SUSTAINABILITY OF GROWING OF SAAZ HOP IN THE CZECH REPUBLIC IN THE CONDITIONS OF CLIMATE CHANGES

Karel Krofta, Hop Research Institute, Žatec, Czech Republic
Alexandr Mikyška, Research Institute od Brewing and Malting, Prague, Czech Republic
e-mail: krofta@chizatec.cz

Introduction

Saaz hops belongs as a variety among regional populations, that has been developing in Bohemia and Moravia for centuries. Similarly, originated varieties Fuggle and Golding in England or Hallertauer Mittelfrüh, Hersbrucker Spät, Spalter and Tettnanger in Germany. The hop-growing areas (Saaz, Auscha, Trschitz), in which hop cultivation is now concentrated in the Czech Republic (**Figure 1**), have developed by natural zoning and over the years have been included in hop legislation.

1. Global warming

Global warming means a long-term increase in the average temperatures of the climate system caused by industrial human activity since the Industrial Revolution. These changes since the middle of the last century are based on the measurement of temperatures and concentrations of carbon dioxide in the air. The most serious anthropogenic effects are emissions of greenhouse gases, CO_2, methane. Since 1960, the concentration of carbon dioxide in the atmosphere, which is responsible for 9-26% of the greenhouse effect, has increased from 320 to 410 µmol/mol of dry air (**Figure 2**). Most developed industrial countries expect a drastic reduction in carbon dioxide emissions by 2050, to which the necessary legislative changes are aimed. Energy is more oriented towards the use of renewable resources, the end of the era of burning fossil fuels is planned for the period 2030-2040.

2. Global warming and hop

Significant effect climatic and weather conditions on yield and alpha acids contents in hops is generally accepted. July temperatures are a critical weather parameter (**Figure 3**). The value of the regression coefficient of dependence alpha acids-temperature in July (R = 0.82) is significantly higher than for the June (R = 0.48) and August (R = 0.39). Longer tropical periods without precipitation have a very negative impact on the alpha acid content not only in Saaz hops, but also in many other varieties.

In the past 30 years, three weather-critical years were recorded (1994, 2006, 2015), in which the average monthly temperatures in July were 3 to 4 °C above long-term values. The average content of alpha acids in Saaz hops in these years ranged from 2.0 to 2.5% by weight. Extremely hot and precipitation-poor years are usually not limited to the Czech Republic, but cover the entire region of Central Europe (Germany, Poland, France and Slovenia). The losses in hop production in these years are such that they can have a global impact on market prices, especially in the range of aromatic hops. **Table 1** shows data on alpha acid production in selected countries in the period 2014 to 2018, of which a deep decline in the Central European region in 2015 is quite evident.

Another accompanying phenomenon of global warming is the more frequent occurrence of extreme weather events (floods, hail, storms accompanied by strong winds). They cause great damage not only to hop plants and hop constructions, but also lead to major production outages (**Figure 4**).

Figure 4: Hop growth damaged by hailstorm (2021)

The impact of global warming can be reduced in several ways. Very important is planting of new hop gardens with virus-free seedling and regular change of hop growths. Lack of precipitation can be eliminated by installing systems with artificial irrigation. Also important is the zoning of hop gardens, planting hops in areas where there are good soil and other environmental conditions.

3. Planting of new hop gardens with virus-free seedling and regular change of hop growths

Planting of new hop gardens with seedlings free of viruses and viroids (VF) and regular change of hop growths is another tool how to minimize the impact of climate changer to hop cultivation. The content of alpha acids in hops from VF hop gardens is significantly higher compared to infected ones, by approximately 50% in the first years after planting. Heathhy hops cope with unfavorable weather conditions (high summer temperatures, lack of precipitation) much better than older ones, which was clearly reflected in the critical years 1994, 2006 and 2015. Over the past 30 years, the majority of hop gardens with Saaz hops in the Czech Republic have been transplanted with virus-free seedlings, which still retain their high quality (**Table 2**).

Table 2: Content of alpha acids (% w/w) in new and older growths of of Saaz hops in the years 2011 to 2020

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Old hop gardens	4,3	3,4	3,0	3,1	2,4	3,5	3,0	2,9	3,1	3,5
Virus-free hops	4,9	4,7	3,5	3,9	3,1	4,6	4,0	3,7	4,8	4,8
Difference (% rel.)	114	138	117	126	129	131	133	128	155	137

The construction of irrigation systems in hop gardens is subsidized by the state. Since 2001, almost 1,200 ha of irrigation systems have been built in hop gardens. The total area of irrigated hop gardens is currently estimated at 1,400 ha, which represents approximately 30 % of the cultivation area.

4. Irrigation

Irrigation is an important stabilizing factor for profitable hop cultivation. The most common is drip irrigation located on the ceiling of the structure, another alternative is underground irrigation, where the irrigation pipe is located at a depth of 50 to 60 cm in the axis of the row of hop plants. Some growers use micro-spray irrigation, which best simulates rainfall. The results of a several-year comparative test of the effectiveness of additional irrigation for Saaz hop, showed that irrigation increased the hop yield by at least 20%, while no significant differences were found among irrigation systems (**Table 3**).

Table 3: Comparison of hop yields in different irrigation systems (Saaz)

Irrigation system	Yield (t/ha)					Average	Index
	Year I	Year II	Year III	Year VI	Year V		
control, (no irrigation)	1,22	1,31	2,01	1,69	1,32	1,51	100
underground drop irrigation	1,54	1,81	2,19	2,11	1,78	1,89	125
drop irrigation (top of trellis)	1,35	1,84	2,30	1,86	1,70	1,81	120
sprinklers	1,51	1,78	2,12	2,08	1,86	1,87	124

Figure 1: Hop growing regions in Czech Republic

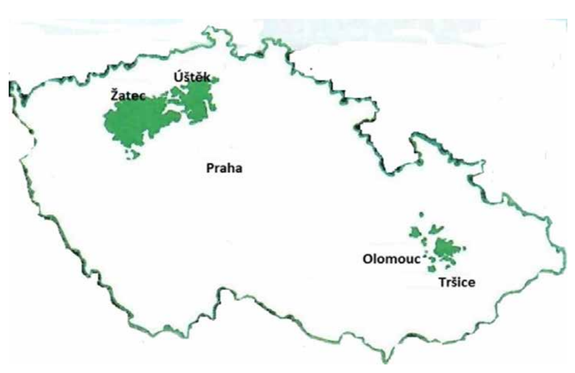


Figure 2: Increase of carbon dioxide concentration in the atmosphere in the period 1960-2020

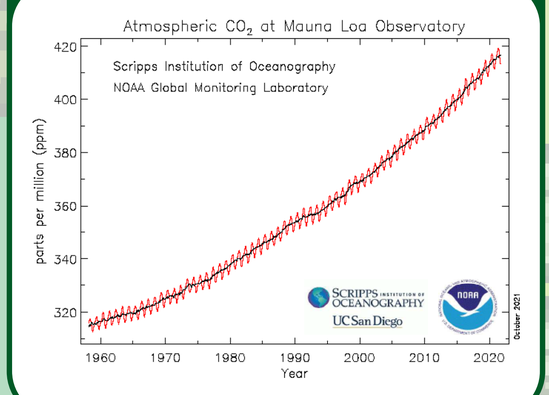


Figure 3: Dependence of alpha acid content in Saaz hops on average temperatures in July

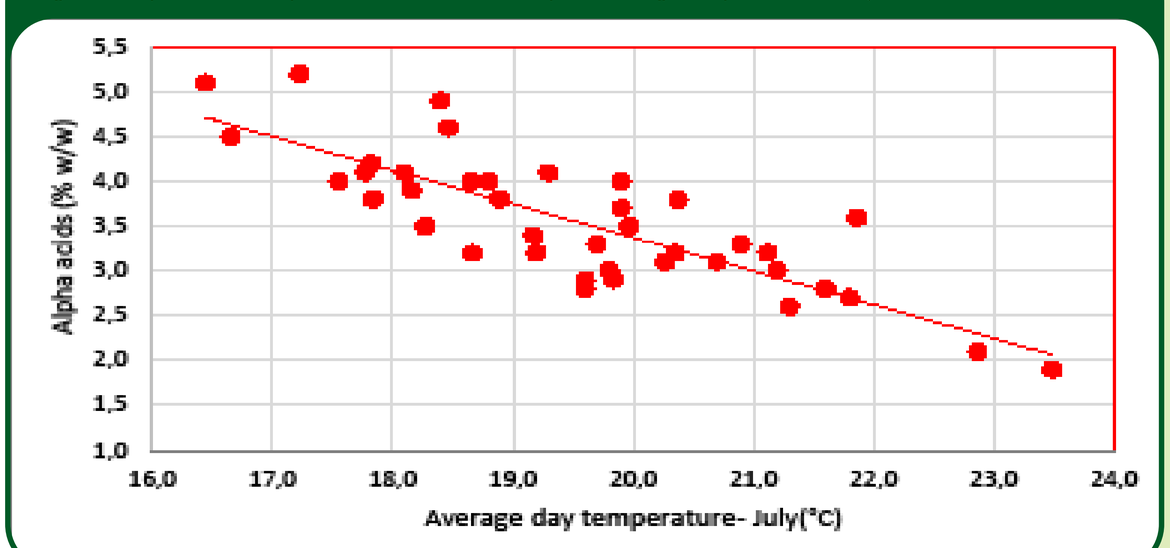


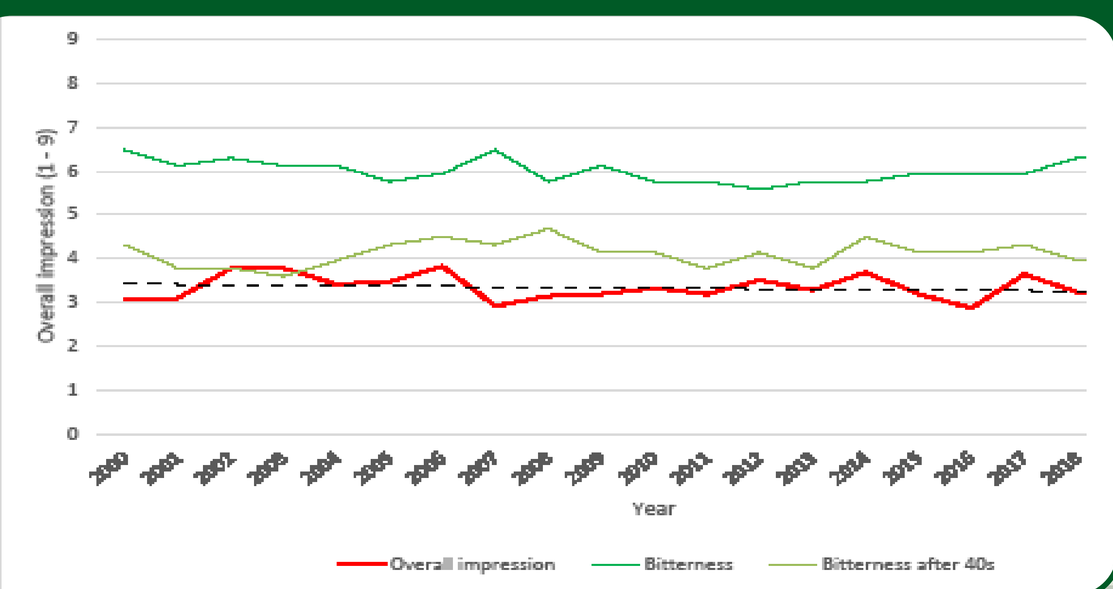
Table 1: Production of alpha acids in selected European countries in the period 2014-2018

Country	Alpha acids production (t)				
	2014	2015	2016	2017	2018
Germany	3916	2405	4501	4047	3828
Czech Republic	209	133	317	249	164
Slovenia	177	87	131	134	165
France	24	17	29	30	27
Poland	157	164	254	236	234
England	91	84	105	126	93
TOTAL	4574	**2890**	5337	4822	4511

5. Impact of global warming on brewing industry

When testing the properties of new hop varieties in the production of lager beers, beer hopped by Saaz hops is always included as a comparative variant. From the overview of the results of sensory tests for the last 20 years (**Figure 5**) it is clear that beers hopped by Saaz hops maintain their constant quality. The impact of global warming on the brewing industry in terms of hop supplies does not appear to be significant. Year-on-year fluctuations in alpha acid content cannot be avoided in the future. For the brewing industry, however, this is not a serious problem, as brewers are able to handle such situations.

Figure 5: The overal sensory impression and sensory bitterness of experimental lager beers hopped 100% with Saaz hops in the years 2000-2020



Conclusion

By regular renewing the hop gardens and planting quality seedlings, compensating for the temporary lack of rainfall by irrigation, the cultivation of Saaz hops in the Czech Republic can be maintained at an economically profitable level in the years to come. Year-on-year fluctuations in alpha acid content cannot be avoided in the future either. For the brewing industry, however, this is not a serious problem, as brewers are able to handle such situations. However, a serious problem of global warming is extreme weather events such as torrential rains, hail, strong winds (storms, tornadoes). They cause great damage not only to hop plants and hop constructions, but also lead to major production outages. Scope of this problem already extends beyond the borders of the Czech Republic and Saaz hops, but it concerns hop growing in the entire region of Central Europe.

References

Gahr, A., Forster, A.: The Saaz Hop variety – how great is the influence of climate and growing region? Hopfen-Rundschau International 2020/2021, 38-44.
Ježek J.: Utilization of irrigation systems in hop growing. Czech hops, 2009, 20-21, ISBN 978-80-7084-853-1.
Krofta, K., Brynda, M., Nesvadba, V.: Zoning of Czech hop varieties. Methodology for practice 04/10. Chmelařský institut, 2010, ISBN 978-80-87357-04-0.
Krofta, K., Kučera, J.: Mathematical model for prediction of yield and alpha acids content from meteorological dada for Saaz aroma variety. Proc.SC IHGC, Leon Spain, 2009, 23-31.
Mikyška, A., Jurková, M.: Analysis and prognosis of bitter acids content in Czech hop varieties - year 2018 and long-term comparisons and trends. Kvasny Prumysl, 2019, 65(1): 23–31.

Acknowledgement

This study was supported by the Ministry of Agriculture of the Czech Republic within the institutional support MZE-RO1321 and MZE-RO1918.