

A research on monitoring the canopy temperature variation of rice based on the infrared thermal imaging technique

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Abstract. The experimental results show that the infrared thermal imaging can observe the overall temperature distribution of canopy in rice much more intuitively. The canopy temperature of different soil water potentials in the field showed a regular change, and the rice canopy reached the highest temperature at 13:00-15:00, and the lowest at 2:00-4:00. The range of temperature difference between the crown and the air is gradually increased with the prolongation of the water stress. And the best effect of water stress to observe was at 13:00-15:00 through canopy temperature.

1. Introduction

The canopy temperature not only can screen and separate out the drought resistance genotype under the same growing environment, but also can be used to diagnose the degree of rice water deficit, and then guide the time and volume of irrigation.

It is becoming a new hotspot of crop quantitative and water saving research that determine the canopy temperature of rice and diagnose the crop water status by infrared thermal imaging and then take the corresponding irrigation measures.

As a convenient technology that applies infrared automatic temperature measurement device to observe the canopy surface temperature of crop, so as to diagnose whether the crop suffered water stress or not, the Infrared Thermal Imaging has already developed maturely [1]. Orta et al. (2004) [2] in Turkey through the study of wheat developed corresponding equation which can be used to qualify crop water stress index Luquet et al. (2004) [3] assessed the limitations of water stress indices using directional thermal infrared (TIR) measurements and 3D simulations. Mahan et al. (2005) [4] determined peanut irrigation threshold by the canopy temperature and its time. Möeller (2007) [5] used infrared thermal image to detect grape canopy water status. Alchanatis et al. (2010) [6] applied infrared thermal image to map the flow of water on cotton leaf. Susan O'Shaughnessy (2012) [7] established sorghum automatic irrigation model via the study of water stress index. Many experiments showed the infrared thermal imaging technique is feasible to estimate crop water demand.



2. Materials and Methods

This experiment took place at the test field of Rice Institute of Shenyang Agriculture University. (N41°8′, E123°38′). Applied terrier 1 variety and established districts in the field by using plastic pool, and the properties of soil in this region was brown. The test established five different water gradient treatments that the field capacity of soil maximum water content 100%(building water courses, CK, corresponding soil water potential is 0), above 80%(corresponding soil water potential 0.025~0.03MP), 60%(corresponding soil water potential 0.045~0.05MP), 40%(S3, corresponding soil water potential 0.055~0.06MP), and 20%(S4, corresponding soil water potential below 0.08MP). At early jointing stage (about 13-14 leaves) began to control the water, soil potential instrument and weighing method combines to be applied in water control. In order to prevent rain from affecting the water stress treatments, the mobile rain-proof sheds were set-up. It took a 24 hours experiment to measure the canopy temperature and air temperature in no wind, sunny day.

Other paragraphs are indented (BodytextIndented style). The convenience and accuracy of Infrared thermal imaging system that can observe the overall temperature distribution of rice canopy temperature much more intuitively, so as to achieve the Synchronous measurement of each part temperature. Earing and full heading time Figure 1. shows after water controlling in earing and full heading time, from the infrared thermal imaging pictures of each test fields that most of the plants in the whole plot came into view under the infrared thermal imaging, and they can freely select the point or space to the canopy Temperature for statistical analysis.

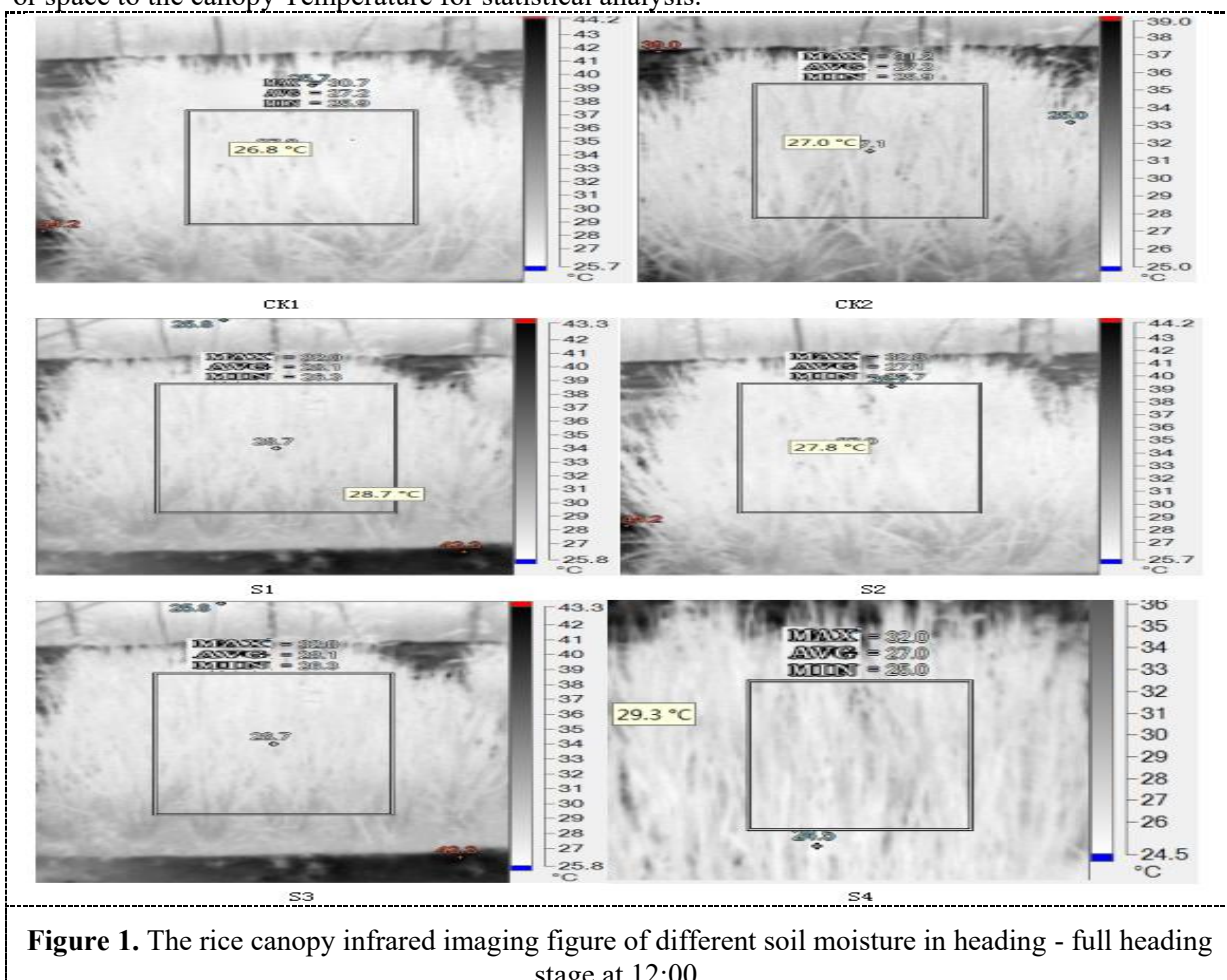


Figure 1. The rice canopy infrared imaging figure of different soil moisture in heading - full heading stage at 12:00.

In order to understand the canopy temperature of different rice water potentials, the test chose the infrared thermal imaging in seventh day of earing and full heading time water controlling at 12:00 for 3D-IR drafting. (Figure 2.) In previous studies, many researchers believe that plants become the

vegetative growth into the reproductive growth stage during this period, and the contradictory of plant and soil water supply conditions is the most outstanding. As the pictures showed that the distribution of canopy temperature under different water treatments was quite different. In the whole water layer CK1 treatment of 3D-IR diagram can be seen, in addition to the four corners of the area affected by the outside, the central area of the district temperature is low, the temperature is evenly divided, and the temperature of the division of the whole area of the plant temperature difference is not significant. From the beginning of CK2 can be seen with the increase in the degree of water stress, 3D-IR diagram of the temperature reaction became more and more intensely. CK2 area due to high soil moisture content, the performance was still relatively uniform, and S1-S3 treatment, it can be seen the temperature distribution was become more and more clutter, the stress treatment area due to low soil moisture that the entire canopy space and the uneven distribution of water within the plant directly leads to the uneven distribution of canopy temperature; S4 treatment is the highest water stress with the lowest moisture in the soil. Although the temperature distribution was more stable than that of the other treatments, the canopy temperature was significantly higher than CK1 treatment. It can be seen from the 3D-IR diagram that the canopy temperature in different soil water potentials is quite different.

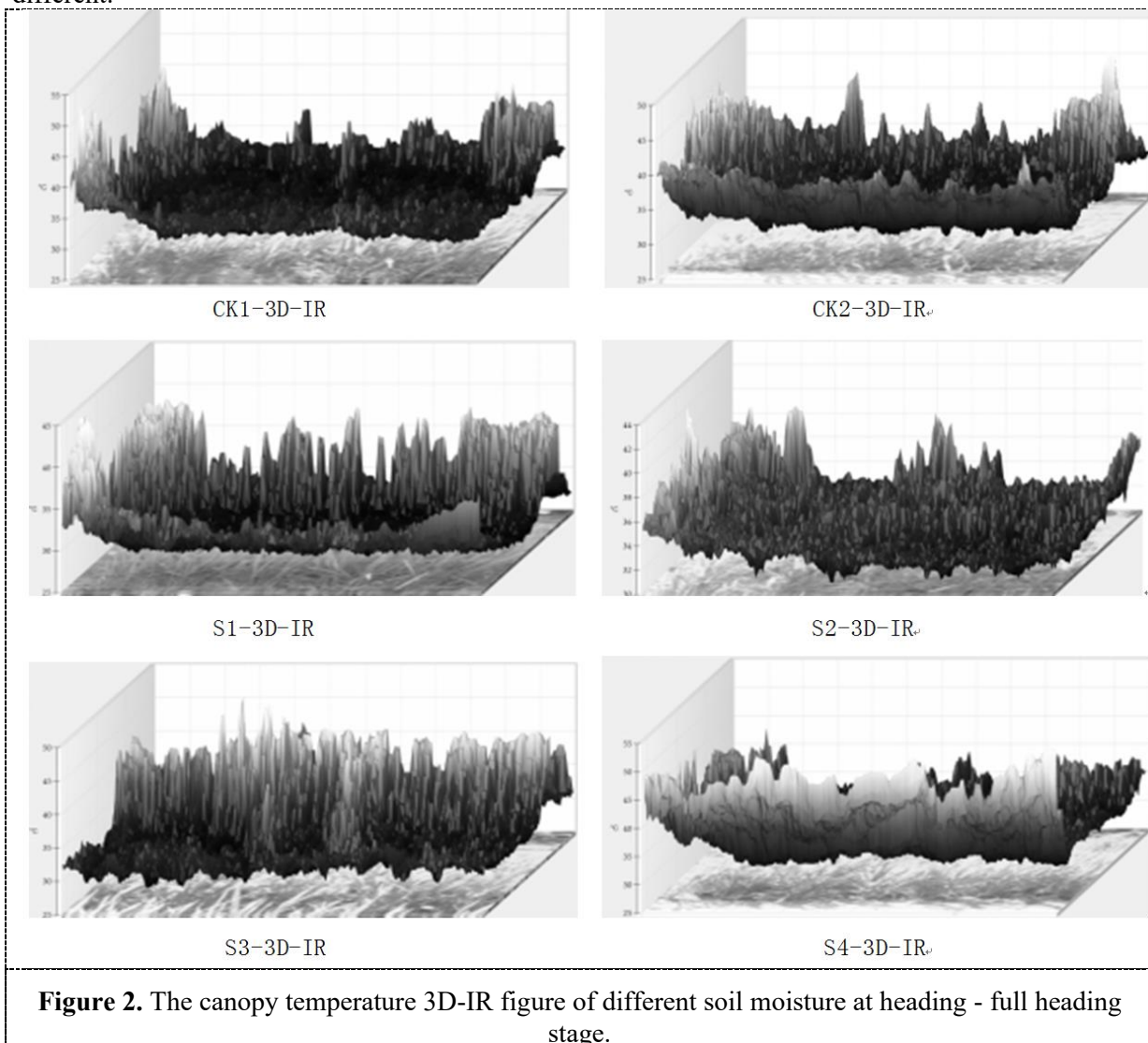


Figure 3. and Figure 4. separately showed the diurnal changes of water control at 7th and 14th day of tiller-jointing stage of Kaigeng 1. During the Tillering jointing stage, the canopy temperature changes with the trend of atmospheric temperature. And the canopy temperature of the rice increased

gradually with the increase of the atmospheric temperature, and the other canopy temperatures except S4 were peaked at 14: 00-15: 00, which is later than the peak of the temperature. It showed that the change of canopy temperature is generally lagging behind the change of temperature, while the S4 treatment stress is the most serious, which leading to the poor regulation ability of rice itself, and the most close to other temperatures in the daytime. Meanwhile, it also showed that the trend of canopy temperature during daytime was $S4 > S3 > S2 > S1 > CK2 > CK1$, and the canopy temperature decreases with the decrease of temperature after 16:00 pm. However, since the rapid decline of solar radiation and the rising of air humidity, that the temperature of the canopy can be reduced gradually, and the difference of the canopy temperature between the treatments is not obvious. After 14 days of water control. The difference in canopy temperature between treatments was more pronounced at 10: 00-16: 00, such as S4 and S3 with high water stress, their temperature increased, which were close to the temperature at 7 days. Due to the role of air humidity, the temperature difference at is not obvious among each areas at night 22: 00-4: 00, and the temperature difference is also small, but always lower than the temperature. In the 7 days and 14 days water controlling which measured the temperature of the S4 and S3 treatments were higher than other treatments at night, which may be related to the tiller-ectonic stage, and the canopy temperature is related to the influence of water layer and soil water content at night.

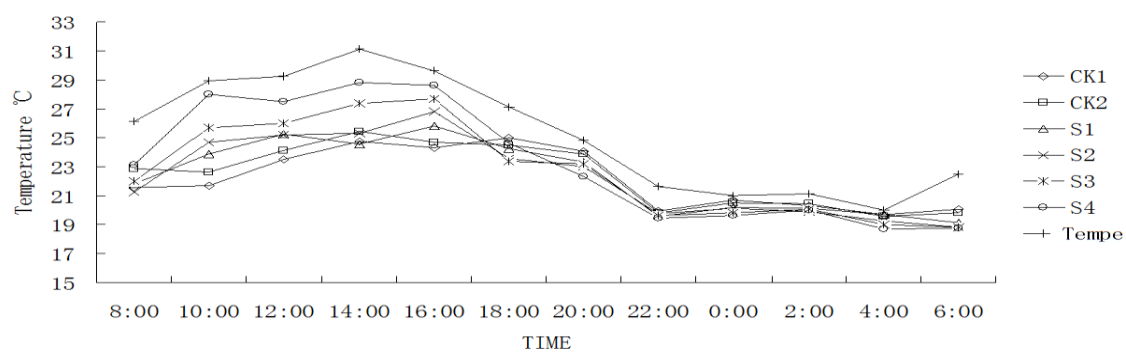


Figure 3. The daily changes of the canopy temperature of Kaijing 1 after 7 days under different water treatments at tiller-jointing stage.

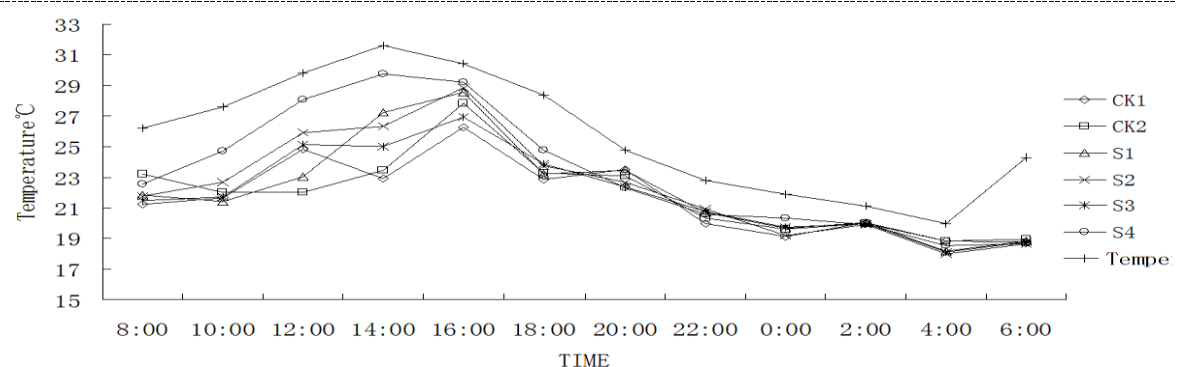


Figure 4. The daily changes of the canopy temperature of Kaijing 1 after 14 days under different water treatments at tiller-jointing stag.

3. Conclusions

It can observe the status of rice water stress via infrared imaging intuitively. There was a significant difference in canopy temperature between rice under different water treatments, and this difference gradually increased with the prolongation of water stress. In the daytime, the temperature of canopy

was higher in rice with higher water stress, which was more obvious than that without stress treatment. The degree of water stress can be observed by the observation of canopy temperature, and the observation effect of different water stress levels is the best at 13: 00-15: 00. At the same time, it can judge whether the rice suffered from water stress or not by the difference of canopy temperature.

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