Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 1, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

DETECTION OF CUCURBIT POWDERY MILDEW, *SPHAEROTHECA FULIGINEA* (SCHLECH.) POLACCI BY THERMAL IMAGING IN FIELD CONDITIONS

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Abstract

Plant diseases are one of the leading causes of yield losses in agricultural areas. In the fight against these diseases, chemical control methods are frequently used. However, this method of combat usually begins after the disease has spread throughout the entire field. The most essential thing here is to control the disease before it spreads throughout the entire country. Thermal imaging methods can now be used to accomplish this. Plant diseases stress the plant as a result of infection. The plant's stress causes activities that cause a temperature increase or reduction in the area where the infection has occurred or has begun. Thermal imaging technologies can be used to identify this condition. This work focuses on the potential early detection of Cucurbit powdery mildew (Sphaerotheca fuliginea (Schlech.) Polacci), which causes considerable yield loss in Cucurbitaceae, utilizing thermal imaging technologies. According to the findings, the lowest temperature in infected leaf tissues was 8.2 °C, whereas the maximum temperature in plant tissues without infection was 10.2 °C. The findings suggest that thermal imaging technology could be used to identify powdery mildew in cucurbits. In this case, early detection will potentially enable the detection of the disease that has started to spread in a certain region and will allow the disease to be potentially controlled with less labor and chemical use.

Key words**:** *thermal imaging, cucurbitaceae, powdery mildew*

INTRODUCTION

Plant diseases and pests are the most significant causes of production loss in agriculture. The control generally begins after the signs of diseases and pests have spread throughout the entire field [1]; [4]. Chemical control measures are usually utilized in this instance [21]. However, the primary focus should be on preventing the spread of diseases and pests across the agricultural cultivation field [2]. At this point, early detection methods are being used. Thermal imaging technologies are typically used for this. Thermal imaging technologies are commonly used to do this [6]; [11].nStress develops in the region where the plant is damaged as a result of infection or infestation by diseases and pests. An invisible temperature increase or reduction happens in the region where this damage originates. These temperature changes are potentially detected using by thermal imaging technologies [19]; [12]; [23].

Cucurbit Powdery Mildew, *Sphaerotheca fuliginea* (Schlech.) Polacci, one of the most important diseases of *Cucurbitaceae*, causes yield loss in the areas where this plant is grown [9].

The disease appears initially on the plants' old leaves, then spreads to the young ones. Piecemeal, somewhat spherical dots form first on the top side of the leaf, then coalesce and cover both surfaces of the leaf, the petiole, and the stem. The spots look like a layer of powder of white color at first, browning as time goes on. The plant's growth halts as the leaves dry up and fall off.

As a result, product loss happens [14]; [7]; [18]; [16].nThe aim of this study was to maked a potential detection of *S. fuliginea*, which is a powdery mildew disease factor in cucurbits by using thermal imaging methods. With the detection of the disease at an early stage, it will be easier to put the cucurbits under pressure using the necessary control methods without spreading the disease in the areas where the disease is grown.

MATERIALS AND METHODS

Temperature changes induced by the infection in the plant can be identified using thermal imaging technologies [17]. That study was carried out in the agricultural areas where cucurbits are grown in Bursa Uludağ University. The study concentrated on the potential detection of temperature changes induced by disease stress using thermal imaging technologies.

A portable thermal camera with 464 x 348 pixels and a thermal sensitivity of less than 40 millikelvin (mK) was utilized in the study.

A lens with a spatial resolution of 0.90 m/rad pixels was employed to provide more accurate imaging. Leaf surfaces that started to be infected by *S. fuliginea*, uninfected leaf surfaces and temperatures of the environment were recorded simultaneously. Samples were taken from the infected Cucurbits leaves in order to examine them in the laboratory. Conidia morphology and germ tubes were examined under a light microscope (1,000x) and the disease was confirmed as *S. fuliginea*. The FLIR Thermal Studio program was used to measure the temperatures of infected leaves, while healthy leaves served as a control.

Because various external factors might cause temperature fluctuations on the plant [5], temperature readings were taken every 30 minutes between 05.00 and 16.00 for three weeks. Furthermore, the ambient temperature was collected instantly using a portable thermometer. Performing the imaging process from a close distance during thermal imaging reduces the margin of error during imaging [15].

Therefore, in this study, all thermal imaging processes were carried out at a distance of 0.3 m from the plant leaf surface and with 90°. The statistically significant difference of the temperature differences was determined using the analysis of variance (ANOVA) technique in the JMP®7.0 program. The Student's t test was used to analyze the difference between the means (0.05).

RESULTS AND DISCUSSIONS

For three weeks, the mean temperature of the leaf surface affected with powdery mildew (*Sphaerotheca fuliginea*) and the healthy leaf surface was monitored everyday between 5:00 and 16.00. It has been discovered that the temperature differential between the diseased leaf surface and the healthy leaf surface can vary by up to an average of 4 °C depending on the period of day (Figure 1). Significant variations were found when the average weekly (21 days) temperature values of ambient, *Sphaerotheca fuliginea*-infected leaves and healthy leaves surfaces were analyzed.

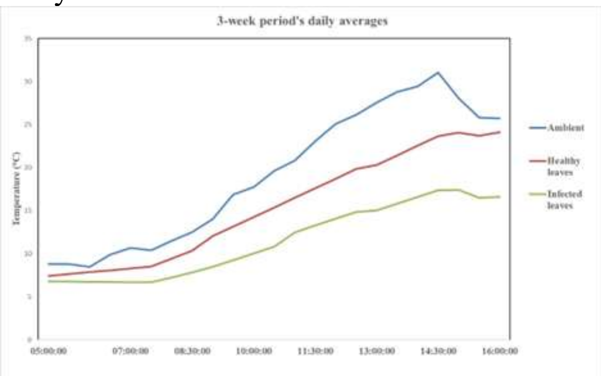

Fig. 1. The mean temperatures of infected and healthy leaves were monitored every 30 minutes between 5:00 and 16:00 on a daily basis, and their weekly (21-day) averages were shown with ambient temperature.
Source: The author's Excel calculations based on field data

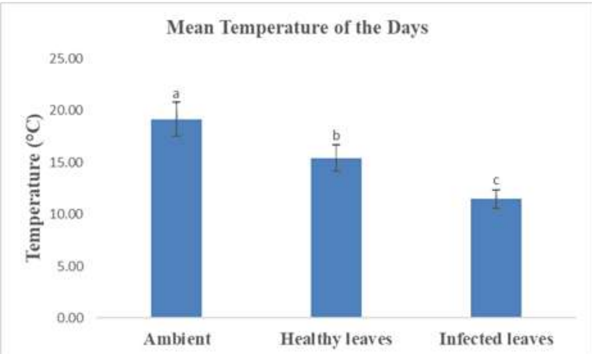

Fig. 2. Analysis of variance and Student's t test were performed with the mean of ambient, infected leaf surface and healthy leaf surface temperatures measured daily for three weeks (df: 2;66, F:8.6027, $P < 0.0001$).
Source: The author's JMP®7.0 program calculations based on field data.

According to statistics, the average weekly (over 21 days) ambient temperature is 19.17 °C, which is greater than the temperatures at the surfaces of infected and healthy leaves.

However, the mean temperature of diseased leaf surfaces (11.48 °C) is statistically lower than that of healthy leaf surfaces (15.44 °C) and ambient temperatures (Figure 2).

As illustrated in Figure 1, measurements taken between 5:00 and 16:00 in the Cucurbit production area revealed that the infected leaf surfaces were typically cooler than the healthy ones. Similarly in Photo 1, the temperature of completely infected leaf vary between 8.2 °C and 9.4 °C according to thermal imaging. However, the temperature values on the newly infected leaf were found to vary between 8.3 °C and 10.2 °C (Photo 2).

Photo 1. The lowest temperature value on the infected leaf was found to be 8.2 ^{0}C.
Source: Original thermal images taken by the authors from field

Photo 2. Temperature differences were seen on the leaf completely infected (Fig. 3.) by the disease and on the leaf where the symptoms of the infection are newly formed.
Source: Original thermal images taken by the authors from field

Cucurbit powdery mildew *S. fuliginea*, one of the most serious diseases of cucurbits, reduces the yield considerably [9]. Disease agents spread relatively quickly by wind, precipitation, and other means, especially in plant diseases. For this reason, early detection and timely control of plant diseases are of great importance [20]; [8]. Early control of diseases prevents the spread of the disease to the whole field and brings benefits such as less chemical use, less waste of time, and labor [10]; [3]. Thermal imaging methods are one of the most effective approaches for early detection. In response to infections produced by plant diseases, a temperature shift occurs in the part of the plant where the infection occurs compared to the region where the infection does not exist. These temperature changes are determined using thermal imaging methods [13]; [22]; [23].

Thermal imaging has already been used to detect certain plant diseases. Pineda et al. (2020) found that leaves infected with the tobacco mosaic virus had a significantly higher temperature increase compared to healthy leaves.

Zia-Khan et al. (2022) found a temperature differential of more than 3 °C between plant leaves contaminated with vineyard mildew and healthy plant leaves, with the temperature being greater in disease-infected plant leaves [23].

CONCLUSIONS

According to the findings of this study, the temperature of the powdery mildew-infected region ranges between 8.2 °C and 8.3 °C, while it ranges between 10.2 °C in healthy tissue. With this result, not only powdery mildew in cucurbits, but also numerous plant diseases, may be detected at an early stage without spreading to the entire field. Approaches such as the development of these approaches and their incorporation into other agricultural equipment will allow for early disease management. Thus, although the disease spreads from a specific location before spreading to the entire land, controlling it will need less manpower and chemical use. Thus, while the disease spreads from a certain area before it spreads to the whole land, it will provide less labor and chemical use by taking it under control.

ACKNOWLEDGEMENTS

We appreciate the technical assistance provided by undergraduate students.

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