Dependence of leaf area surface and leaf number of apple trees on the sum of temperatures: utilization for protection against apple scab

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Abstract

Scanning of the leaves of four apple cultivars at weekly intervals during the 2012 growing season made it possible to calculate their surface area. The calculation of the surface area of scanned leaves revealed that the leaf area surface is determined by the multiple of the leaf width and leaf length, which is then multiplied by the factor 0.71. Measurement of the leaf width and the leaf length on annual shoots in the years 2013 and 2014 at weekly intervals during the growing season made it possible to calculate the leaf surface using a non-destructive method. Monitoring of the number of leaves and measurement of the leaf area of four apple cultivars, 'Idared', 'Golden Delicious', 'Melrose' and 'Rubín', during the growing season showed that the change in the leaf area surface has a very close algorithmic relationship to the ambient temperature condition characterized by the daily sum of effective temperatures above 5°C.

Keywords: surface measurement, leaf growth, non-destructive method, *Venturia inaequalis,* growing season

INTRODUCTION

Development of apple scab (*Venturia inaequalis*) is closely linked with the phenological development of the host plant. The critical period in terms of fungicidal protection occurs at strong infection in the intensive growth of leaves, which are very sensitive to the penetration of the pathogen into their tissues. The risk of infection depends on the growth of apple leaf area (Carisse et al., 2008). Currently, most programs deal with signalizing to protect against scab focused on the pathogen – i.e. the amount of ascospores released in certain weather conditions and the intensity of possible infection. Alternatively the protection of newly developed leaves by a suitable device is using a type of protection oriented to the host. In this case it uses the information on the quantity of released ascospores and intensity of infection, but also the amount of newly formed exposed leaf surface. There is little information about the influence of weather conditions on the development of apples leaves, and even less for the climatic conditions of the Czech Republic.

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MATERIALS AND METHODS

In year 2012 approximately 200 samples (leaves on rosettes and leaves on annual shoots from each cultivar) of four apple cultivars 'Idared, 'Golden Delicious', 'Melrose' and 'Rubín' were collected in weekly intervals during the growing season - from April 23th till July 9th - and subsequently scanned. In the years 2013 and 2014 measurement of the width and length of leaves was also performed in weekly intervals. Leaves on 20 rosettes and 20 annual shoots from each cultivar were monitored twice a week on leaf rosettes and at weekly intervals on annual shoots during the growing season, each year on five trees in randomized blocks. Leaves emergence was monitored on cultivars grafted on M9 rootstocks with a planting distance 4.5×2 m in the experimental orchard in Breeding and Research Institute of Pomology Ltd. located in Holovousy (Czech Republic, Eastern Bohemia, average altitude 305 m above sea level, average temperature 8.1 °C and annual rainfall 655 mm). Extensive observational material contained several thousand of measurements from leafs sprouting to July period whereas the further enlargement of leaf area and increase of their number were not recorded.

RESULTS AND DISCUSSION

The assessment was focused on tracking of the dependence between the number of leaves, their individual area and the climatic conditions.

Observation in the year 2012

Approximately 200 leave samples (leaves on rosettes and leaves on annual shoots) of four apple cultivars 'Idared', 'Golden Delicious', 'Melrose' and 'Rubín' were collected in weekly intervals and subsequently scanned. By a calculation of the width and length based on leaves scanning we verified that the leaf area surface is determined by the multiple of the width and length of the leaves that is subsequently multiplied by the factor 0.71 (R^2=0.99). Results are in agreement with observation of Eftekhari et al. (2011) and Silva et al. (2004) (Figure 1).

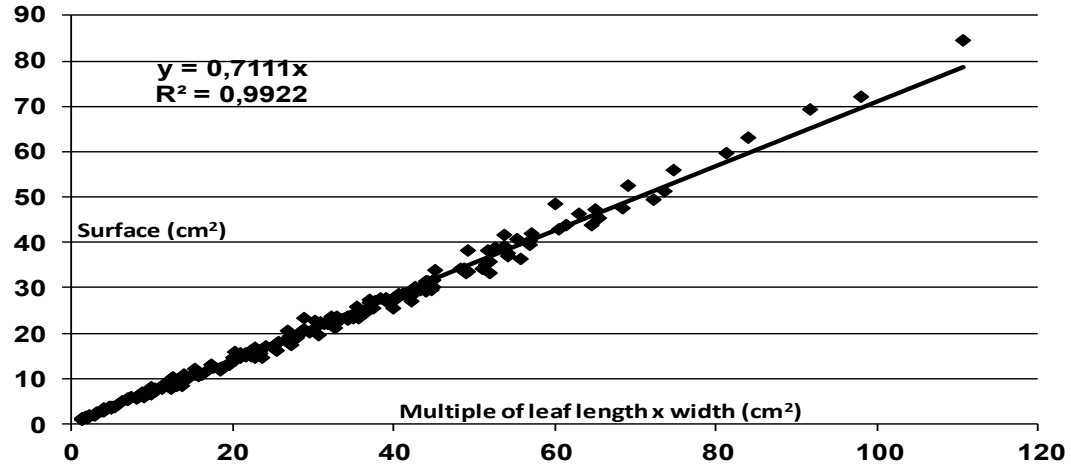

Figure 1. Relationship between multiple of the leaf length and the leaf width and its surface

Observation in years 2013 and 2014

Measurements of the leave number and leaf area on leaf rosettes and on annual shoots on all four varieties ('Idared', 'Golden Delicious', 'Melrose' and 'Rubín') continued in the years 2013 and 2014 by non-destructive methods recording leaves length and leaves width during the growing season. The results of the measurements show the dependence of the increase in the average area of individual leaves and number of leaves on the daily sum of effective temperatures above 5 °C (SETd5), also used by Carisse et al. (2008). Relationship between the number of leaves, leave surface and daily sum effective temperatures above 5 °C (SETd5) showed close logarithmic connection. The rate of change in apple leaf emergence in response to degree-days (SETd5) was nonlinear (Figure 2, Figure 3) with an initial phase followed by a linear response (Figure 4, Figure 5) reaching a maximum after which the rate remained low or reached zero (no more new leaves). Similar results were recorded by Carisse et al. (2008).

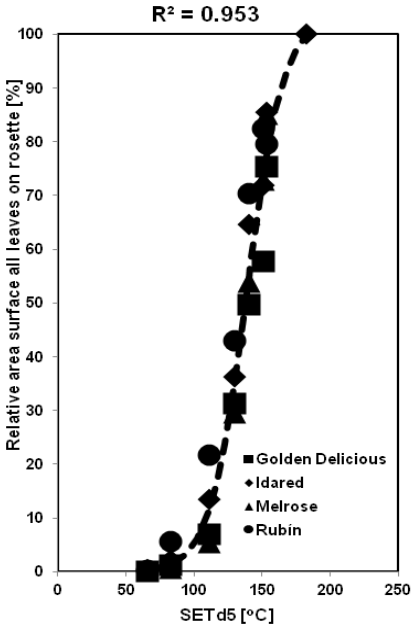

Figure 2. Relative dependence of the leaves area surface of rosettes on SETd5 (in % of the final)

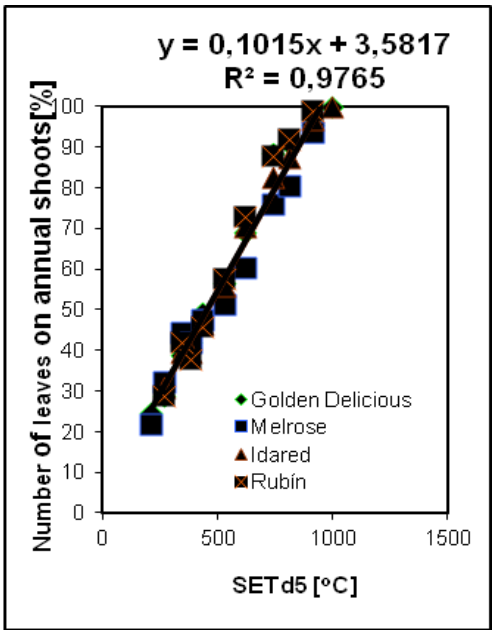

Figure 3. Relative dependence of the area surface on annual shoots on SETd5 (in % of the final)

The measurements made from 2012 till 2014 on four cultivars of apple trees confirmed that the size of the area of each leaf can be detect by non-destructive and time-saving method.

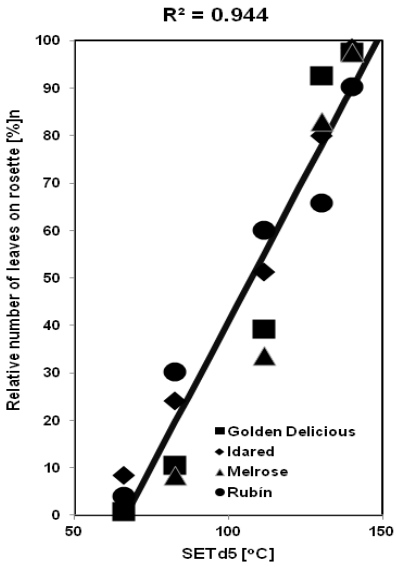

Figure 4. Relative dependence of the leaves number on rosettes on SETd5 (in % of the final)

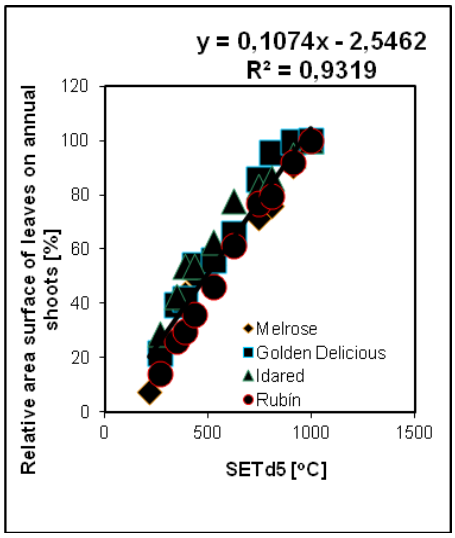

Figure 5. Relative dependence of the number of leaves on annual shoots on SETd5 (in % of the final)

CONCLUSIONS

The results of measurements show the dependence of the increase in the average surface area of individual leaves and number of leaves on the daily sum of effective temperatures above 5 °C (SETd5). Obtained results led to the introduction of a simple web application that allows apple growers determine the relative changes in the area leaves surface between two dates, e.g. between the last application against apple scab the next application based on data from a nearby weather station (http://www.amet.cz/listy.htm). This new tool can be used to improve timing of fungicide applications against primary apple scab infections.

ACKNOWLEDGEMENTS

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