed at the 1.3 meters distance from the playground, twenty readings per treatment were collected, and the reflectance standard measurements were made immediately before and after the canopy reflectance spectral data measurement. Then, the average value of the twenty readings was our final result.

RESULT AND DISSCUSS

After processing on the field unit quantitatively and hierarchical, spectral curves and the characteristics of nine LAI’s group gradients were shown in Figure 1 and 2. Analysis shows that the canopy spectral reflectance rose in red light region and decreased in near infrared region as the LAI was gradually getting smaller.

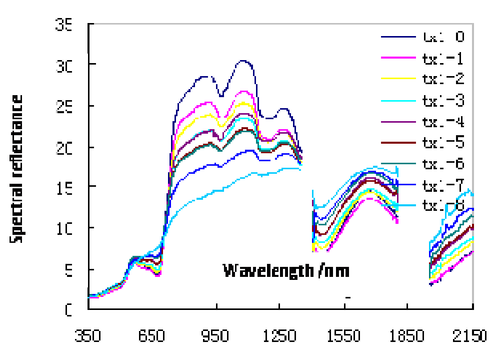

Figure 1 : The spectral reflectance of winter wheat with same DI in different LAI (tx1)

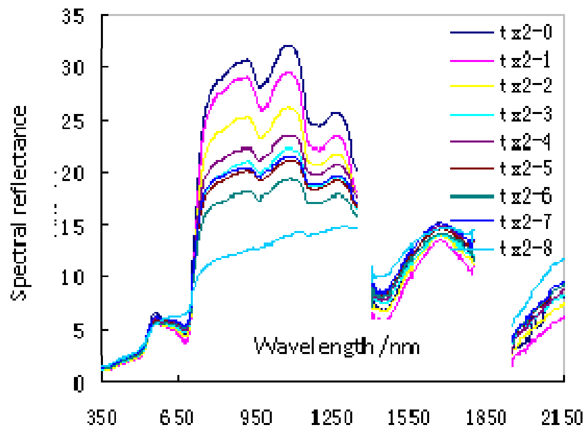

Figure 2 : The spectral reflectance of winter wheat with same DI in different LAI (tx2)

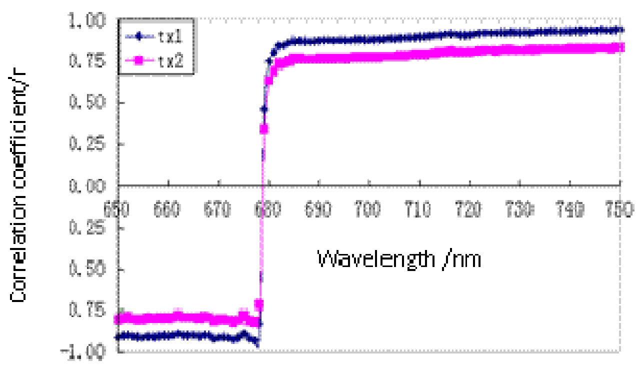

Figure 3 : The correlation coefficient between the LAI and the first derivation of canopy spectral reflectance

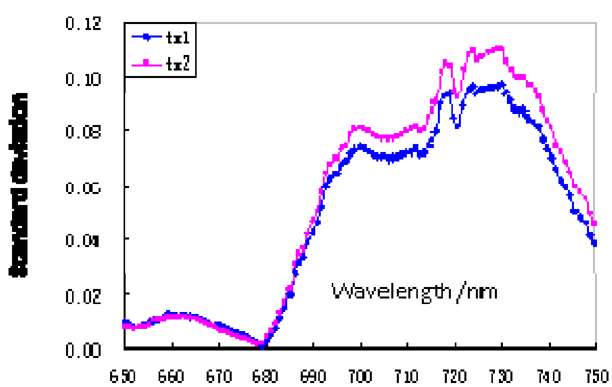

Figure 4 : The standard deviation of first derivation of canopy spectral reflectance of winter wheat in different LAI

In this paper, all canopy reflectances of different winter wheat variety were treated as the first order derivative, and derivative spectral curve as shown in figure 5 and 6. Analysis shows that when the disease index (DI) remains the same, the correlation between the LAI and the canopy reflectance of the first order derivative was negative correlation and positive correlation in the red light and near infrared platform respectively.

For different LAI group of the two varieties, the standard deviation of first order derivative of canopy spectral reflectance near 680 nm was the minimal, as shown in figure 4. It indicates that the LAI at 680 nm wavelength has no effect on the first order derivative of canopy spectral reflectance. The results show that the spectral reflectance at 680 nm was not sensitive to the change of LAI based on analysis of the two varieties. The correlation coefficient between the first order derivative of canopy spectral reflectance and the DI by regression was shown in Fig.7.

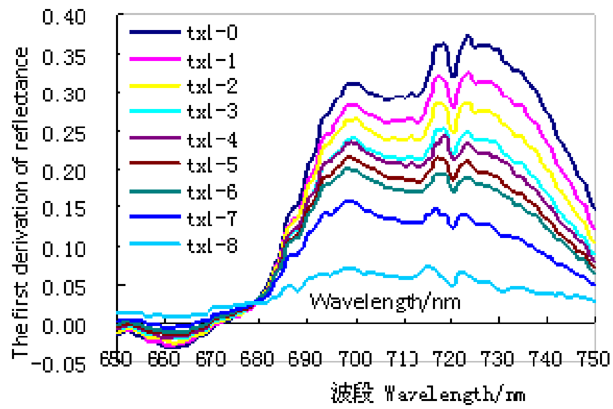

Figure 5 : The first derivation of canopy spectral reflectance of winter wheat in different LAI (tx1)

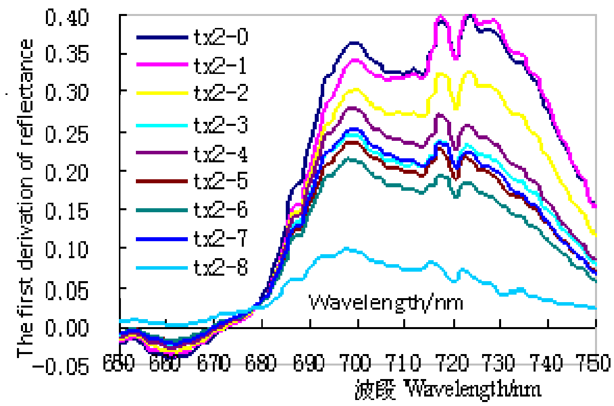

Figure 6 : The first derivation of canopy spectral reflectance of winter wheat in different LAI (tx2)

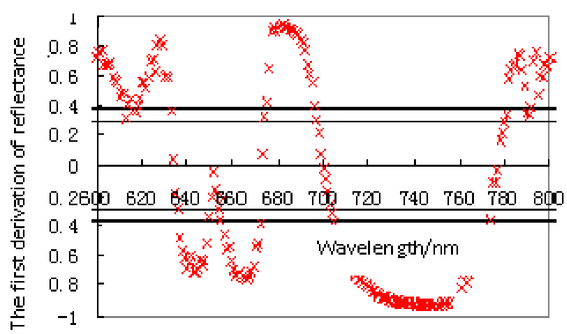

Figure 7 : The correlation coefficients between the first derivation spectral data and the DI

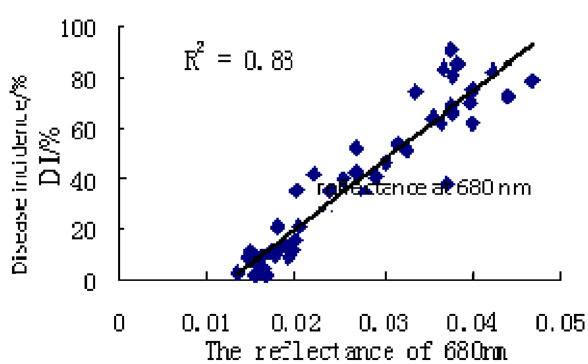

Figure 8 : The model between the first derivation reflectance at 680 nm and the DI

CONCLUSIONS

The analysis shows that the standard deviation of first order derivative of canopy spectral reflectance near 680 nm is the minimal. Therefore, the spectral reflectance at 680 nm is not sensitive to the changes of LAI. It indicates that reflectances around the 680 nm wavelength have relative good stable relationship with the DI, and R^2 more than 0.8, So the reflectance of one individual band with a highest correlation coefficient around the 680 nm wavelength can be selected to establish model with the DI, as shown in Fig.8, which can restrain effectively the effect of LAI's change on disease index inversion, so that it can improve the accuracy of DI inversion to some extend.

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