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Application of Hyperspectral Imaging System on Detection of Oilseed Rape Waterlogging stress

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China is the largest oilseed rape-growing country in the world, with 80% of this crop planted at the middle and lower reaches of the Yangtze River. In this region, it is often cloudy and rainy in spring, during the oilseed rape flowering period, which is a critical time for overall plant growth and development. Waterlogging of oilseed rape can result in lodging and a decline in the numbers of pollen grains and effective branches per plant. And can also affect the absorption of potash and boric fertilizer, resulting in physiological damage. Furthermore, it can increase the reproduction and dispersal of bacteria, leading to increased generation and spread of downy mildew or clubroot, potentially causing a secondary crop disaster. Hyperspectral imaging technology creates digital images with hyperspectral resolution and uses each spatial point (pixel) of these hyperspectral images (HSIs) to represent the continuous relationship between incident light and wavelength, forming a data cube. However, reports of hyperspectral research on oilseed rape waterlogging remain rare.

Based on this, in the attached article "***Detection of waterlogging stress based on hyperspectral images of oilseed rape leaves (Brassica napus L.)***", a group of Chinese scientists reported the results of a scientific survey aiming to evaluate the application of hyperspectral imaging to the detection and classification of oilseed rape waterlogging.

The experimental field included a total of 36 experimental plots, each with an area of 3.77 m × 2.77 m ≈ 10.44 m^2 (Fig. 1). Each oilseed rape variety was planted in 18 plots, and there were 12 plots per treatment. Waterlogging was achieved by saturating the plots with water supplied continuously by pipe (Fig. 2) for 0, 3, and 6 days in treatments I, II, and III, respectively. To simulate oilseed rape waterlogging under normal field growth, no plots were sealed at the bottom and the water pipe was removed following completion of the water injection. During the fruiting period, 10 fresh oilseed rape leaf samples with no disease, insect pests, or damage were randomly collected from each plot, for a total of 360 leaf samples. HSIs of freshly collected leaves were taken in the laboratory after 2 h of sampling by the Resonon Pika XC (Fig. 3).

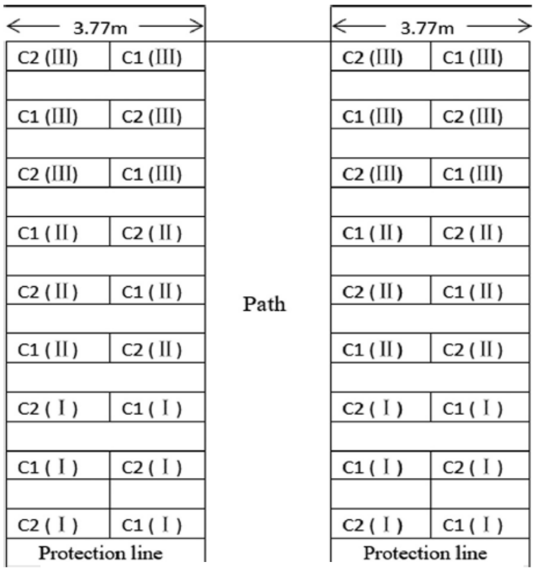

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Fig. 1. Planting scheme of experiment.

Fig. 2. Waterlogging experiment implementation.

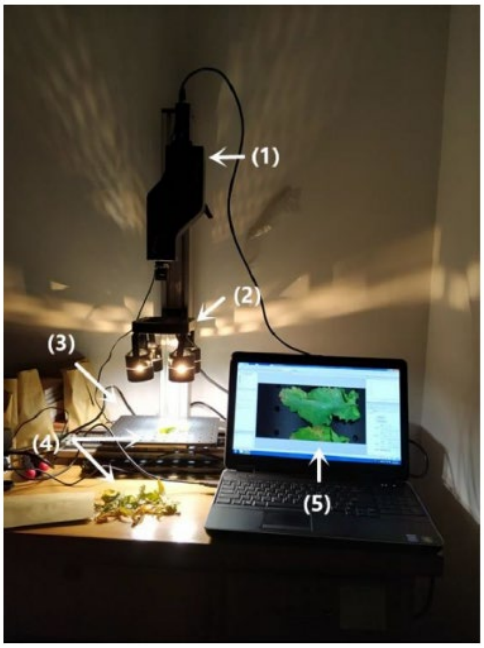

Fig. 3. Hyperspectral image acquisition system (1) Hyperspectral imaging camera (2) Lighting assembly (3)

Linear translation stage (4) Leaf samples (5) Software control system.

The 400-450 nm waveband is a strong chlorophyll absorption band and the 425-490 nm waveband is a strong carotenoid absorption band, there was a single red valley within a blue waveband, centered at 450 nm (R≤10%). The 650-700 nm spectral band is a strong chlorophyll absorption band; therefore, a red waveband centered at 670 nm exhibited one red valley (R≤20%); absorption decreased between these two wavebands (near 550 nm), forming a green peak (490-600 nm). Near the 670 nm waveband, a red edge was formed by strongly absorbing chlorophyll. Due to spongy mesophyll, the 750-1000 nm near-infrared waveband had a large reflecting surface, and reflectance was high (60%≤R≤80%). There were also narrow absorption bands of water and oxygen near the 760, 850, 910, and 960 nm bands, such that the 750-1000 nm waveband exhibited wavy characteristics (Fig. 4). Then, the optimal wavebands determined using SPA algorithm are shown in Fig. 5.

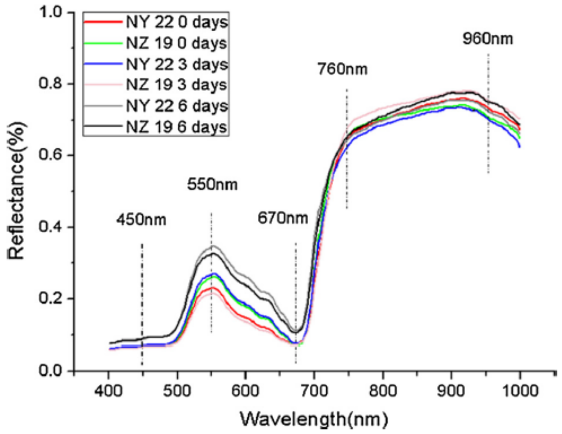

Fig. 4. Mean reflectance spectra of six types of experimental leaf samples

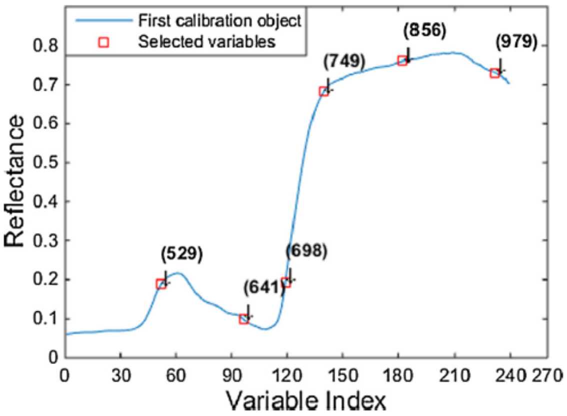

Fig. 5. Optimal wavebands selection by SPA algorithm.

The authors used the QDA, KNN, and SVM algorithms to classify HSIs and spectra of oilseed rape leaves under three levels of waterlogging stress, and found that the highest accuracies were for the QDA model and NZ19 dataset, followed by the SVM and KNN algorithms. The performance of the VNIR spectrum classification was better than that of image classification. To reduce modeling complexity, the SPA algorithm was applied to classify and analyze images and spectra at six optimal wavebands. The results showed that the QDA model and NZ19 dataset always maintained high classification accuracy and stability; the corresponding images at the 698 and 979 nm wavebands showed high classification accuracy, and images at the 529 nm waveband had poor classification accuracy.

In short, compared to traditional color images, the classification of HSIs has significant potential. This technology is feasible and useful for the detection of oilseed rape waterlogging stress. As hyperspectral technology is applied more broadly in modern agriculture, data mining and model identification based on HSIs will become a research and development area that combines computer science and precision agriculture.