Utilizing Canopy Temperature to Establish Irrigation Requirements for Western Kentucky

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Introduction

The use of irrigation systems has long been a solution to the problem of water shortages during the crop growing season. Being able to monitor crop water status has been done using different methods such as the checkbook method and utilizing soil moisture sensors. The checkbook method is based on soil moisture balances to determine water needs. Soil moisture sensors are used to measure when the soil reaches a soil water suction value just before permanent wilting value. For silt loam like in Princeton, Ky, the value would be between 85 and 93 kPa.

The lack of structure in the checkbook method can lead to overirrigation and the labor intensity of the soil moisture sensors can be too difficult to use properly. A more straightforward method to know when crops need irrigation is needed. Recent research has been done with infrared thermal cameras to evaluate canopy temperature in wheat (Canopy Temperature and grain yield of irrigated wheat in Kentucky, Carrie Ann Followell)[1] and corn (Establishing Corn Irrigation requirements for Western Kentucky, Hunter Adams, Carrie Knott)[2]. This study is going to research the relationship between canopy temperature and ambient temperature to see if canopy temperature can be monitored and used to determine irrigation needs.

The environmental conditions were less than ideal for determining irrigation needs since the soil never reached below the 85 kPa soil water suction value during the beginning reproductive stages. The greatest need for irrigation is through the beginning reproductive stages and there was enough rainfall this season to prevent the need for irrigation. This led the investigation into the direction of understanding the relationship between canopy temperature and ambient temperature and starting to determine if infrared radiometers can be used as tools to determine irrigation.

Materials and Methods

The field experiment was located at the University of Kentucky Research and Education Center in Princeton, Ky in 2021. There was a total of eight approximately 4'x 24' corn plots (AgriGold A654-16) with a planting population of 32,000 planted on May 15, 2021 and eight approximately 4'x 24' soybean plots (pioneer 46A86X) with a planting population of 150,000 planted on April 14, 2021. Infrared Radiometer stations are placed at four of the corn plots and four of the soybean plots. The Infrared radiometer stations included three different sensor data collectors: infrared thermal camera (Apogee Infrared camera model SI 113), rain gauge tip bucket (Onset HOBO Rain Gauge RG3 and pendant event data logger, part number UA-003-64), and an ambient temperature thermometer (Onset HOBO Pro v2 exterior temp/RH, U23-002). Each of these sensors recorded data every minute starting late June through the middle of August.

A FLIR (Forward Looking Infrared Camera) was used to take thermal images of each plot every weekday starting at 2:00 pm, the hottest part of the day according to 2019 IR data taken in the same field. The FLIR images gives a visual of the thermal distribution throughout the canopy through color-coded images as seen in **Figure 1**.

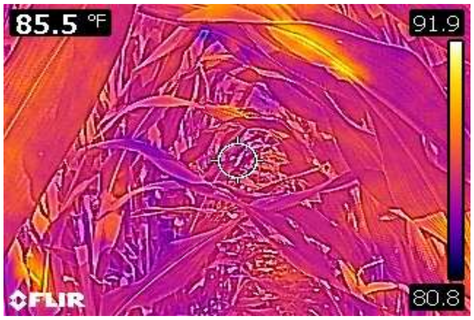

Figure 1. FLIR image taken between rows of corn in Princeton, Ky.

The FLIR images are then compared to the MESONET weather station data. The weather station is located on the farm in Princeton, Ky. The FLIR images of the corn were taken at ear leaf height down the row. The soybean images were taken on the top of the canopy from five feet off the ground angled down towards the top of the canopy.

Soil moisture probes were installed early August to record soil moisture. The probes used were Sentek Drill and Drop Bluetooth probes. Two probes were placed in corn plots and two probes were placed in soybean plots. The soil moisture readings were used to determine if the crops needed irrigation. If the soil water suction value rose higher the crops would then be irrigated.

Data and Analysis

Figure 2 displays eight soybean FLIR images averaged together and the eight corn FLIR images averaged together to get the single green and yellow points. The ambient temperature was taken directly from the field using the Onset HOBO Pro v2 sensor placed in the soybean plots.

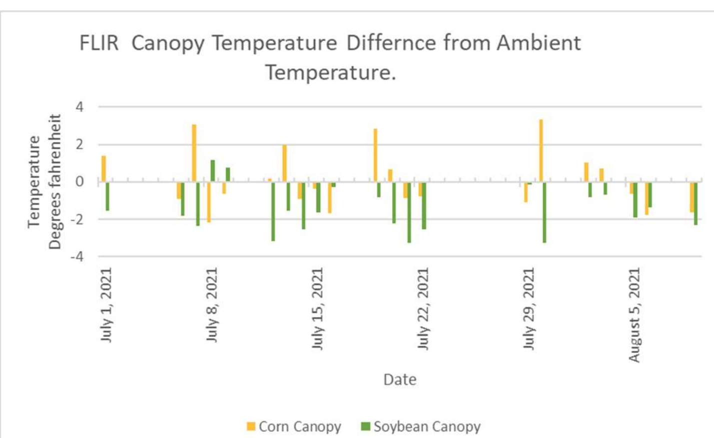

Figure 2. This graph shows the relationship between the ambient temperature measured from a sensor in the field and the FLIR temperatures of the corn and soybean.

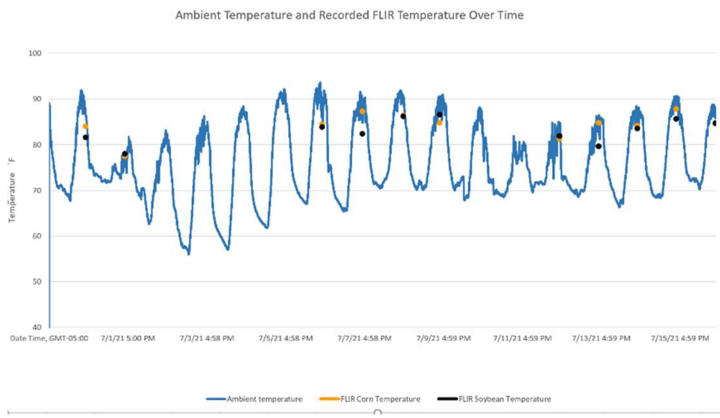

Figure 3. FLIR images from each plot were averaged then compared to WKU MESONET ambient temperature. The difference between the canopy temperature and the ambient temperature can be seen above.

The FLIR images were also compared to the Western Kentucky MESONET station located on the Research and Education center farm. **Figure 3** shows how the canopy temperature varied from the ambient temperature at the time the FLIR picture was taken.

Along with the FLIR data recorded, the canopy temperature was also measured with the stationary infrared radiometer. The results compared to the ambient temperature can be seen below.

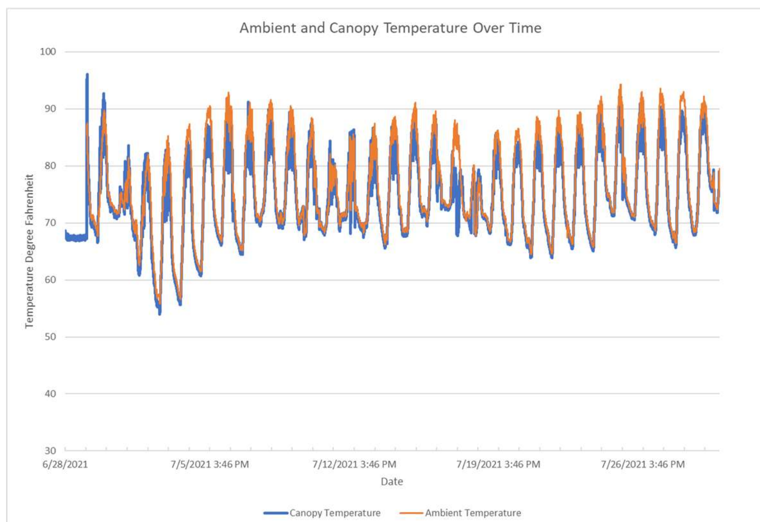

Figure 4. This graph displays the ambient temperature and canopy temperature of one corn plot.

There are a couple things to note about **Figure 4**. First, during the troughs, the canopy temperature dipped lower than the ambient temperature. Second, at the peaks, the ambient temperature rose higher than the canopy temperature.

Preliminary Results

There seems to be no difference between the canopy temperate and the ambient temperature during the prime irrigation time frame of the crops. We do plan to complete statistical analyses later to verify this. The canopy temperature does drop lower than the ambient temperature in the troughs but doesn't get as high during the peaks, but they overall follow the same pattern. This pattern may be because we didn't need to irrigate, and the need for irrigation could change these results.

There will need to be further studies done with the use of irrigation to see if there is a change in canopy temperature when irrigation is needed and after irrigation. There will need to be data taken on crops that are in need of irrigation. No conclusion can be drawn on the question of if canopy temperature can be used to determine irrigation.

Discussion

There are a couple weather conditions noted that could easily alter the data just based on when the FLIR image was taken. One condition was that on windy days, especially sunny, windy days, the temperature displayed on the FLIR would run through a range of up to ten degrees difference. The wind would expose part of the canopy that wasn't in direct sunlight and therefore change the given temperature, raising the temperature when the wind wasn't blowing, lowering the temperature when the wind was blowing. Capturing the FLIR picture a couple seconds different would change the results of the data. It was important to try and capture the median temperature the FLIR would display to get the most accurate reading of the canopy.

Another condition that made taking the FLIR pictures difficult was partly cloudy days. When taking pictures of the plots, one would be the direct sun and another one would be in the shade for the just few minutes it took to take the FLIR picture. The difference between shade and direct sun would be up to five degrees different. It would just solely depend on if that plot was shaded the moment the FLIR was taken.

With these factors considered, the assumption can be made that the stationary IR camera provides a more reliable source of data in terms of canopy temperature. Taking the data more frequently and from the same exact position gives better controlled results and therefore more reliable results.

Acknowledgments

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References

1. Followell, C.A.*, K.S. Rod*, and **C.A. Knott†.** 2020. *Canopy Temperature and Grain Yield of Irrigated Wheat in Kentucky.* Crop, Forage,Turfgrass Management. 6:e20000. http://acsess.onlinelibrary.wiley.com/doi/full/10.1002/cft2.20000.
2. Adams, H.*, K. Rod*, and **C.A. Knott**. *Establishing Corn Irrigation Requirements for Western Kentucky.* [abstract]. In: ASA-CSSA-SSSA International Annual Meeting.; Nov 10-13, 2019 San Antonio, TX.