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Minimum Temperatures above Different Surfaces in Strawberry Cultivation

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Abstract

The paper focuses on the evaluation of temperature data from close-to-ground readings above different surfaces used in cultivation of strawberries (open soil, straw mulch, mulching cloth), with grass as a standard surface used in meteorological readings. It is apparent that straw mulch significantly limits inputs and outputs of heat to and from soil, and therefore, under specific weather conditions, temperatures above straw are lower than above other surfaces. These variations are the highest in spring months when low temperatures at ground level are common, and if straw is layered too early it may lead to an increased risk of frost damage to strawberry buds and flowers.

Key words: frost, strawberry, mulch, ground temperature

Introduction

Growing of strawberries has a hundreds of years old tradition in our climatic zone. To protect the ripening fruit from moist soil and consequent fungal diseases, the traditional method has always been to cover the beds with straw (Fig. 1). This also reflects in the English name of the fruit, which refers to straw directly. In the past few years there have been numerous cases of early onset of vegetation upon which the buds, flowers or fruitlets were damaged by ground frost. Greater damage was observed in those parts of plantations where straw was already piled up in between the beds; less severe damage or no damage occurred where the straw was not laid yet. As the information on the influence of different types of mulch on ground temperatures is very sparse, we decided to set up an experiment aimed at studying

the differences between minimum temperatures above various surfaces used in strawberry cultivation.

Plíšek, 2002, Dušková and Kopřiva, 2005 state different possibilities of using mulching materials in strawberry production. The most commonly used materials include black PVC, unwoven and woven mulching cloths, biodegradable foils, straw, wood shavings, organic waste mixes (wood chips, peat, sawdust) or mowed grass. Each of the materials has its pros and cons. The colour of the mulching material significantly influences the permeability of photosynthetically active radiation, and therefore the development of weeds. Good warming of the soil and weed control is ensured if brown and green mulch is used, while blue and reddish brown foils are used to cover the soil (Johnson and Fennimore, 2005). Black unwoven or black woven cloths absorb sunlight and accelerate ripening (Matuškovič, 2004, Sing et al. 2007). The disadvantage is a risk of higher frost damage to early-flowering varieties and overheating in summer. Another option could be the use of blue and white foil for postponing harvest (Pokorný, 2006). Kasperbauer and Loughrin (2002) expressed a hypothesis that red colour or mulch influences the FR/R ratio – phytochrome activity – which leads to increased allocation of assimilates in the strawberry fruit and consequent improving of quantitative (size, weight) and qualitative (aroma, content of organic acids and sugars) parameters of the fruit. Kikas and Luik (2002) proved a positive influence of organic mulch (straw, wood pulp) and black foil, which both supported the occurrence of beneficial insects.

The effect of mulch, either made of plant material or foil, influences temperature and humidity in the soil underneath. As Andrade et al (2010) say, a layer of straw on soil surface, with its heat-insulating properties, reduces the average temperature of soil underneath and the temperature amplitudes. In night hours it reduces heat loss through longwave radiation and during the day the soil is protected from direct sunlight, which reduces the heat input.

Mulch layer contributes to reducing evaporation from the surface of open soil. The research of Taparauskiemé and Miseckaité (2014) showed that humidity of top soil layer is higher under straw mulch than under exposed soil. It is therefore assumed that straw mulch, insulating plants above it from heat longwave heat input from the soil, would have a greater influence on reducing temperature of objects present in this layer compared to other surfaces, which do not protect from the soil heat output

so effectively. Besides straw, strawberry cultivation practice uses various foils and mulching textiles, therefore our experiment focused on minimum temperatures above black woven mulching cloth. Practical meteorology uses shortly-mown lawn as a standard surface for measuring ground temperature, which is why we also included this type of surface in the comparative measuring.

Fig. 1 Straw layering still belongs to traditional technologies of strawberry cultivation in our environment

Materials and methods

The experiment took place between May 2013 and May 2014 at the premises of Mendeleum, Faculty of Horticulture of Mendel University, Lednice. Surfaces with grass, open soil, wheat straw mulch and black woven mulching cloth were prepared and maintained within a relatively small distance of several metres. Temperature sensor (DS18B20, Dallas Semiconductor) in copper nickel-coated casing on a special stand was placed 5 cm above each of these surfaces (Fig 2), in accordance with ČHMÚ regulations (Žídek, Lipina 2003). Thermometers are not protected by any

radiation cover, which aims to ensure the resulting energy balance, influencing their temperature, which should be approximately the same as on the surface of the surrounding plants. Data provided by a thermometer installed in this way represents not only the ambient air temperature, but also the effect of longwave radiation balance, and of heat loss through evaporation in case of dew, or its gain from condensation of vapour on the thermometer's surface. The readings from thermometers were recorded in regular 15-minute intervals using Meteo-UNI datalogger (AMET, Velké Bílovice). The lowest values for each day (0 – 24 hours) were selected from the measured data, and were further evaluated using standard statistic methods presented below.

Fig. 2 Position of sensors above the different surfaces

Results and discussion

Fig. 3 captures the differences between minimum temperatures above open soil and three other alternatives. It is clear that lower minimum temperatures occur throughout

the entire monitored period above straw-covered surface than above open soil. Differences are smaller above cloth: both negative (i.e. lower temperature above cloth than above open soil) and positive (higher temperature above cloth surface). The grass patch yielded similar results – differences are both positive and negative.

This is clearly visible on the curves of variation excess for individual surfaces on Fig. 4, which shows that in 90 % of cases the temperatures above straw-mulched surface were lower than above bare soil; the two other alternatives show almost zero inclination. In 10 % of the cases a temperature lower by more than 1.8°C can be expected above straw than above open soil, while in the same number of cases it is only by more than 0.7°C lower above grass and cloth.

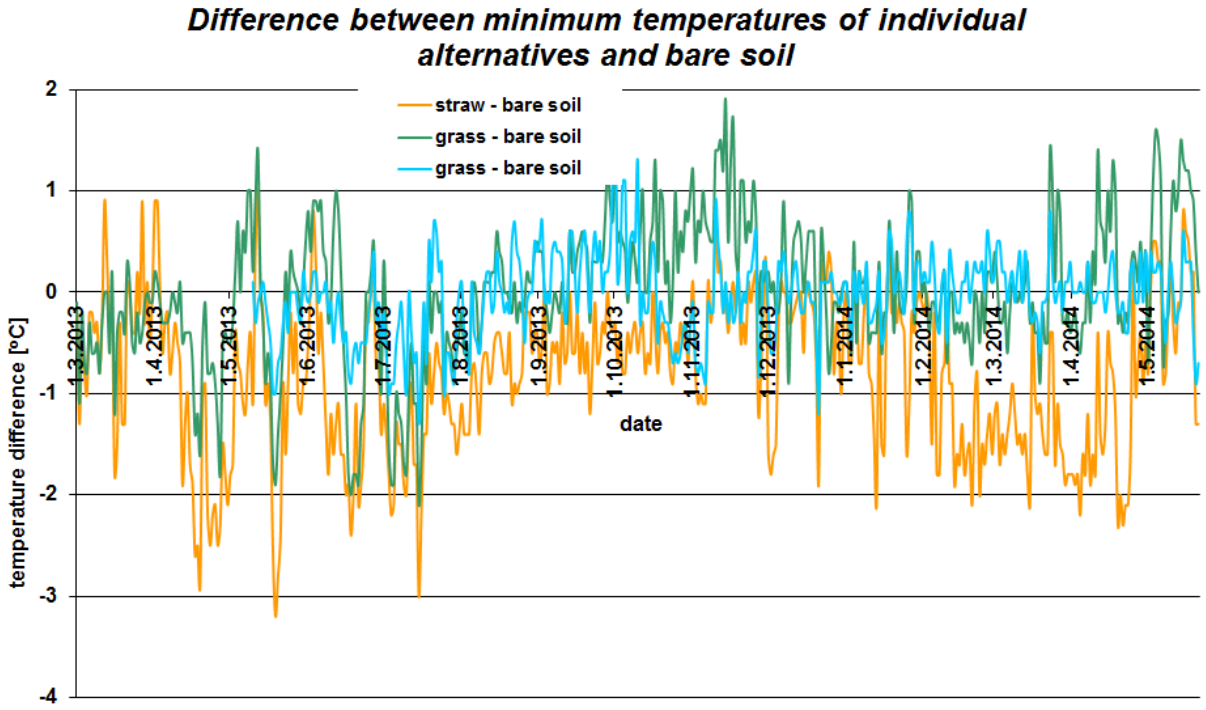

Fig. 3 Difference between minimum temperatures of individual alternatives and bare soil

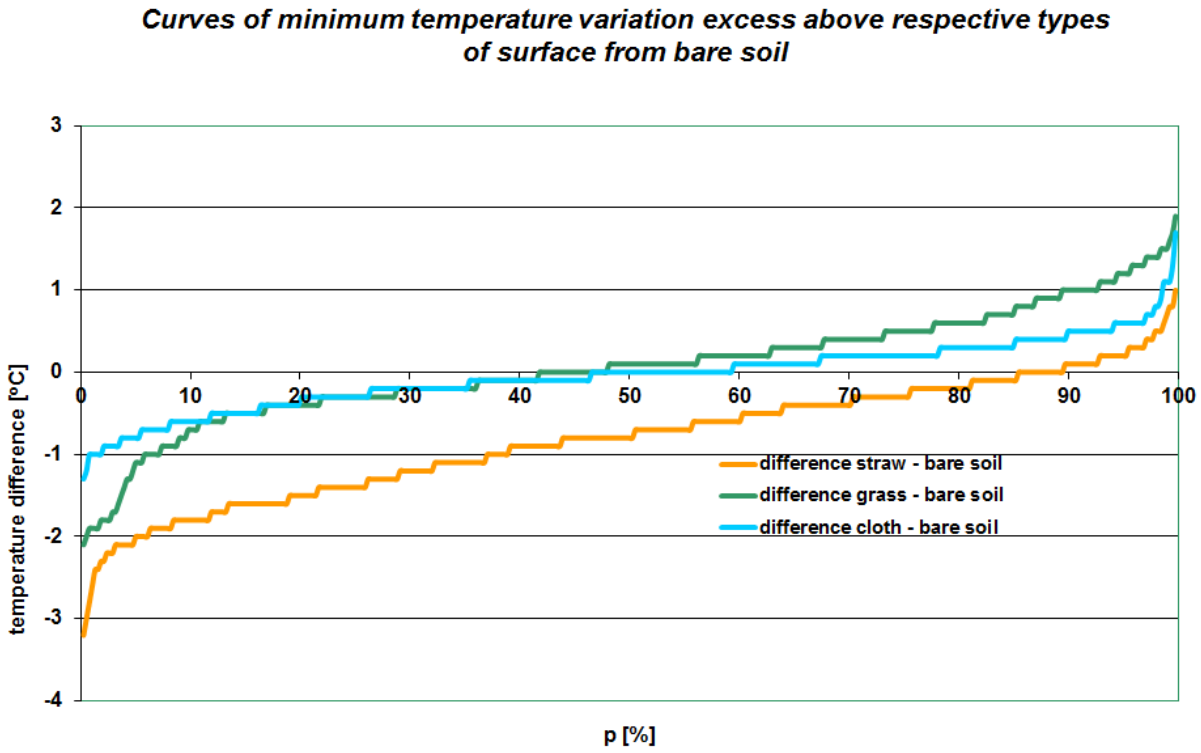

Fig. 4 Curves of minimum temperature variation excess above respective types of surface from bare soil

Fig. 3 suggests that minimum temperature variations do not remain the same throughout the year; their year-round progress can be seen on Fig. 5, which shows average monthly negative variations of the individual alternatives. In case of straw it is clear that negative variations occur practically throughout the entire first half of the year from February to July, while towards the autumn months they gradually drop, achieving their minimum in October and November. The grass patch showed maximum negative variations in June and flat minimum in the autumn months, which is probably related to the growth of the grass patch. The lowest negative variations were noted with the cloth – these temperatures peak in July.

For potential frost damage to strawberry plants the ground temperatures in spring are crucial, especially in April and May. The lowest temperatures in these months were recorded above straw mulch, approximately by 1.0 – 1.4°C lower than above open soil. Use of woven mulching cloth leads to substantial reduction of these variations, on average to 0.2 – 0.4°C.

An example of typical course of temperatures in a period of negative energy balance with radiation weather regime is shown on Fig. 6, documenting the course of

temperatures in 5 cm above the respective surfaces. A relatively fast drop of temperature above straw occurred shortly after sunset, while above other surfaces it decreased more slowly. This difference was maintained until dawn, but while above straw the temperatures reached negative values after midnight, they stayed above freezing point above the remaining surfaces. This proves the insulation capability of straw, which reduces heat penetration into the soil during the day, and at night it prevents heat loss through longwave radiation.

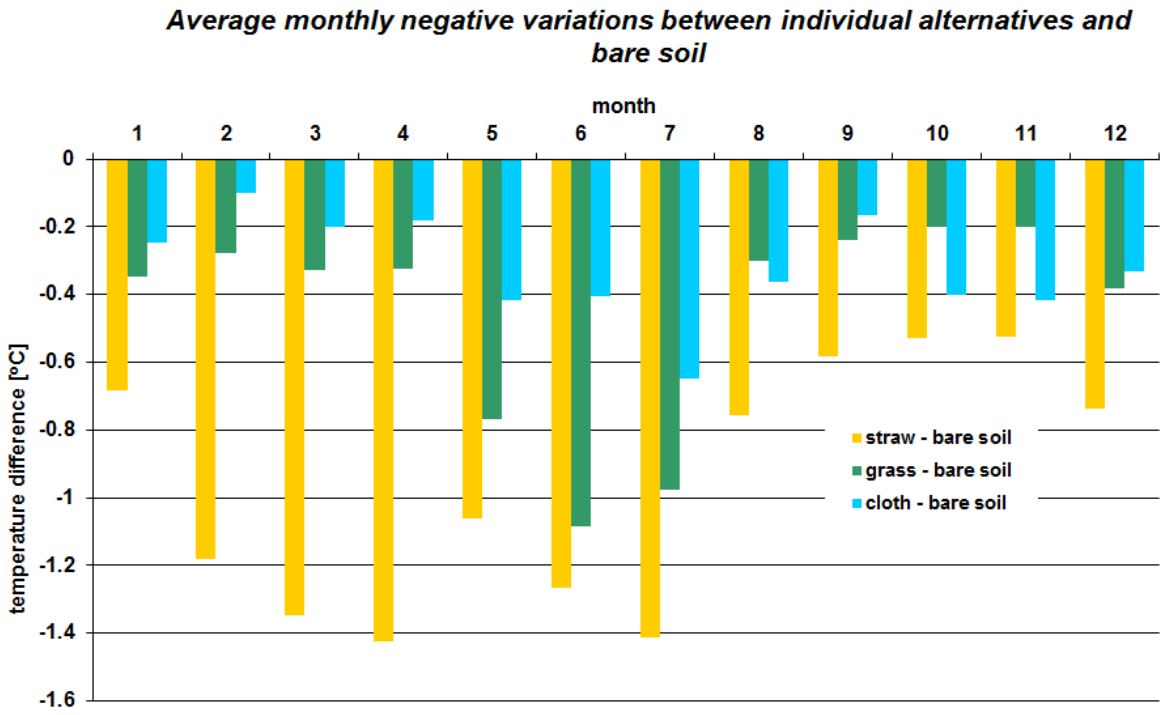

Fig. 5 Average monthly negative variations between individual alternatives and bare soil

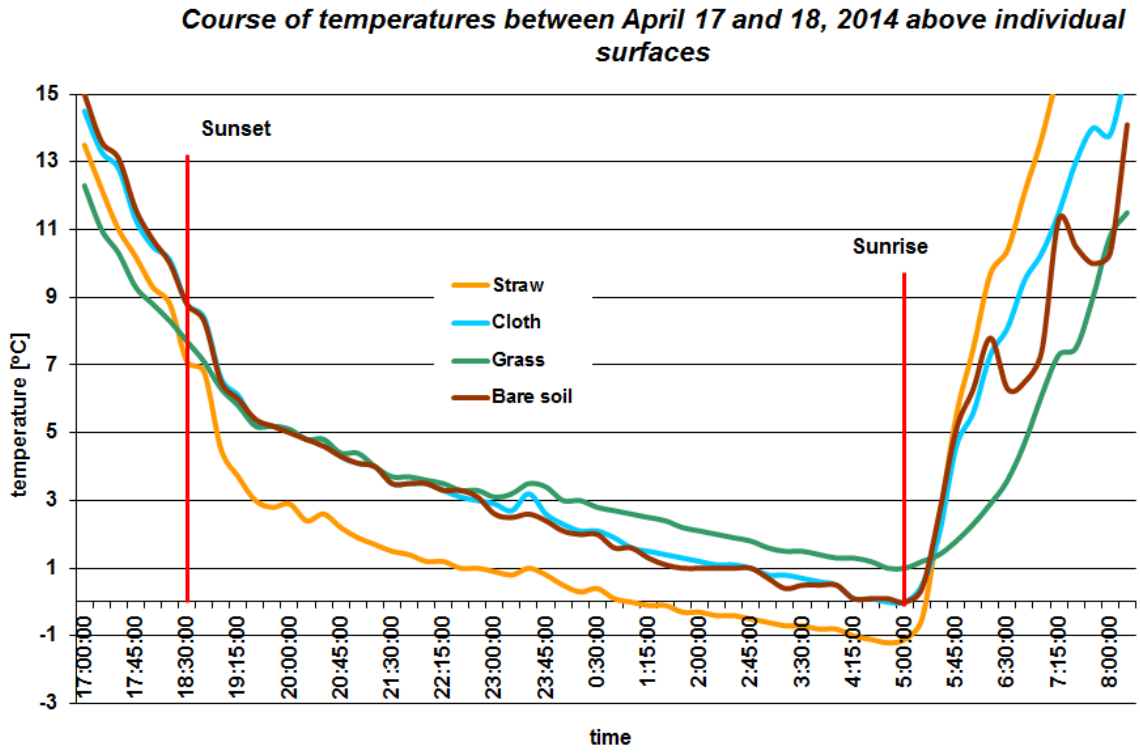

Fig. 6 Course of temperatures between April 17 and 18, 2014 above individual surfaces

Conclusion

The presented analysis shows a significant effect of the straw mulch on the minimum temperatures 5 cm above its surface. In extreme cases the differences may reach up to 3°C compared to bare soil. At nights with radiation regime of weather and in temperatures near the freezing point, plants above straw are much more prone to freezing than above tested surfaces. It was noted that the temperature difference occurs shortly after sunset, and that lower temperatures persist until sunrise. Temperatures are slightly higher above the cloth, and the difference from open soil is not as high as with straw. In some cases, higher minima were recorded above cloth than above open soil, but the difference is not a great one and in most cases it represents just several decimal points of Celsius, especially in the critical spring period.

The conclusion for growers of strawberries: if applying straw mulch, you can wait until the risk of ground frost has passed, i.e. until the second half of May. If applying mulching cloth, the probability of frost damage is the same as above open soil.

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Summary

Příspěvek se zabývá vyhodnocením naměřených přízemních teplot nad různými povrchy, vyskytujícími se při pěstování jahod (holá půda, slámový mulč a textilie), travní porost byl zvolen jako standardní povrch používaný v našich podmínkách při meteorologických měřeních. Ukazuje se, že slámový mulč výrazně omezuje toky tepla do a z půdy a proto i teploty nad ním jsou za příhodných povětrnostních podmínek nižší než nad ostatními povrchy. Tyto odchylky jsou největší v jarních měsících, kdy se ještě vyskytují nízké přízemní teploty a v případě předčasného nastlání slámy se zvyšuje riziko mrazového poškození květů.

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