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Application of Hyperspectral Imaging System on Monitoring Stomatal Behavior

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In the North China Plain, improper brackish water irrigation and the dry-hot wind (DHW) stress crops and produce physiological drought and subsequent crop yield reduction. And the effects of salt and DHW stress are closely related to stomatal behavior, which is an important channel for the exchange of water and gas between crops and the external environment. Therefore, we need to monitor stomatal behavior.

Traditional stomata investigation methods involve experimental laboratory measurements of specific plants using stoma-related instruments or a field plot, they are highly costly and cannot be applied to regional agricultural management. Canopy resistance represents the stomatal behavior of an entire crop and is easier to measure than stomatal conductance, so a new remote sensing model must be constructed to simulate canopy resistance for regional applications.

Based on this, in the attached article "***Remotely sensed canopy resistance model for analyzing the stomatal behavior of environmentally-stressed winter wheat***", a group of Chinese scientists reported the results of a scientific survey aiming to construct a remote sensing model to estimate winter wheat canopy resistance, compare the estimations with ground observations of canopy resistance and assess the accuracy of the model, and study the effects of salt and dry-hot wind stress on winter wheat stomatal behavior.

Experimental site: The experiments were conducted at the Yucheng Comprehensive Experiment Station (YCES) of the Chinese Academy of Sciences (CAS) in Yucheng, Shandong Province, China (36°57′ N, 116°36′ E, 28 m.a.s.l.) from 2017 to 2019 in the winter filling period when winter wheat is salt-sensitive.

Experimental design: Six plots (5 m × 10 m (Fig. 1)) were used for the brackish water irrigation experiment. Because of space and experimental condition limitations, three irrigation treatments with a repeated plot for each treatment were arranged as: freshwater irrigation (CK with a TDS of <1 g/L), moderate brackish water irrigation (MS with a TDS of 3 g/L), and severe brackish water irrigations (SS with a TDS of 5 g/L). Freshwater was transported from the Yellow River, and brackish water was created using freshwater and sea salt with target TDS values of 3 g/L and 5 g/L.

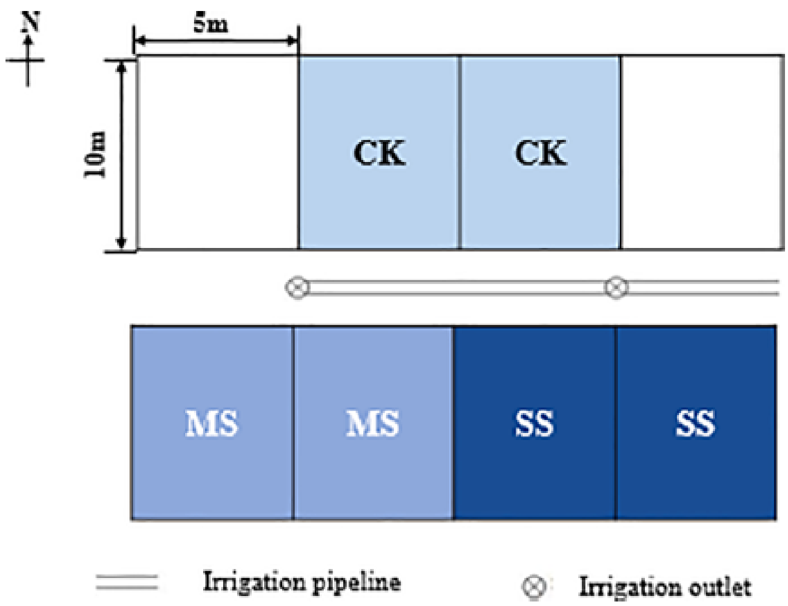

Fig. 1 Diagram of the experimental area for brackish water irrigation treatment. CK was treated with freshwater irrigation (TDS < 1 g/L); MS had moderate brackish water irrigation (TDS = 3 g/L); SS underwent severe brackish water irrigation (TDS = 5 g/L).

Hyperspectral measurement: Hyperspectral images were taken under cloudless conditions using a Resonon Pika XC2 hyperspectral camera (Resonon Inc., USA).

A comparison of the evapotranspiration (ET_{veg}) and stomatal resistance (r_s) of winter wheat at a field scale under different treatments in the observation range showed significantly different responses to different treatments and proved the feasibility of the remote sensing model (Figs. 2

and 3).

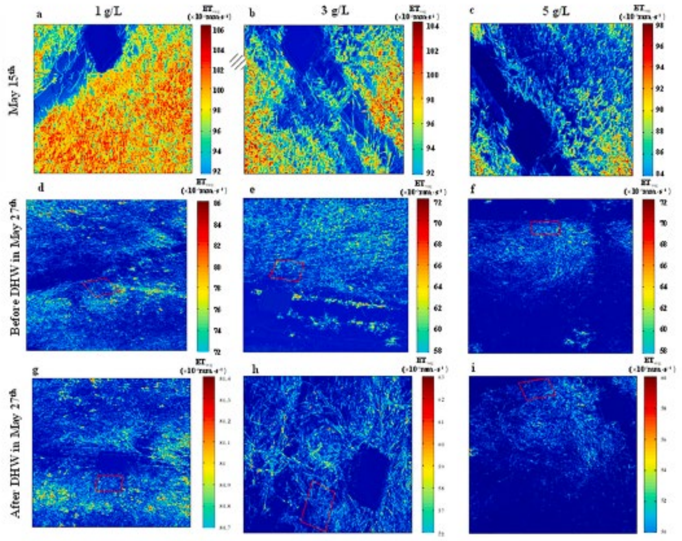

Fig. 9. Evapotranspiration of winter wheat (ET_{veg}, $\times10^{-6}$ mm/s) at a field scale with different irrigations or dry-hot wind (DHW) treatments in 2017. The red boxes refer to the samples with DHW treatments. The irrigation treatments contain fresh water irrigation (1 g/L, left column) and two brackish water irrigations of 3 g/L (middle column) and 5 g/L (right column). The blue area denotes vegetation-free areas.

Fig. 2 Evapotranspiration of winter wheat (ET_{veg}, $\times10^{-6}$ mm/s) at a field scale with different irrigations or dry-hot wind (DHW) treatments in 2017. The red boxes refer to the samples with DHW treatments. The irrigation treatments contain fresh water irrigation (1 g/L, left column) and two brackish water irrigations of 3 g/L (middle column) and 5 g/L (right column). The blue area denotes vegetation-free areas.

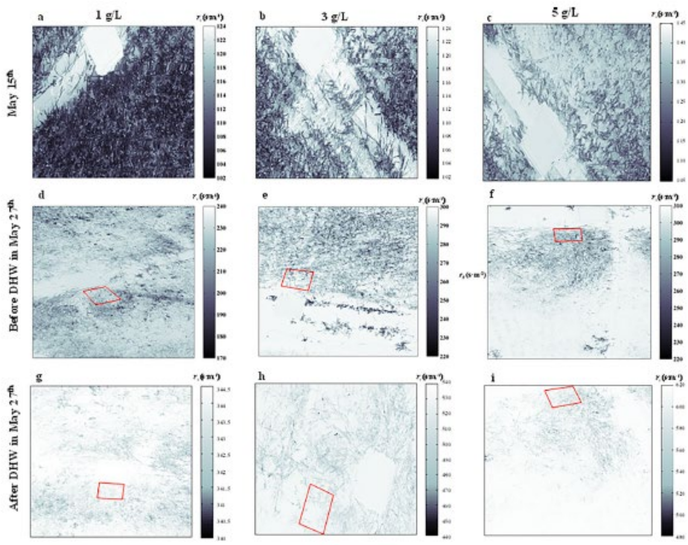

Fig. 3 Stomatal resistance of winter wheat (r_s, s·m^{-1}) at a field scale under different irrigations or dry-hot wind (DHW) treatments in 2017. The red boxes refer to the samples with DHW treatments. The irrigation treatments

include fresh water irrigation (1 g/L, left column) and two brackish water irrigations of 3 g/L (middle column) and 5 g/L (right column). The white area denotes vegetation-free areas.

The authors concluded that the remote sensing model successfully determined stomatal behavior (regression coefficient= 1.25; $R^2 = 0.98$, RMSE = 29.84 $s \cdot m^{-1}$; MAE = 9.44 $s \cdot m^{-1}$), which provided a scientific basis for more-accurately monitoring crop growth with remote sensing model and regional precision agricultural management. Although salt and DHW stresses reduced the degree of stomatal opening, results showed that irrigation with moderate brackish water of 3 g/L TDS decreased the DHW stress indices and, consequently, the effects of dry-hot wind stress. Moderate brackish water irrigation was suggested to increase DHW tolerance for practical applications, offering significant guidance for future water-saving irrigation management.