A COMPARISON OF VINEYARDS SOIL TEMPERATURES IN SOUTHERN FINLAND AND ESTONIA

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Abstract

In recent decades, the cultivation of grapevines for wine production has been undertaken in Scandinavia and in the Baltic countries. This study measured vineyard soil temperatures in Southern Finland (Tuusula) and Estonia (Räpina) throughout the year. During the coldest months of January, February and March, soil temperatures at depths of 25 cm and 45 cm were 0 °C or higher in both localities, so the roots of the vines did not freeze. In April, in Tuusula, the mean temperature of the soil was significantly lower than in Räpina ($P < 0.001$). This difference grew smaller during the growing season, but remained in Tuusula significantly lower than in Räpina ($P < 0.001$). The Estonian locality Räpina fits the warmer 'frigid' temperature regime, and the southern Finnish locality Tuusula is cryic. However, it did not prevent grapevines from survival from winter, nor the cultivation of grapevines using suitable varieties in these regions.

Introduction

The outdoor cultivation of grapevines is expanding northwards. Its success depends on the temperature of the climate, the length of the growing season, and the temperature of the soil. The length of the growing season is affected by the climate, air temperature, soil quality, and soil temperature. The soil grows warm earlier at about the same altitude, as one moves to south and west. This has been confirmed in studies by Värnik (2001) and Koivisto (2005).

Air and soil temperatures are highly interdependent. Mokma, Sprecher (1995) found that the mean annual soil temperature is 1 °C higher than the air mean for the year. As with climate, soils are classified into different categories. According to the U.S. Soil Taxonomy system (1999) and Yli-Halla, Mokma (1998), Finnish mineral agricultural soil belongs primarily to the cryic temperature regime (mean annual soil temperature 0–8 °C, mean summer soil temperature below 15 °C). The land is suitable for agricultural production, but its coldness limits the cultivation of crops such as corn and grapevine.

Yli-Halla (2001) considered whether the southernmost Finnish farmland belongs to the cryic or frigid regime and deduced, by comparing Swedish and Finnish crop yields, that it belongs within the cryic regime. Due to the the climate change in the Baltic Sea Region (Zorida 2012), the southernmost area of the Finnish cryic regime might belong currently to the frigid temperature regime.

The aim of this study was to investigate the extent to which vineyard soil temperatures in Southern Finland (Tuusula), Estonia (Pärnu) differ from each other when measured at the same time, and to draw conclusions on whether the southernmost Finnish farmland still belongs to the cryic temperature regime.

Materials and methods

Soil temperatures were recorded using waterproof temperature and humidity loggers *(Thermo Button 21G, Proges-Plus, France)* at the same time in Tuusula and Räpina from 1 December 2009 to 30 November 2010. The loggers measured soil temperatures at one minute intervals at depths of 25 cm and 45 cm, which they recorded to memory, from which the data were transferred for analysis. Mean soil temperatures ($\overline{X}$) and standard deviations (± SD) were calculated using an Excel spreadsheet. Two tailed TTEST (Student´s t-test) were used to estimate statistical significance ($P < 0.05$). n = number of samples.

Table 1. Research locations

Community	Country	Location latitudes and altitudes	Above sea level (m)	Distance to Tuusula
Tuusula	Finland	N 60° 24', E 25°01'	63	0
Räpina	Estonia	N 58° 05', E 27°27'	41	230

Results

At Tuusula and Räpina, soil temperatures at a depth of 25 cm remained at or above zero all winter. At this depth, ground temperatures at the locations, in degrees Celsius, differed only slightly from January until March, but the differences were statistically significant ($P < 0.001$). From April to August mean temperatures at 25 cm at Tuusula were 0.2 – 3.5°C lower than mean soil temperatures at Räpina. This difference was greatest 3.5°C in April. In both localities, the lowest soil temperatures were recorded in February or March.

Table 2. Vineyard soil temperature changes at a depth of 25 cm

Month	Tuusula		Räpina		Tuusula><Räpina	
	°C	n	°C	n	t	P
December	1.6±0.9	124	1.5±1.7	124	0.058	>0.05
January	0.5±0.0	124	0.0±0.0	124	-	-
February	0.3±0.2	112	0.0±0.0	112	15.873	<0.001
March	0.2±0.3	124	0.0±0.0	124	7.722	<0.001
April	1.7±1.7	120	5.2±2.2	120	13.834	<0.001
May	9.8±3.1	124	12.9±3.4	124	10.432	<0.001
June	13.2±0.9	120	15.6±0.9	120	20.690	<0.001
July	18.7±1.5	124	20.6±1.5	124	10.000	<0.001
August	17.5±2.0	124	19.0±2.3	124	5.494	<0.001
September	12.1±1.2	120	12.6±1.1	120	0.415	>0.05
October	6.1±1.8	124	6.2±1.7	124	0.450	>0.05
November	4.1±1.4	103	4.7±0.9	83	3.550	<0.001
Mean	7.2±6.8	1463	8.2±7.5	1463	3.788	<0.001

From September to November, the soil temperature differences between the localities decreased, but the mean soil temperature at Tuusula was still lower than at Räpina (2 table). At Tuusula and Räpina, mean soil temperatures in the summer months (June, July and August) were at a depth of 25 cm 0.2 – 1.3°C higher, and in the winter months of January, February and March 0.2 – 1.4°C lower than at 45 cm (2, 3 tables). At Tuusula these soil temperatures of winter months were significantly lower than at Räpina ($P < 0.001$).

The soil temperature was maintained throughout the winter at zero degrees Celsius or above at depths of 25 cm and 45 cm (2, 3 tables). On this basis, soil temperature does not restrict the cultivation of suitable grapevine varieties in these areas. However, the quite short

growing season and late spring has meant that not all European grapevines can be made productive using outdoor cultivation. Earlier Gustafsson, Mårtensson (2005) have made the same conclusions in their review article.

Table 3. Vineyard soil temperature changes at a depth of 45 cm

	Tuusula		Räpina		Tuusula><Räpina	
Month	°C	n	°C	n	t	P
December	1.6±0.9	124	1.5±1.7	124	0.058	>0.05
January	0.5±0.0	124	0.0±0.0	124	-	-
February	0.3±0.2	112	0.0±0.0	112	15.873	<0.001
March	0.2±0.3	124	0.0±0.0	124	7.722	<0.001
April	1.7±1.7	120	5.2±2.2	120	13.834	<0.001
May	9.8±3.1	124	12.9±3.4	124	10.432	<0.001
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September	12.1±1.2	120	12.6±1.1	120	0.415	>0.05
October	6.1±1.8	124	6.2±1.7	124	0.450	>0.05
November	4.1±1.4	103	4.7±0.9	83	3.550	<0.001
Mean	7.4±6.3	1460	8.8±6.9	1463	5.737	<0.001

In Southern Finland, planting depths of 40 – 45 cm can be considered safe for grapevines in normal winters. In addition, a thick layer of snow reduces the danger of frost damage to the vines (Zhang, Ping, Wang, Sun, Wang 2007) and (Karvonen 2013). At this depth, the ground temperature in April is already so high (5 – 7°C) that the liquid circulation of the grapevines begins, at Räpina, at latest in the first half of the month and at Tuusula in the second half of the month. The annual mean value of soil temperatures at Tuusula, at a depth of 45 cm, was 1.4°C lower than at Räpina ($P < 0.001$) (3 table). The north-south distance between the localities was 230 km (2.2° of latitude).

Conclusions

It can be concluded that the soil temperature at Tuusula still fits the cryic temperature regime while Räpina fits the warmer frigid temperature regime. Some areas of the southernmost Finland might be frigid. The success of the grapevine is affected, not only by the north-south or east-west geographical situation of the growth location, but also by the thermal conditions of the soil and the local micro climate.

Acknowledgements

I thank viticulturists Jaan Kivistik and Raimo Saar (Estonia) for soil temperature measurements, and MSc Jyrki Ollikainen of the School of Information Sciences of the University of Tampere for his helpful comments on the statistical treatment of the results

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Gauta: 2015 m. kovo mėn. 13 d.
Gauta recenzija: 2015 m. kovo mėn. 23 d.
Priimta: 2015 m. balandžio mėn. 4 d.

Received: March 13, 2015.
Revision received: March 23, 2015.
Accepted: April 4, 2015.