2015 BRNO - CZ

XXII ENOMETRICS CONFERENCE

Climate Change and Grapevine Growing in the Southernmost Finland

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Abstract

According to the scenarios estimating climate change, the annual mean air temperatures could rise from the current by 3°C to 4°C in the Helsinki area, and the growing season will become 30 to 40 days longer by the year 2100. The purpose of this study was to establish how much the annual mean air temperature between the years 2005 to 2014 have risen in the Helsinki area and how much the growing season has been extended in comparison to the mean in the years from 1971 to 2000. In addition, the air temperatures from May to October, grapevine growth and soil temperatures from late May to early June in 2014 were compared between the Helsinki area and Central European grapevine growing areas (Herrlisheim-prés-Colmar, Freyburg-Saale, and Neubrandenburg).

In the Helsinki region, the annual mean air temperature has risen by 1.1°C, and growing season has extended by 27 days between the years 2005 and 2014, as compared to the 1971 to 2000 levels. The mean air temperature in the Helsinki region was significantly lower in May, June, September and October of 2014 than in the comparison regions ($p<0.05$), but during July and August, there were no significant differences ($p>0.05$). Soil temperatures in the Helsinki region between 25 May and 3 June were lower by 3.4°C at a depth of 20 cm, and 4.6 °C at a depth of 40 cm than they were in Herrlisheim, and 1.8°C to 1.2°C and 0.9 to 0.6°C lower than those in Freyburg and Neubrandenburg, respectively. The grapevine growth stage (Eichhorn-Lorenz 17) in the Helsinki region on 4 June was equal to that of Herrlisheim's on 26 May.

The result indicates that over the past ten-year period, the climatic temperature and the length of the growing season during the summer months in the southernmost Finland have moved closer to the climate and growing season of Central Europe, and thanks to this, it is possible to grow a harvestable grapevine in the southernmost regions of Finland. Moreover, if according to the scenarios spring will arrive earlier and winters become milder, this will provide more and more opportunities for grapevine growing.

Key words : climate change, air temperature, Nordic grapevine growing

JEL-Code : Agricultural and Natural Resource Economics

Introduction

During the past 100 years, the annual mean air temperature in the southernmost parts of Finland (60°N; 24°E) has risen by 1°C (Tietäväinen, Tuomenvirta and Venäläinen 2010). The current ever-increasing usage of fossil fuels has increased the global carbon dioxide concentration which has accelerated global warming together with the increase in the water vapour concentration in the air caused by this warming (IPCC 2007). According to the Rosby Centre's regional climate model, these greenhouse gases are predicted to raise the mean yearly temperatures of the Northern European climate by +4°C by the year 2100. This increases in temperatures at its greatest during the winter months in particular (Samuelsson, Jones, Willen, Ullerstig, Gollvik, Hansson, Jansson, Kjellsröm, Nikulin and Wyser 2011).

In Finland, a warming of the climate has been detectable since the years 1971 - 2000 as an increase in the annual mean air temperatures and an extension of growing season (Finnish Meteorological Institute 2010). At the same time, there has been a significant increase in temperature sums of growing degree days +5°C and +10°C (Karvonen 2014). This has introduced to the southern regions of Finland and the other Nordic countries some new cultivated plant species for experimentation, such as corn and grapevine. In these regions, interest towards wine growing has increased year by year. Sweden and Denmark are already listed as EU wine-producing countries, and in Finland will also become a wine-producing country in the coming years.

The purpose of this study was to examine how much the climate and grapevine growing conditions, start of growth, and harvest ripening in Helsinki region differ from the growing conditions and growth cycle in Central Europe at the present time.

Material and methods

The study was undertaken in three locations in Central and in one location in Northern Europe (Table 1). It studied the changes in the climatic temperature and growing season length in the Helsinki region over the past 15 years. In addition, a comparison was made of the air and soil temperatures in the Helsinki region from May to October with the temperatures of the three Central European areas, and the development of grapevine sprouts and blossoms was observed in these areas based on phenological observations (12 leaves separated, inflorescence well developed, single flowers separated; E-L number 17) (Eichhorn and Lorenz 1977), and harvest maturing was observed by measuring total grape sugar concentrations.

Table 1: Observation Locations and Grape Varieties

Community	Country	Location	Above sea level m	Distance to Herrlishein-prés-Colmar km	Grape variety
Herlisheim-prés-Colmar	France	48°01'N, 07°19'E	242	0	Pinot Noir
Freyburg, Unstrut	Germany	51°13'N, 11°46'E	110	360	Regent
Neubrandenburg	Germany	53°33'N 13°16'E	53	550	Regent
Helsinki region	Finland	60°24'N, 25°01'E	63	1390	Rondo

Observations on air temperatures were based on the statistical data of the Finnish Meteorological Institute and Meteorological Servis Foreca (www.foreca.com). Soil temperature measurements were taken at depths of 20 cm and 40 cm using digital thermometers that recorded maximum and minimum temperatures (Waterproof In-Out Door Max-Min Thermometer with Hygrometer, Shenzhen Hong Tong Yuan Technology Ltd, China, Shenzhen). The total sugar content of the grapes (°Bx) was measured using a Brix refractometer (HR-180, Optika, Ponteranica, Italy). A statistical treatment was completed with a t-test: $t = \frac{\bar{X}-\bar{Y}}{V^{1/2}}$

As part of the t-test, $\bar{X}$ was the mean value of the variables, and $\bar{Y}$ was the mean value of the other variables, and V an estimate of the variance of random error. $p<0.05$ was used to estimate statistical significance

Results and discussion

The temperature of the Finnish climate over an observation period of 160 years has increased in the 21st century by 0.6°C in comparison to the mean of 160 years, and this increase has been most obvious during spring (Tuomenvirta 2004). Tables 2 and 3 show that the yearly averages of the temperatures of the ten-year periods between 1971 to 2010 have constantly risen, and that the temperature averages of single years during the last ten-year period (2005 to 2014) have risen by 1.1°C in comparison to the average of years 1971 to 2000; this supports the results published by Tuomenvirta (2004). Finland is the northernmost agricultural country in the world, and due to its northern location, average temperatures in Finland vary more from one year and one decade to the next, than the global average temperatures. The noticeable increase by 1.1°C in the Table 3 was apparently caused by a large deviation, and was not statistically significant ($p>0.05$).

Table 2: Mean values of air temperatures in the Helsinki region over a 40-year period (1971 – 2010) and the ten-year period (2005 – 2014)

Periods of ten years 1971 – 2010	Mean air temperatures °C	Years 2004 – 2014	Mean air temperatures °C
1971 – 1980	5,0	2005	6.6
1981 – 1990	5,3	2006	6.7
1991 – 2000	5,4	2007	7.0
2001 – 2010	6,0	2008	7.6
2011 – 2020[1)]	6.5	2009	6.2
2021 – 2030[1)]	6.8	2010	5.1
2031 – 2040[1)]	7.2	2011	7.2
2041 – 2050[1)]	7.5	2012	6.2

[1)] The prediction is based on trend line of ten-year periods of 1971 – 2010

The temperature of the Finnish climate is predicted to rise by 2°C by the year 2050, and by 3°C by the year 2080, at the same time as rainfall increases up to 30% (IPCC 2010). Such a significant warming of the climate will allow for the profitable cultivation of plants thriving in mild climates, such as the grapevine, in southern Finland. Should the yearly average temperature of southern Finnish climate rise 2°C by the year 2050, the yearly mean temperature of the Helsinki

region will reach 8°C to 9°C in 40 years, i.e., close to the temperatures of the current wine growing regions of Central Europe. In the new growth condition, - thanks to the long day, humus-rich soil, and sufficient rainfall - the grapevine could produce even more abundant and superior quality crops than in the current wine-growing areas, where heat and drought would, according to forecasts, increase and hamper farming.

Table 3: Changes of air temperatures and lengths of growing seasons in the Helsinki region during the ten-year period (2005 – 2014) compared to the 30-year period (1971 – 2000).

Mean air temperature 1971 - 2000	Mean air temperature 2005 - 2014	Difference of mean values	Statistical significance
5.6±0.4 °C	6.7±0.7 °C	1.1 °C	*t*=1.5607; *p*>0.05

Mean length of growing season 2005 - 2014	Mean length of growing season 1971 - 2000	Diffference of mean values	Statistical significance
198 (±18) days	171 (±15) days	27 days	*t*=5.5214; *p*<0.05

In this study, the lengthening of the growing season in the Helsinki region was demonstrated more clearly than the increase in climatic temperature. In comparison to the lengths of the growing seasons between 1971 and 2000, the growing periods' mean values during the past ten-year period have lengthened by 27 days, which is statistically significant ($p<0.05$). The lengthening of the growing period has manifested itself in earlier springs (Tuomenvirta 2004). According to Bauer (2002), the grapevine requires, depending on variety, a growing season of approximately 200 days. According to Table 3, the mean growing season length in the Helsinki region has been 198 days in the years 2005 to 2014, in 6 of these years it has been over 200 days (Karvonen 2014).

Table 4: Mean monthly air temperatures

Locality	May	June	July	August	Sept.	October
Helsinki	10,9±4,2	13,9±4,6	19,8±3,0	17,2±3,9	12,1±3,3	5.7±4.3
Herrlisheim	14,3±2,9	18,6±3,2	20,2±2,5	17,7±2,7	15,1±2,4	12,5±2,9
Freyburg	12,5±3,6	16,6±4,1	20,0±2,8	16,9±2,9	15,8±2,6	12,6±2,8
Neubrandenburg	12,1±3,4	15,7±3,1	20,0±2,6	16,7±2,9	15,1±2,4	11,6±2,6

Tables 4 and 5 compare the six-month temperatures of the Helsinki region growing season to the temperatures of the three Central European comparison regions. It shows that the mean monthly temperatures in July and August in the Helsinki region are statistically not significantly different from those of the comparison regions ($p>0.05$). During other months, the differences between the temperatures of the Helsinki region and other regions are statistically significant, with the exception of northern Neubrandenburg, where wine growing is being restarted. In 2014, June was exceptionally cold in southern Finland, but July and August were sweltering, as usual. During July and August, there were 44 days of hot weather, when the highest temperature of the day exceeded 25°C and of which in 22 days temperatures exceeded 35°C (Finnish Meteorological Institute 2014).

Table 5: Statistical significance of mean air temperatures between localities during three midsummer months

Month	*n*	Helsinki ><Herrlisheim	Helsinki><Freyburg	Helsinki><Neubrandenburg
June	30	*t*=4.5988; p<0.05	*t*=2.4107; p<0.05	*t*=1.7822; p>0.05
Jyly	31	*t*=0.5714; p>0.05	*t*=0.2702; p>0.05	*t*=0.2857; p>0.05
August	31	*t*=0.6849; p>0.05	*t*=0.3448; p>0.05	*t*=0.6579; p>0.05

n = number of days

In late May, early June of 2014 (25 May to 3 June), soil temperatures measured in Herrlisheim-prés-Colmar at depths of 20 cm and 40 cm were at least 2.5°C higher than in other regions, due to the earlier spring and shorter duration or lacking of snow coverage. Moving northward, the temperatures of soil were lower. In Helsinki region, the soil temperatures were clearly lower, even on 3 June than in other regions. Compared with the soil temperatures in Neubrandenburg, the differences at 20 cm and 40 cm depths were clearly the lowest as compared with others, i.e., 0.6°C to 1.2°C (Table 6).

Table 6: Mean soil temperatures at the depths of 20 cm and 40 cm, grapevine growing stage (Eichhorn-Lorenz), total sugar content of grapes (°Bx) and measurement dates

Locality	Depth of 20 cm °C	Depth of 40 cm °C	Dates for temperatures	Dates for Eichhorn-Lorenz: 17	°Bx	Dates for °Bx
Helsinki	13,6	12,0	3 June	4 June	16,6±0,5	2 October
Herrlisheim	17,0	16,6	25 May	26 May	17,9±1.0	7 September
Freyburg	14,5	13,8	30 May	1 June	13,1±0,8	9 September
Neubrandenburg	14,2	13,2	1 June	1 June	13.0±1,3	9 September

Grapevine growth stage 17 (Eichhorn and Lorenz 1977), which is equivalent to the BBCH scale 55 (Maier 2001), was reached in the Helsinki region 9 days later than in Herrlisheim, and just 3 days later than in Freyburg and Neubrandenburg. Although during the vines' sprouting and inflorescence stages producing red wine grapes the regional differences were only 3 to 7 days, at the harvesting stage they were several weeks, based on the grape total sugar level (°Bx), ; this may be due at least in part to both climatic differences and different grape varieties (Tables 1 and 6).

During the last 40 years, the temperatures of the Helsinki region have risen over 1°C which is the equivalent of a lengthening of the growing season by 10 to 11 days (IPCC 2007). The

temperature increase has been most obvious during the past 10 years. By the end of the century, and with the realisation of the IPCC A1B scenario, thermal growing seasons will get longer during the autumn and spring in the whole of Finland by a total of 35 to 40 days (Neitiniemi-Urpola 2010). When at the same time snow coverage will diminish, the climates of southern parts of Finland and the other Nordic countries will change to resemble the current climate in central Europe.

The results of this study show that the temperatures of the midsummer months in Helsinki region will often not differ significantly from the temperatures of central Europe, and that the growing seasons have become significantly longer. As the climate continues to become warmer, the grapevine may become a cultivated plant in the southernmost parts of Finland most likely by the year 2040.

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