KVASNÝ PRŮMYSL

Kvasny prumysl (2023) 69: 700–706
https://doi.org/10.18832/kp2023.69.700

A different approach to hop growing

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Abstract

The current study aimed to examine how various growers in the Czech Republic hop-growing regions approached the production of hops (Saaz variety). The work also keeps track of how different growers approach fertilization and nutrition, as well as how often plant protection chemicals containing these ingredients are used. The Saaz hop variety samples from the primary Czech hop-growing regions, gathered in 2020 and 2021, were assessed. The average spindle length (14–18 mm), average number of spindle segments (9.3–11.9 pcs/needle) and conductometric parameters (2.7–4.7% w/w) in the samples were identified.

Keywords: hops; Saaz; conductometric value; agrotechnics; integrated production

1 Introduction

Hops are one of the most intensively farmed agricultural crops, which are very demanding in terms of nutrients and fertilisers. Hops produce a large amount of above-ground biomass during their short growing season (April to August), for which they need sufficient quantities of available nutrients in the soil. Among the most important elements are nitrogen, phosphorus, potassium, calcium and magnesium, and the microelements include zinc, copper, and boron. Hops extract the following amounts of nutrients from the soil on an average harvest (per hectare): 75–90 kg N (Vent et al. [2019] reported even an amount of 120 kg N); 40–50 kg P_2O_5; 83–120 kg K and 140–180 kg CaO (Vavera et al., 2017; Zima and Zázvorka, 2017). The nutrients are extracted by the hop plant from the soil solution in which they are dissolved. In the soil, nutrients are bound in the so-called temporary bonds during biological, physical, physicochemical, and other types of sorption. These bonds are not permanent, and nutrients can be gradually released from them. However, certain elements can form very resistant chemical compounds that prevent the release of nutrients from the soil (Rybáček et al., 1980). Application of organic, phosphate, potassium, magnesium, and solid calcium fertilisers is recommended in the autumn season, while nitrogen and liquid fertilisers are applied during the growing season. For the actual determination of fertiliser rates, the results of agrochemical soil analysis (ASA) should be used (Kopecký et al., 2008).

The aim of this study is to evaluate the approach to the cultivation of the hop variety Saaz by different growers in different growing conditions (hop-growing regions of the Czech Republic) with respect to the weather in the growing years 2020 and 2021. The framework of the evaluation is based upon the methodology by Krofta (2008). An average spindle length, number of spindle segments and conductometric parameters were measured for the samples.

2 Materials and methods

The aim of the study was to obtain material for assessing the quality of hop cones from the 2020 and 2021 harvests. The most widely grown variety in the Czech Republic, Saaz, was selected for the evaluation. The hop samples were obtained through the organisation Chmelařství, družstvo

Research Institute of Brewing and Malting
Published online: 15 January 2023

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Žatec and came from four randomly selected hop growers from the three hop-growing regions of the Czech Republic.

2.1 Samples of hops from the Žatec hop-growing region

Samples of hops from the Žatec hop-growing region came from the Family Agrofarm Karel Dittrich, that is farming near the village of Lenešice (Louny district). Hops are grown on approximately 45 hectares. The hop farm can be localised according to the GPS N 50°22.01212', E 13°45.91765', the soil parcel number is 4519/2, the square is 780–1000. The fertilisers applied, including their doses, are shown in Table 1.

Table 1 *Overview of selected hops from different hop production region*

Hop-growing region	Žatec		Úštěk		Tršice					
	Agrofarma Karel Dittrich		Veltrusy Jiří Kejkrt		Tršická zemědělská, a.s.				JVR spol. s.r.o.	
Growing year	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
The average altitude above sea level	179 m		164 m		284 m		272 m		284 m	
Age of hop farm	14	15	6	7	4	5	7	8	37	38
	clone 31		clone 31		clone 31		clone 114		clone 72	
Date of harvest	19.–20.8.	20.8.	30.8.–2.9.	30.8.–4.9.	1.9.	6.9	3.9.	31.8.	15.–16.9	9.–10.
Date of hop-cutting	2.4.	10.4.	16.4.	17.4.	7.4.	15.4	9.4	21.4.	4.–9.4.	12.–17.4
Date of implementation	6.–12.5.	22.–29.5.	7.–11.	16.–18.5	9.–15.5.	15.–22.5.	30.4.–5.5.	3.–14.5	6.–10.5.	21.–30.5
Harvesting weather		heavy rain before harvest	rain		rain					

In 2021, nitrogen fertilisers were not applied, but zinc fertilisers were spread over more frequently. In terms of a plant protection, in both years, a treatment with the active substance thiamethoxam was used to combat foxtail mildew. Products containing the active substances mandipropamid, fosetyl-Al and basic copper sulphate were utilised as a treatment against hop blight. To protect the plants against *Phorodon humuli,* a preparation with the active substances flonicamid, spirotetramat, was applied. Products based on boscalid and pyraclostrobin were used against *Sphaerotheca humuli*.

2.2 Samples of hops from the Úštěk hop-growing region

Samples of hops from the Úštěk hop-growing region come from a grower from Veltrusy, Mr. Jiří Kejkrt, farming near the village of Vojkovice (Mělník district). The he hop farm can be localised according the GPS N 50°17.95937', E 14°22.74588', soil block part number 2901/7, square 740–1010. Fertilisers such as DASA, DAM, NPK and Solinure 5 from ICL were applied in 2020 and 2021. Solinure 5 is similar to NPK and contains 20% N, 20% P_2O_5 and 20% K_2O.

In both years, products with the active ingredients thiamethoxam, spirotetramat and bifenazate were used to provide protection against *Otiorhynchus ligustici*, *Phorodon humuli* and *Tetranychus*. Among other fungicides used againstperonospora and *Sphaerotheca humuli*, also treatment with the active ingredients amethocradine+dimethomorph, fosetyl-Al, folpet, metalaxyl-M, boscalid, pyraclostrobin, basic copper sulphate and copper hydroxide was applied.

2.3 Samples of hops from the Tršice hop-growing region

The hop samples from the Tršice hop-growing region come from two growers. The first, Tršická zemědělská, a.s., is farming near the village of Tršice (Olomouc district) on an area of 60 ha of hops. The company cultivates hop varieties Sládek, Premiant and Saaz. Samples of hops come from two hop farms which can be located according to GPS N 49°31.92692', E 17°23.09005', the soil parcel number is 7801/16, square 530–1120 and GPS: N 49°32.12577', E 17°25.28440', soil block part number 5903/16, square 530–1120.

In both years, and for both hop farms, the fertilisers chosen were identical, including their doses. In 2020, urea and then Kieserit were applied during May. In 2021, urea was applied during March and Kieserit with LAD in May. In addition, foliar application of Litofol+, Fortestim beta or fertilisers containing microelements, especially zinc and boron, was carried out.

In both years, significantly more applications of products were used for plant protection than, for example, in the region Bohemia. However, the active substances in the control of the cotyledon, hop aphid and silkworm are similar and include such chemicals as spirotetramat, acequinocyl, lambda-cyhalothrin and flonicamid. Among the fungicides applied against peronospores and hop aphid are products with active ingredients such as fluopicolide, fosetyl-Al, folpet, metalaxyl-M, boscalid, pyraclostrobin, basic copper sulphate and azoxystrobin.

The other grower from the Tršice hop-growing region is JVR spol. s r.o., farming near the village of Tršice (Olomouc district). The company grows hops of the Saaz variety on an area of 4.75 ha. The hops are grown in an organic farming system. The hop samples come from a hop farm located as GPS N 49°32.08367', E 17°25.83465', the soil block part number is 4901/9 and 10, square 530–1120. After the harvest 2021, the outdated hop farm was demolished, and in 2022 a new hop farm was built. On 26th November 2019, a mixture of cow and horse manure was applied in the hop field at a rate of approximately 55 t/ha. As the grower is involved in growing organic hops, the hop fields were not fertilised with mineral nitrogen fertilisers at all the time. All fertilisers used were applied on the leaf during the growing season. The fertilisers used were Topstim N13 from BIOFORCE (rabbit skin hydrolysate) with a minimum nitrogen content of 12.5%, ALGA 600 from Floraservis (biostimulant, brown seaweed extract) containing 17% K_2O and WOLF TRAX Cropmix with the microelements manganese, zinc and boron. In 2021, a mixture of cow and horse manure was applied at a rate of about 80 t/ha. Foliar fertiliser was applied in 2021 based on the results of the soil analysis. The fertilisers used were Topstim N13, WOLF TRAX Cropmix, bitter salt containing 15% MgO, Yara Agri Mantis, E-Wine from Hycol containing water-soluble natural oligopeptides, amino acids, and trace elements; Wuxal aminocal containing 15% CaO, 0.5% zinc and manganese.

The product Skleník protekt from AgroBio KP was used against *Tetranychus* in 2020. Application against *Phorodon humuli* was not carried out. Fungal diseases were suppressed with products based on highly concentrated copper–sulphur suspension, copper hydroxide, chlorothalonil and basic copper sulphate.

2.4 Weather in the Žatec hop-growing region in 2020 and 2021

The average monthly air temperatures and precipitation for the study years 2020 and 2021 are shown in Figure 1.

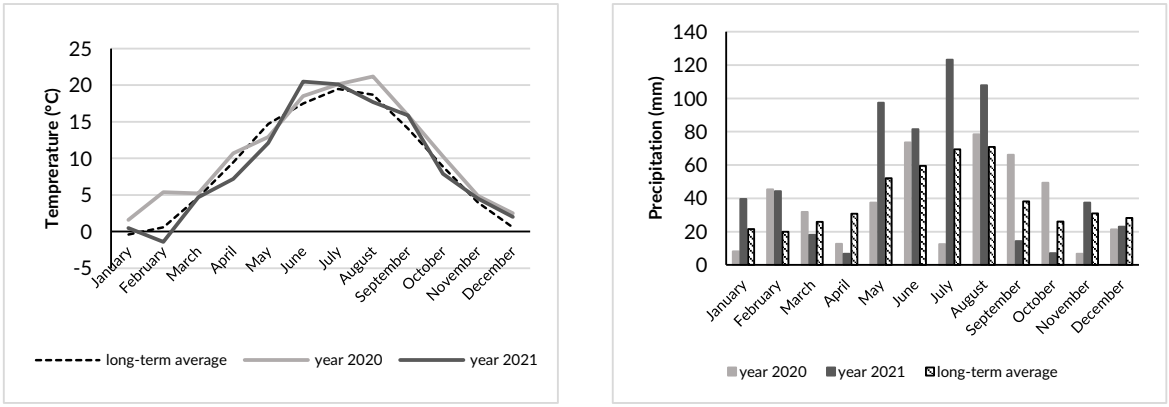

Figure 1 *Monthly averages of air temperature and precipitation in 2020 and 2021 and the long-term average (1981–2010) in the Žatec hop-growing region.*

2.5 Weather in the Úštěk hop-growing region in 2020 and 2021

The average monthly air temperatures and precipitation for the study years 2020 and 2021 are shown in Figure 2.

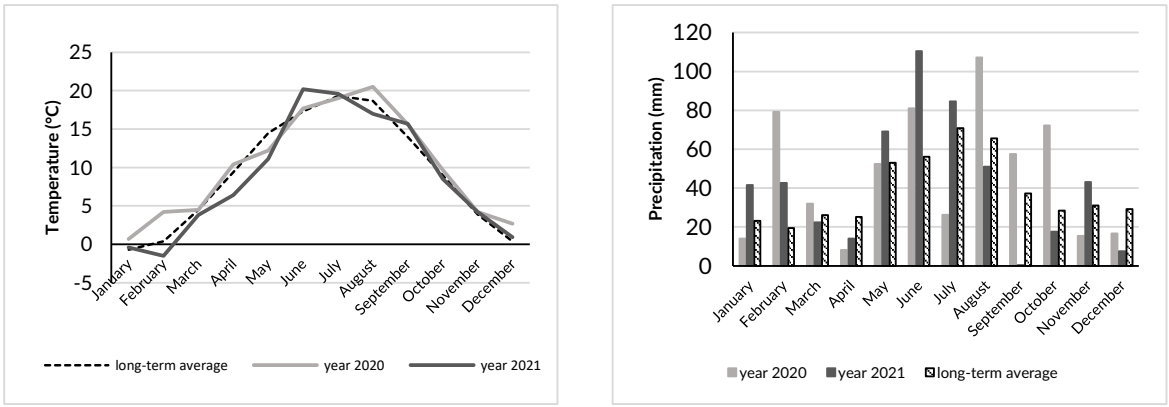

Figure 2 *Monthly averages of air temperature and precipitation in 2020 and 2021 and the long-term average (1981–2010) in the Úštěk hop-growing region.*

2.6 Weather in the Tršice hop-growing region in 2020 and 2021

The average monthly air temperatures and precipitation for the study years 2020 and 2021 are shown in Figure 3.

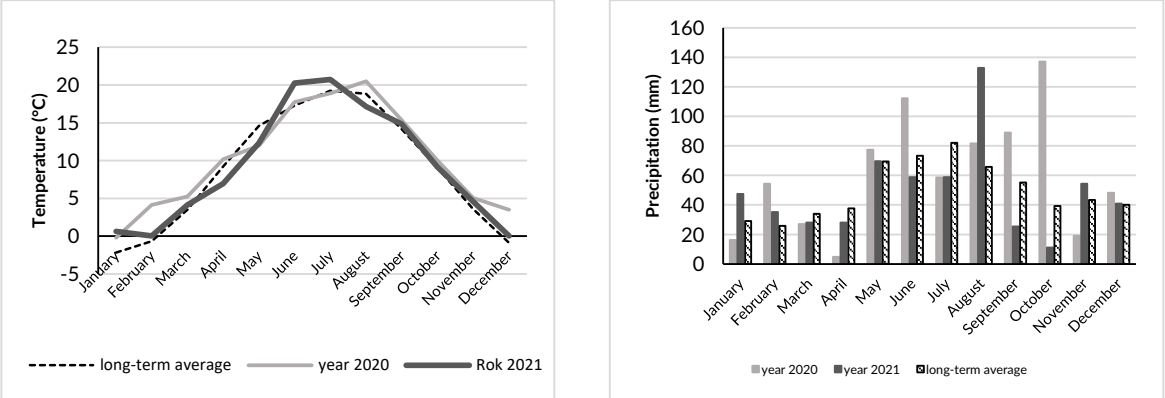

Figure 3 *Monthly averages of air temperature and precipitation in 2020 and 2021 and the long-term average (1981–2010) in the Tršice hop-growing region.*

2.7 Evaluation methods of hop cone samples

The content of foreign and hop admixtures in % by weight was determined for individual hop samples according to the valid methodologies (ČSN 46 2520-4 and ČSN 46 2520-5), as well as the moisture content of the hop heads, and the length of the spindle and the number of segments were monitored as part of the mechanical analysis (Krofta, 2008). The conductometric value (further as CV) is one of the quality parameters of hops. It expresses the content of bitter acids, which is highly variable depending on the weather conditions in the year during the growing season (Krofta, 2008). This value includes other bitter substances besides α-bitter acids; therefore, CV tends to be higher than the value of α-bitter substances (Altová, 2005). Specifically, for the variety Saaz, the minimum CV value of 2.6 % w/w or more is considered as a measure of high quality (Krofta, 2008). The CV of hops is determined according to ČSN 46 2520-15 (Altová, 2005). The results obtained were processed using MS Excel and Statistica 14.

3 Results and discussion

The evaluation of hop quality parameters are unmissable factors for the final evaluation of hop production in given years. The average spindle length, average number of spindle segments and conductometric parameters were determined for the samples. The results of the work are presented in figures and tables.

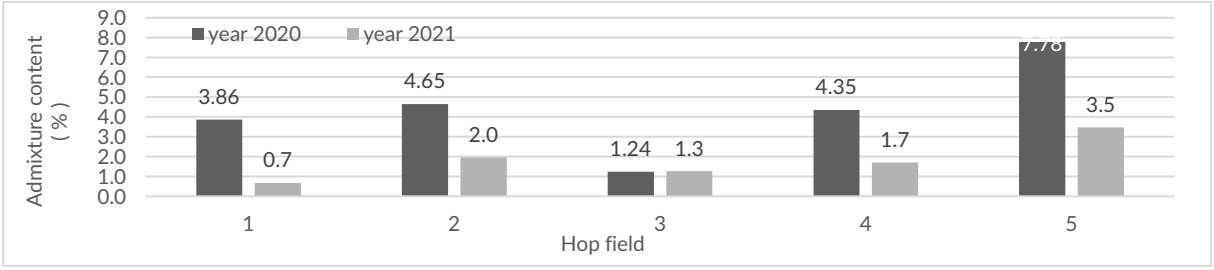

Figure 4 *Hop admixtures in hop samples from 2020 and 2021*

Figure 4 shows the proportion of hop (biological) admixtures in the hop samples. Foreign admixtures were not detected in the hop samples. In 2020 and 2021, the highest proportion of hop admixtures was found in the bio-hop samples from the Tršice hop-growing region (hop-growing region 5), with hops containing 7.78 and 3.48% w/w of hop admixtures. In contrast, the lowest proportion of hop admixtures was found in the samples from hop-growing region 3. The lowest hop admixture in 2021 was found in the samples from hop-grower 1 (0.68% w/w of admixture).

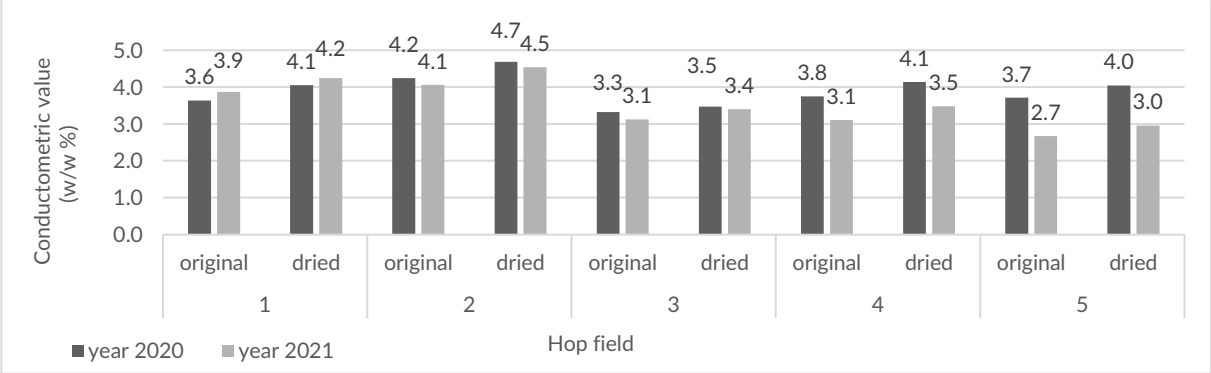

Figure 5 *Conductometric values in original and dried hop samples from 2020 and 2021*

Higher CV values were recorded in the 2020 hop samples, with the highest amount of hops coming from the hop garden (4.24% w/w). The exception was hop field 2, where the CV was lower in 2020 (3.64% w/w) compared to 2021 (3.87% w/w). In 2021, the highest CV was found in the samples from hop yard 2 (4.06% w/w). The lowest CV was found in 2021 in the samples from hop farm 5 (2.67% w/w). The main reason for this is probably the high age of the hop plant, which was already 37 years old in 2021 (Figure 5).

The analysis of variance and the subsequent testing of spindle length and number of segments shows that the differences between samples from individual hops are statistically insignificant.

The average yields of hops on the individual farms were as follows:

- 1.4 t/ha in 2020 and 1.8 t/ha in 2021 on the farm 1 in the Žatec hop-growing region (GPS N 50°22.01212', E 13°45.91765');
- 1.89 t/ha in 2020 and 2.56 t/ha in 2021 on the farm 2 in the Úštěk hop-growing region (GPS N 50°17.95937', E 14°22.74588');
- 1.5 t/ha in 2020 and 1.78 t/ha in 2021 hop-growing region 3 in the Tršice (GPS N 49°31.92692', E 17°23.09005');
- 1.44 t/ha in 2020 and 1.72 t/ha in 2021 hop-growing region 4 in the Tršice (GPS N 49°32.12577', E 17°25.28440');

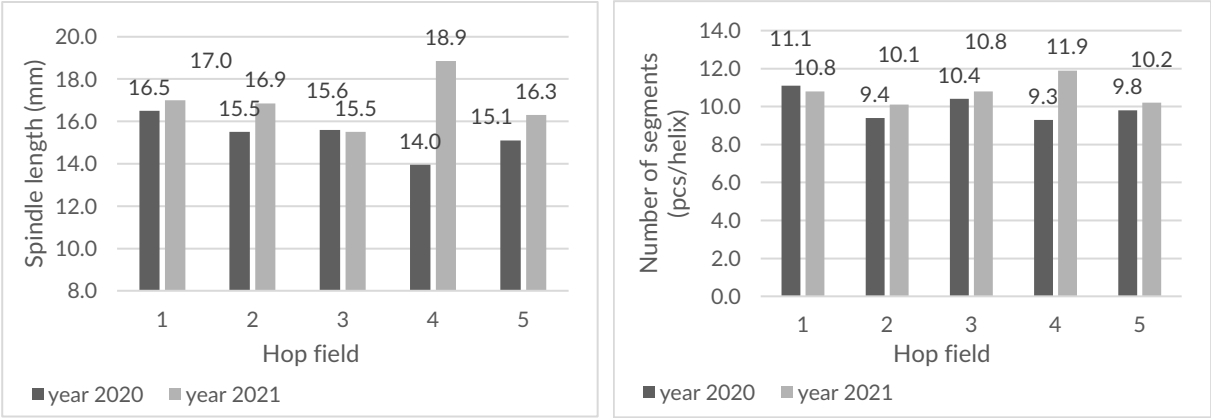

Figure 6 *Comparison of spindle length and number of segments in 2020 and 2021.*

As for the 2020 results, the highest values were taken in hop farm 1: the average spindle length was 16.50 mm, the highest average number of segments was 11.10 pcs/needle. The smallest average spindle length in 2020 was found at hop farm 4 i.e.,13.95 mm. Also the lowest average number of segments 9.30 pcs/needle came from hop farm 4. On the contrary, in 2021, the highest average spindle length and number of segments were measured at hop farm 4 (18.85 mm, 11.90 pcs/needle).

- 0.64 t/ha in 2020 and 0.8 t/ha in 2021 of organic hops from the hop farm 5 (GPS N 49°32.08367', E 17°25.83465').

In the Situation and Outlook Report (Altová, 2021) states that the Czech Republic is ranked as the third largest producer of hops, with the area of hops in 2020 accounting for 7.9% of the world area. One of the quality parameters of hops, that is regularly monitored, is the content of

biological (hop) admixtures. The average biological admixture content in the Czech Republic from the 2020 harvest was 2.52% w/w. However, the results of this paper indicate that all growers, except Tršická zemědělská, a.s., achieved a higher average biological admixture content. The samples of hops from JVR spol., s r.o. even showed a biological admixture content of 7.78% w/w. Altová (2021) points out that as for this quality parameter, the quality of Czech varieties has been very stagnant in recent years and lags behind foreign varieties. Experience shows that there are differences in combability, the size and density of cone set and also in the length of the claws. According to Altová (2021), the differences occur due to the weather patterns in the evaluated years. The average content of biological impurities has fallen below 2% w/w compared with 2020 (the exception being 37year-old hops from JVR spol., s r.o., with a biological impurity content of 3.48% w/w). The results presented by Pluháčková et al. (2011) confirm that more biological admixtures were detected in older hops than in younger ones. Donner et al. (2020) report that yields of Czech hop varieties increase during the first three years after planting, followed by a stabilisation and gradual decrease in yield with each year of the hop plant age. It is consistent with the findings that replanting hop plants with Saaz is ideal after 20–25 years. The bitter substance content of hops is one of the key parameters of hops. Nesvadba et al. (2021) argue that the bitter substance content of hops is more influenced by genetics than by the environment and weather patterns. Genetics is also related to the spindle length and number of segments, which was similar in 37year-old hops to those from younger plants.

There is a logarithmic decrease in α-bitter acid content with increasing age of hop plants (Donner et al., 2020). A characteristic feature of the Saaz is the low content of α-bitter acids (Nesvadba et al., 2020; Nesvadba et al., 2021), which, according to Krofta (2008), tends to be 3–4% w/w. The actual CV for 2020 in the Žatec hop-growing region was 3.51% w/w (Altová, 2021). The results of this work show that the CV of hop samples from the Žatec hop-growing area was 0.73% w/w higher than stated in the Situation and Outlook Report. The claim about an average CV in the Úštěk hop-growing area is also supported by the analysis results of hops from hop-growing area 1, whose CV was 3.64% w/w.

The lowest yield of the hop-growing stations surveyed was obtained from one under organic management where, the plant age was too high. This clearly confirms that hop-growing stations of over 25 years of age lose their yield potential. The yield of hops after application of the fertilisers and preparations mentioned above was 0.64 t/ha in 2020 and 0.8 t/ha in 2021. Nesvatba et al. (2022) also confirm that the yield potential of the oldest hop variety (Saaz) is significantly lower compared to the newer hop varieties; Saaz showed yields lower than 1.5 kg per plant, which is consistent with the yields from the hop gardens studied in this work.

4 Conclusion

The aim of this work was to evaluate hops from the hop-growing area of the Czech Republic in the 2020 and 2021 growing years. Hops from four different growers were analysed. The subject of the evaluation was the variety of Saaz. Both harvest years were characterised in terms of temperature and rainfall patterns.

The results of the work show that more biological admixtures were found in the samples of hops harvested in 2020. As for the 2021 harvest, fewer biological admixtures were detected, which did not exceed 2% w/w (e.g., hop plant 1 contained 0.68% w/w admixtures, and hop plant 4 contained 1.71% w/w). The exception was the sample from hop farm 5, which contained 3.48% w/w of biological admixtures. These differences between the sites may be due to a number of reasons such as size of cones, adjustment and type of combing machine, nutrition and fertilisation of the hops.

The highest CV value was found in both 2020 and 2021 in the samples from hop yard 2 (4.24% w/w) and 4.06 % w/w. The lowest CV in 2021 was found in the samples from hop farm 5 (2.67% w/w). The main reason for this may be the already mentioned age of the hop plant, which was 37 years old in 2021.

Recommendations for optimising hop yields include switching from conventional to integrated farming, e.g., optimum use of sub-crops in the hop-growing row. The integrated farming method is beneficial in terms of reducing the amount of chemicals and the number of passes, which is also linked to optimising the number of operations in the spring period. They comprise an enhanced application at times of pest or pathogen occurrence. In recent years, farmers have come across the concept of Agriculture 4.0, which aims to increase precision work, reduce costs, and increase efficiency, including data processing and evaluation. These practices could also be used in hop-growing.

5 Acknowledgement

This research was funded by the Ministry of Agriculture of the Czech Republic, within Institutional Support MZe-RO1918.

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