THE DETERMINATION OF STRAWBERRY PLANT TEMPERATURE IN SPRING FROST CONDITIONS

V. Palge, M. Pennar

Estonian University of Life Sciences

ABSTRACT. *Measuring the surface temperature of the strawberry flower in spring frost conditions gives new information that helps to explain the damages caused by spring frost. The traditional way of measuring spring frost temperatures does not reflect the actual nature of the process. This paper presents data recorded during spring frost. We have measured air temperature in the traditional way of recording spring frost temperatures. We have also recorded the temperature of the strawberry flower – the part of the plant that is damaged by spring frost. Measurements were made at night in the spring of 2006. Measurements were made with IR thermometer UT-02S, temperature sensor TMCx-HA and data logger HOBO U12-006. The data was retrieved by the programme Greenline. 5 K to 9 K lower temperatures were observed on the surface of the flower and the air temperature sensor. –4.5 °C was the lowest temperature of flower surface that was recorded.*

Keywords: *strawberry, plant, spring, frost, temperature, measuring.*

Introduction

Every spring farmers make an issue of frost damages. Although Estonian horticultural scientists have been trying to establish temperature values causing spring frost damages for flowers of strawberries, the results have been very different. It has not been proved that a certain temperature will damage the flower.

For the engineers the situation is more abstract and point out two major drawbacks in the current research:

1) the temperature field is non-uniform;
2) the fixing of air temperature during spring frost does not reflect the real process and represents just the results.

The present research follows the theory of heat transfer. There have been fixed measuring sets for the measurements of spring frost or a similar situation.

Methods

According to the principles of heat transfer theory, there are three different types of heat transfer: conductivity, convection and radiation. The nature of the process is always different and at least one of those heat transfers is present. Most likely all three are involved and before the process reaches equilibrium, it will go through different stages. When the sky is clear and there is a very low level of water steam, then probably the most important type of heat transfer is radiation. In windy weather, there are very good conditions for convective heat transfer, *etc*. It is very complicated to describe the field situation because equilibrium is never reached due to the swiftly changing circumstances. In order to understand the process better, we must recall the following terms (Rohsenow, 1998): specific heat, heat capacity, thermal conductivity, heat transfer coefficient, emissivity, absorbtivity, body, participating in heat exchange process and its thermophysical properties, spectral transparency of atmosphere, equivalent temperature of surrounding bodies, spectral distribution of radiation, *etc*.

The present article is about strawberry plant temperature in the conditions of spring frost. Spring frost denotes a situation during windless spring nights when the sky is clear and there is very little vapour in the atmosphere. In order to model the process, we have to divide a strawberry plant into different parts, eg leaves, flowers, stems, crown, runners, *etc*. It is very important to follow the air temperature as reference for previous studies on this field. All previous studies have been made on the basis of measuring air temperature during spring frost.

It is common understanding that convective heat transfer is most damaging during spring frost nights. Actually the most important thing is radiation heat flow between plant parts and Space. After sunset when we practically miss the sun heat transfer by radiation, there will be an absolutely new equilibrium situation for all bodies. The rate of speed of cooling is up to the physical parameters of body, such as mass, heat capacity, water content and placement on land.

The temperature of air will be reduced as well, but not because of radiation. The air is transparent for radiation heat exchange. Due to air transparency the air temperature can reduce only due to convective heat exchange with bodies affected by radiation heat exchange. Theoretically it is possible to set the equation for heat exchange balance for different plant parts. But as the system of equations will be very complicated, we will not take to the task.

The measuring was carried out in a strawberry field. The strawberry field was established with black plastic mulch. The plants were planted into holes made in plastic. The measured plants had 7 leaves and 3 stems with flowers. The air temperature was measured with sensor TMCx-HA. The actual flower temperature was measured with IR thermometer UT-02S. All measurements were recorded by data logger HOBO U12-006. Data was measured and recorded once a minute. The measurement scheme is shown on Figure 1.

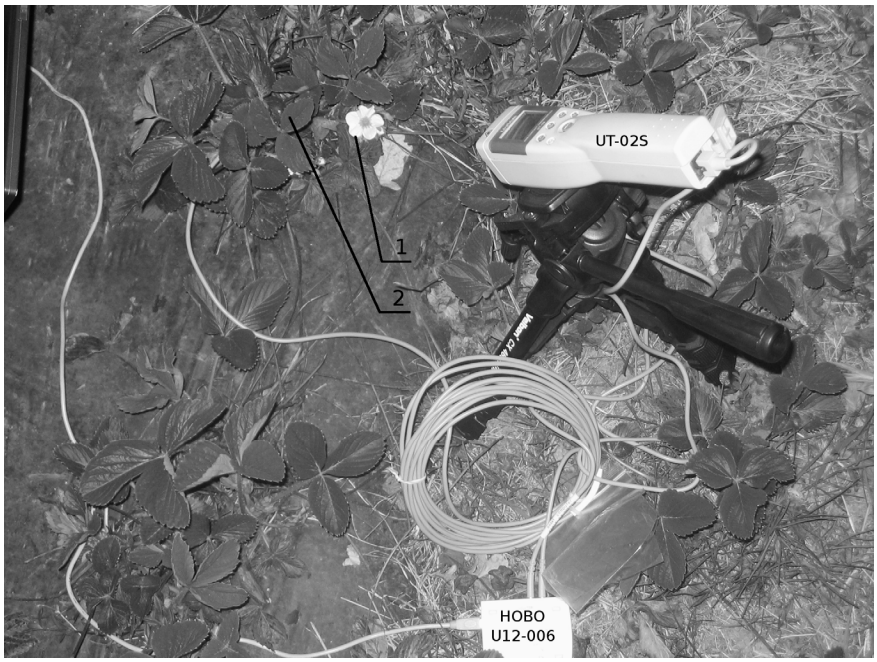

Figure 1. Measuring set for TMCx-HA measuring temperature under the leaf on spot No. 2, for UT-02S measuring temperature on surface of flower spot No. 1 and data logger HOBO U12-006

Data logger HOBO U12-006 (Onset, 2006a) together with temperature sensor TMCx-HA (onset, 2006b) will make a measuring set. Measuring range for sensor is –40…+100 °C. Accuracy of sensor is shown on Figure 2 (Onset 2006b). On the measuring range of this research the accuracy will stay 0.25 K.

There is plastic mulched strawberry plant row. Temperature sensor has been installed inside strawberry plant near crown 2 cm above black plastic mulch.

Data logger HOBO U12-006 has memory for 43000 records with accuracy 12 bits. Time slope for measuring frequency is from 1 second up to 1 hour. In this research results were recorded once a minute. Data transfer was controlled by program Greenline.

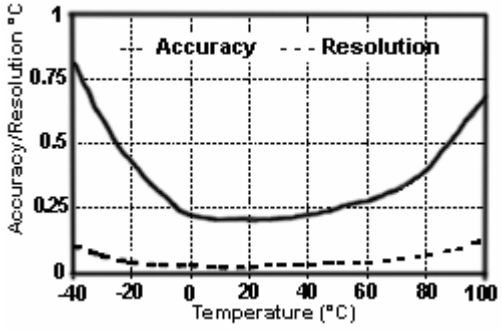

Figure 2. Temperature Accuracy and Resolution with U12 loggers

IR thermometer UT-02S (Tech-Jam, 2006) was used. Data logger HOBO U12-006 mentioned above recorded information issued by UT-02S. IR Thermometer is measuring intensity of heat radiation. IR thermometer is focused on strawberry flower. For that reason this device has got two laser beams to set the area we are measuring and in current research measuring device was installed 20 cm. IR Thermometer measuring range is –50…+500 °C. Currently the measuring range –10…+30 °C was established. Measurements were carried out on May 30, 2006 and there are 436 different measuring results.

Results

The results are presented in Figure 3. The interpretation of results shows that with clear sky and low transparency of atmosphere for radiation the temperature of strawberry flower is different in comparison with temperatures nearby. It is very important to emphasise that the sensor which is measuring the temperature below the leaf of strawberry near its crown, is really measuring the temperature of the sensor itself.

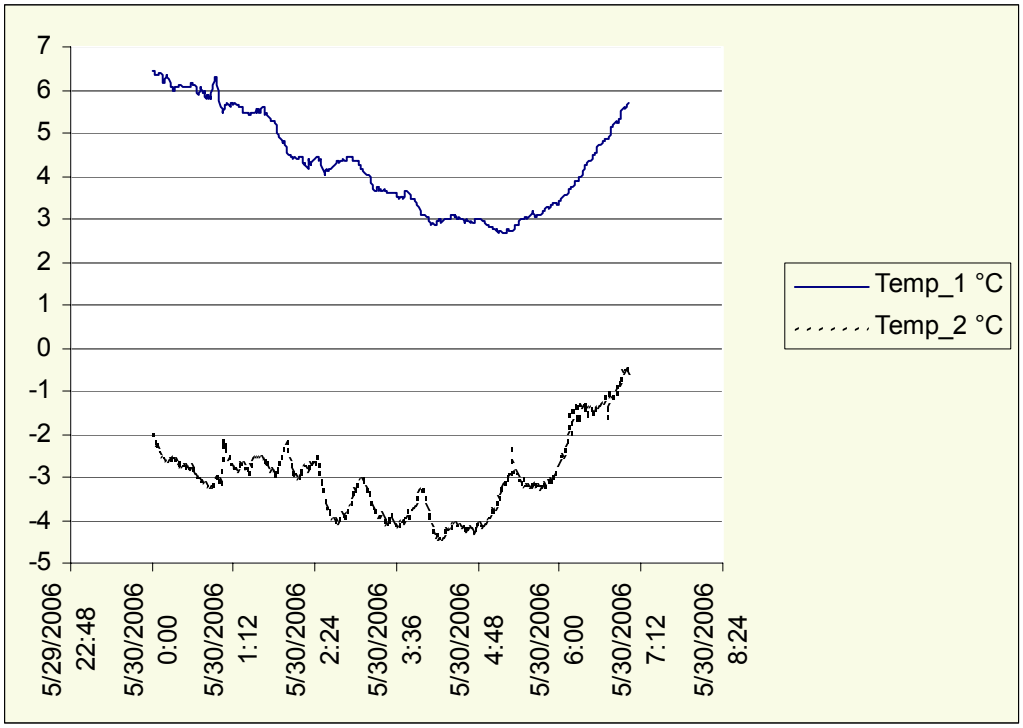

Figure 3. Results of measuring. Graph No. 1 – temperature under leaves by TMCx-HA, Graph No. 2 – temperature on flower

The temperature of the sensor is nearly the same as the temperature of air below the leaf but never exactly the same because the level of equilibrium is changing all the time. Different parts of plant have got also different temperatures because of different heat transfer conditions. According to results of measurements, the temperature of flower has been lower compared to the sensor temperature 5…9 K. The lowest temperature has been recorded –4.5 °C. Even if the temperatures have dropped below zero, we cannot be sure that this temperature has damaged the flower or it had happened a few weeks earlier. At sunrise the flower temperature started to rise immediately. Readings of air temperature by TMCx-HA under leaf started to rise after some time.

Conclusions

The interpretation of results shows that with clear sky and low transparency of atmosphere for radiation the temperature of strawberry flower differs from temperatures nearby.

The temperature of sensor is nearly the same as the temperature of air below the leaf but never exactly the same because the level of equilibrium changes all the time.

According to measuring results, the temperature of a flower has been lower, compared to sensor temperature 5…9 K. The lowest temperature has been recorded –4.5 °C.

Even if the temperatures have dropped below zero, we cannot be sure that this temperature has damaged the flower or it has happened a few weeks earlier.

At sunrise, the flower temperature started to rise immediately. Temperature of TMCx-HA started to rise after some time.

References

Rohsenow, W. M. 1998. Handbook of Heat Transfer. Eds. W. M. Rohsenow, J. P. Hartnett, Y. I. Cho – 3rd ed. McGraw-Hill, 1506 pp.

Onset, 2006a. http://www.onsetcomp.com/Products/Product_Pages/hobo_u12_loggers/U12_family_data_loggers.html, juuli 2006.

Onset, 2006b. http://www.onsetcomp.com/Products/Product_Pages/HOBO_H08/external_sensors.html, juuli 2006.

Tech-Jam, 2006. http://www.tech-jam.com/items/ut-02s.phtml, juuli 2006.