Detection of senescence under heat stress based on leaf reflectance spectra for wheat

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Introduction

Climate change makes extremely high temperature events be more frequent. These events make wheat suffer heat stress and cause the premature senescence. Premature senescence is an important factor resulting in low yield and poor quality in wheat production. Thus, to detect the status of senescence is significant for the assessment of heat stress and the predication of yield lost after the stress. Spectroscopy methods provide a convenient and efficient way to detect the dynamics of biophysical indicators, but few of them are dedicated to senescence. On the one hand, the sensitivity of biophysical parameters response to senescence is still unclear. On the other hand, the accuracy of spectroscopy estimation for these parameters is still not be accessed systematically. In this study, there are two objectives: (1) to observe the responses of biophysical parameters to senescence and (2) to detect senescence using spectroscopy methods.

Materials & Methods

The pot experiment was conducted in an artificial climate chamber located in the base of National Engineering & Technology Center for Information Agriculture, China. In this experiment, 4 levels of air temperature were set as the treatment: T1: 22℃, T2: 26℃, T3: 30℃ and T4: 34℃. Among these four levels, T1 was set as the control, the other 3 levels was set as the different degrees of heat stress. The treatment started at beginning of anthesis and had a duration with 3 days.

Air temperature

Fig. 1. Artificial climate chamber

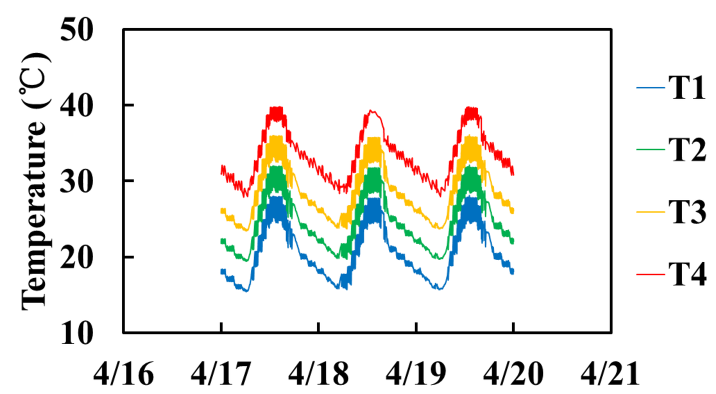

Fig. 2. The temperature of treatment

Data collection was divide into two periods. During the treatment and in the first 3 days after the end of treatment, the data were collected every day. Then the data were collected every five days. Data collected from this experiment included the, chlorophyll content (Chl a+b), net photosynthetic rate (Pn), equivalent water thickness (EWT), specific leaf weight (SLW) and leaf reflectance spectra.

Instruments

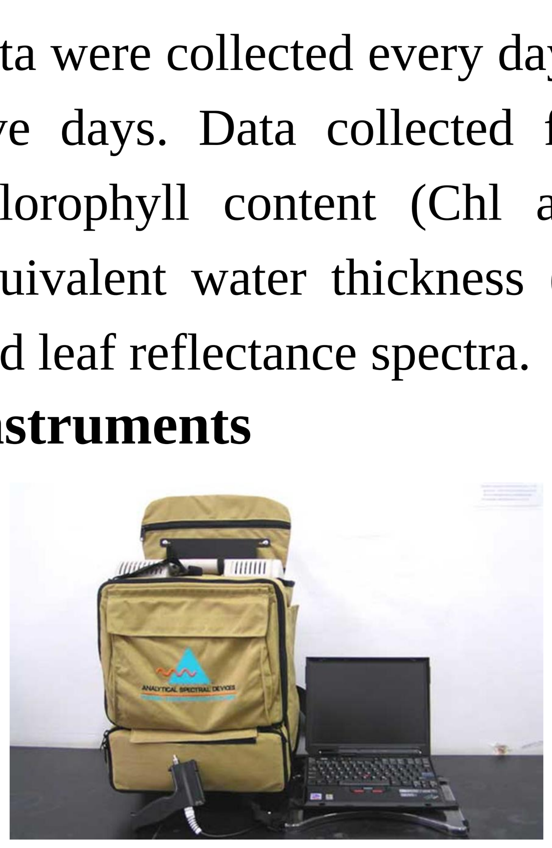

Fig. 3. ASD field spectrometer

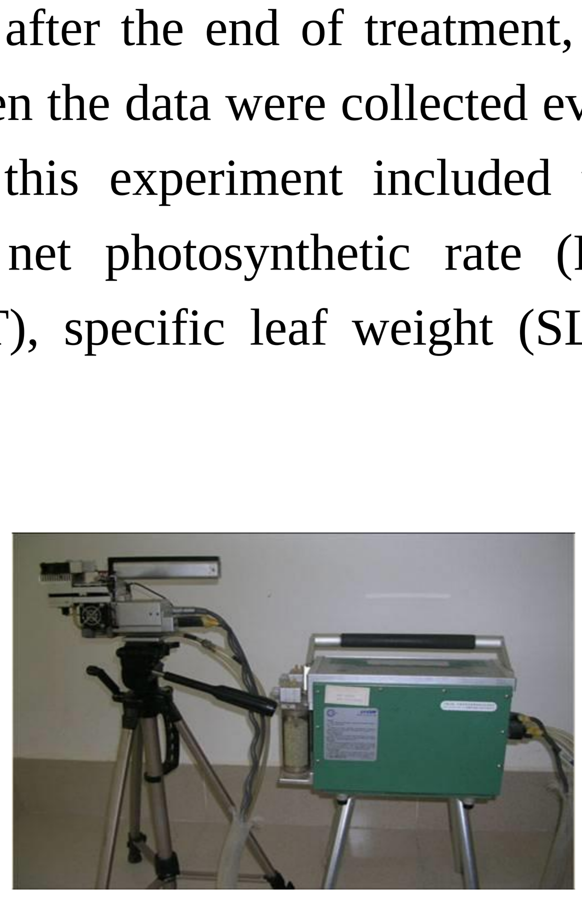

Fig. 4. li-6400XT photosynthesis system

Results & discussions

The changes of the leaf appearance

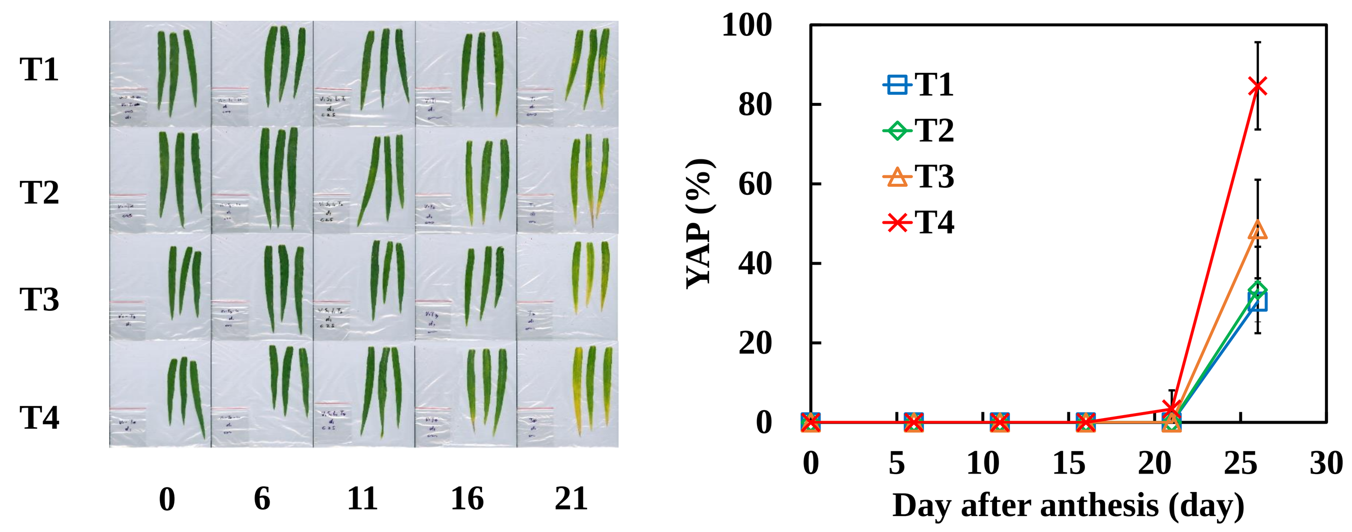

Fig. 5. The changes of the yellow area percent (YAP) under different levels of temperature.

The changes of the biophysics parameters

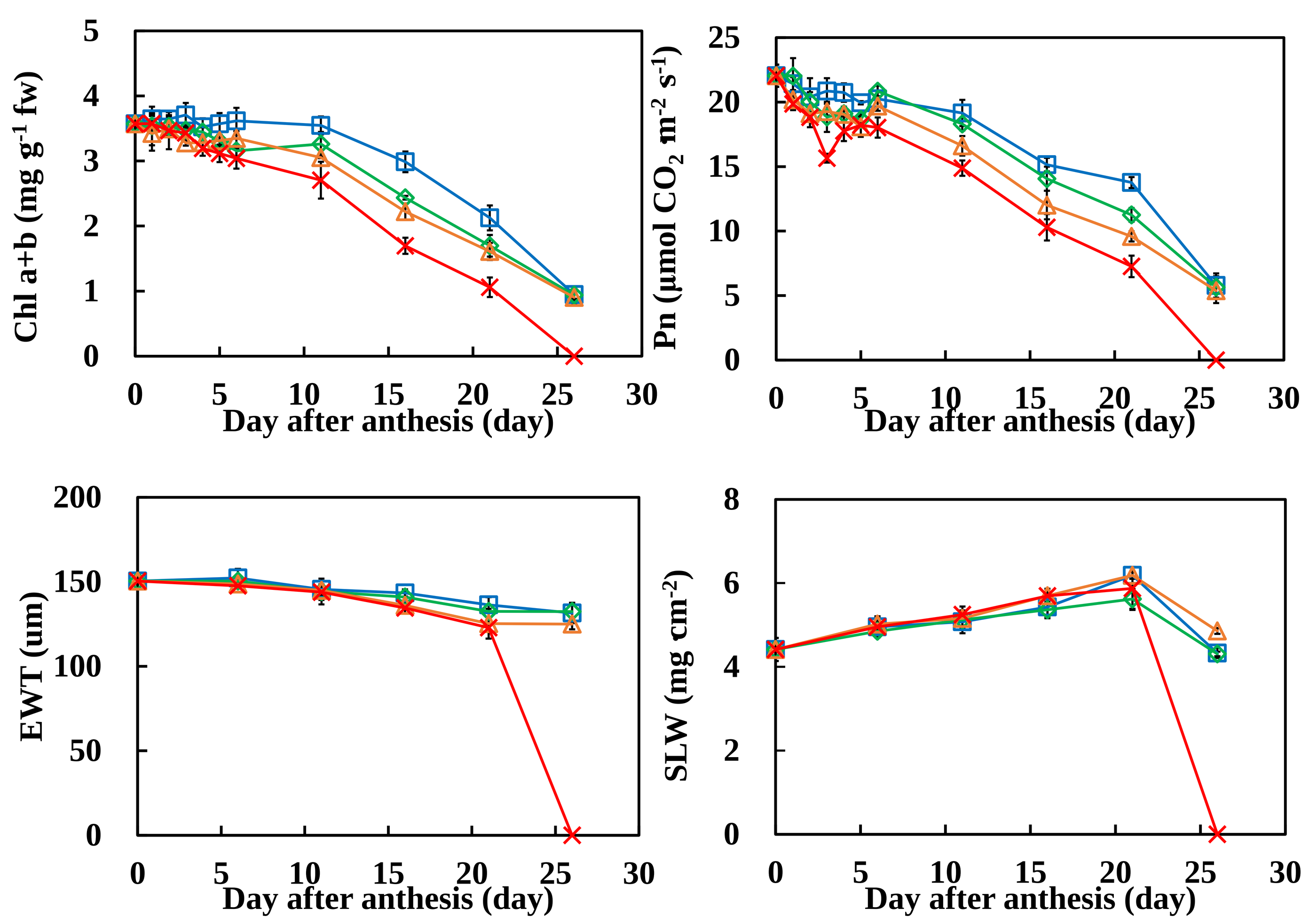

Fig. 6. The changes of chlorophyll content (A), net photosynthesis rate (B), equivalent water thickness (C) and specific leaf weight (D) under different levels of temperature.

In the process of senescence under different temperatures, all parameters display the responses to senescence. Among these parameters, the net photosynthesis rate and chlorophyll content change obviously while the equivalent water thickness and specific leaf weight are not sensitive compared to the former two parameters.

The changes of the leaf reflectance spectra

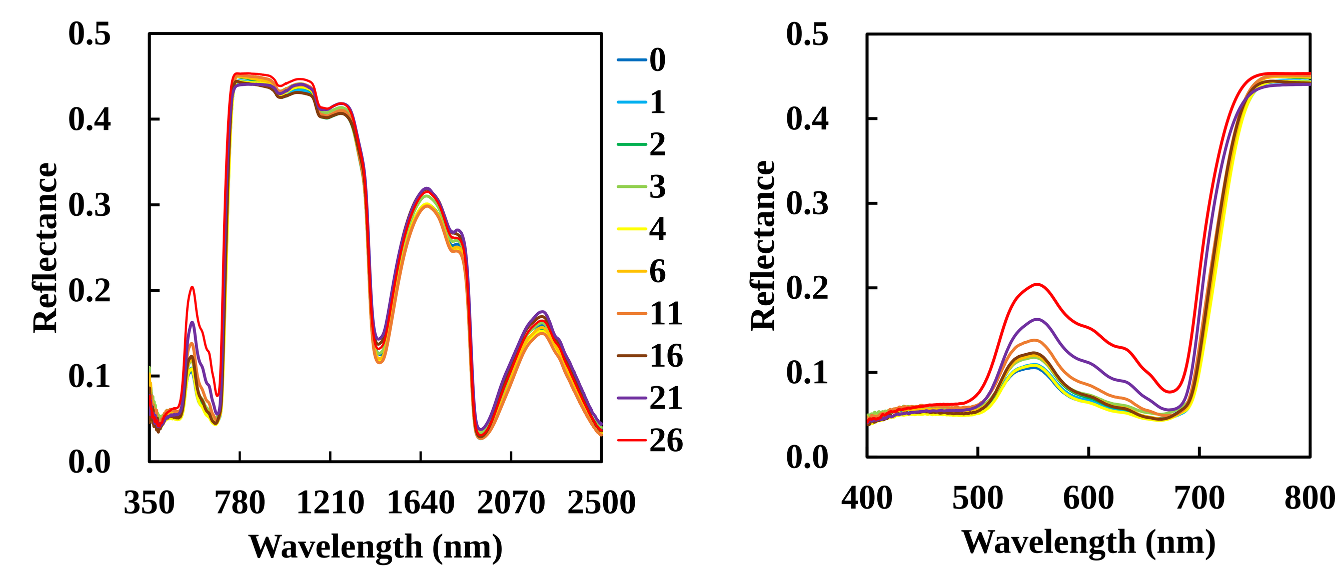

Fig. 7. The changes of the leaf reflectance spectra under different levels of temperature (A: 350 – 2500 nm, B: 400 – 800nm).

The changes of the leaf reflectance focuses on visible region. The other regions seem have no obvious changes.

The relationship between NDSI and parameters

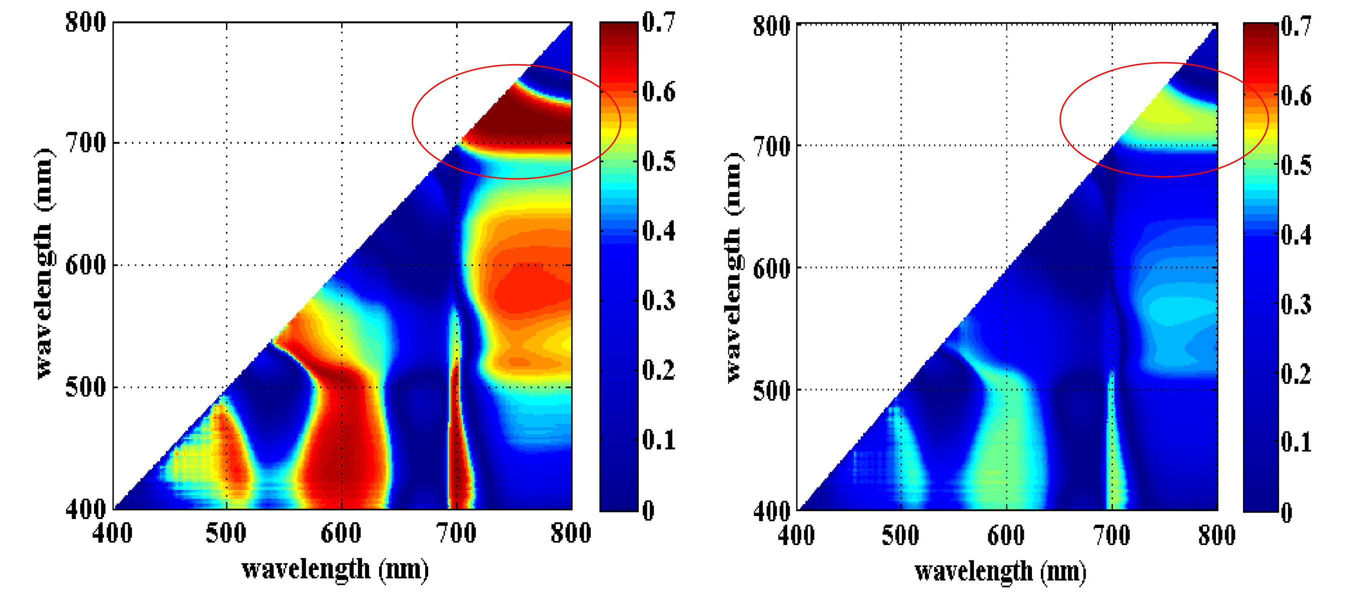

Fig. 8. 2-D contour map of coefficients of determination (R^2) for linear relationship between NDSI and the chlorophyll content (A) and net photosynthetic rate (B).

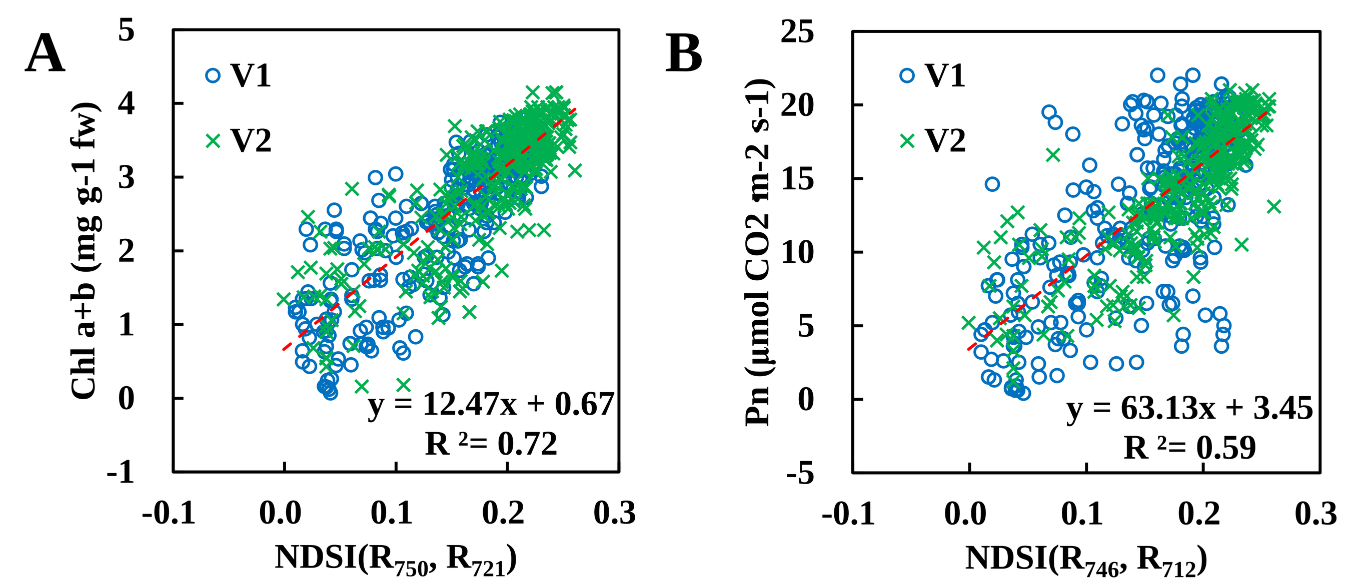

Fig. 9. Relationship between NDSI(R_{750}, R_{721}) and the chlorophyll content (A) and relationship between NDSI(R_{746}, R_{712}) and the net photosynthetic rate (B).

These band combinations of NDSI with high R^2 are mainly located in the red edge region (680-760 nm). Among these combinations, combination (λ1: 750 nm, λ2: 721 nm) is the most suitable one, which has the highest R^2 (R^2=0.72) in the estimation of chlorophyll content. When it comes to the net photosynthesis rate predication, the combinations with high R^2 are also located in red edge, but the R^2 is lower, it just reaches to 0.59.

Conclusion

In this study, we conclude that in the process of senescence after heat stress, net photosynthesis rate and chlorophyll content are the most sensitive parameters that are able to used to reflect the status of leaf senescence. When it comes to the estimation used spectroscopy methods, chlorophyll content show much more accurate. Overall, we suggest that the vegetation index NDSI(R_{750}, R_{721}), which is found efficient in the estimation of chlorophyll content is the most suitable vegetation index with the potential in the detection of senescence.

Acknowledgements

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