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Evaluation of Czech hop varieties (*Humulus lupulus* L.) in a dry area without irrigation

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Abstract

The aim of this study was to determine the difference in performance and variability of selected Czech hop varieties in a dry location without available irrigation. Since 2017, a field experiment has been conducted with 11 Czech hop varieties. The time series of the results helped to show the differences in performance as well as variability between the varieties. The highest yields were achieved by the Uran variety (2.83 t/ha) and Saaz Shine variety (2.76 t/ha), which also exhibited the lowest yield variability, namely 11.17% (Saaz Shine) and 12.53% (Uran), respectively. The lowest hop yield was recorded by the Harmonie variety (1.17 t/ha), which at the same time showed high yield variability (30.92%). The Bohemie variety had the highest yield variability of hops at 35.26%. Furthermore, the Gaia (14.66% w/w) and Uran (13.53% w/w) varieties had the highest alpha acid content. Conversely, the Mimosa variety showed the lowest alpha acid content (1.56% w/w) and also the lowest alpha/beta acid ratio (0.29). The Rubín variety reached the highest alpha/beta acid ratio (3.00). The Uran variety exhibited the lowest variability in alpha (6.16%) and beta (6.28%) acid content and in contrast, the Harmonie variety had the highest variability in these parameters (59.02% for alpha acids and 38.18% for beta acids). The Uran and Saaz Shine varieties showed a very good tolerance to dryness in the dry area. Additionally, the Gaia and Saaz Brilliant varieties showed good performance parameters, i.e. yield and hop resins. The hop varieties Vital, Gaia, Saaz Brilliant, and Saaz Shine had the most intense hop aroma, while the Boomerang and Uran varieties had a high intensity of spicy aroma. The Uran and Saaz Shine are highly resistant to drought.

Keywords: *Humulus lupulus* L.; yield; hop resins; hop aroma; variability

1 Introduction

The total hop cultivation area worldwide in 2022 was 61,235 ha (Kovařík, 2022). The Czech Republic, with an area of 4,950 ha, ranks third, following the USA (20,410 ha) and Germany (20,556 ha). Hop cultivation in the Czech Republic is concentrated in three hop-growing regions: Žatec, Úštěk, and Tršice. Among these, the Žatec region boasts the largest hop cultivation area, covering 3,792 ha (Kršková, 2022).

Historically, the Žatec region has been divided into Žatec and Rakovnice sections. The Rakovnice section is characterized by loamy soils and, most importantly, a water deficit. Water resources for irrigation are severely limited, classifying this area as a dry locality. In recent years, significant fluctuations in high temperatures and precipitation shortages have been observed. These factors contribute to high variability in hop performance in dry regions. Consequently, numerous new hop varieties are being tested in this specific region (Nesvadba et al., 2020a).

From a historical perspective, hop breeding has been focused on clonal selection within the original populations of the Saaz-type hop. Until 1993, ten clones of the Saaz hop had been registered. Currently, only three clones (Osvald clones 31, 72, and 114) are cultivated, covering an area of

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4,121 hectares. Unfortunately, clonal selection is based solely on choosing the best clones within a given population, and this method does not enhance the performance of newly acquired genotypes. Therefore, other breeding methods such as crossbreeding, polyploidy, and mutation have been employed in hop breeding. Several hop varieties have been obtained through mutation, with the Bor variety being an example in the Czech Republic. However, polyploidy did not increase hop yields as it can be observed in some leguminous crops. Crossbreeding, often referred to as hybridization, has been the most successful method in hop breeding. In the 1960s, these new methods started to be utilized in hop breeding. In 1994, the varieties of Bor and Sládek were registered, and they were not obtained through clonal selection (Rigr, 1997). Since 1993, clonal selection has been discontinued in the Czech Republic, and only the crossbreeding method has been employed. Eight more hop varieties (Nesvadba et al., 2020b) were registered between 1996 and 2010 (Premiant, Agnus, Harmonie, Rubín, Vital, Kazbek, Bohemie, and Saaz Late). In 2017, two new bitter hop varieties, Gaia and Boomerang, were registered (Nesvadba et al., 2017). In 2019, aromatic hop varieties were registered under the names Saaz Brilliant, Saaz Comfort, Saaz Shine, and Mimosa (Nesvadba and Charvátová, 2020c).

Breeding objectives have always been established to include resistance to fungal diseases, high yields, desired content, and composition of hop resins and oils (Trefilová et al., 2022). Naturally, throughout the breeding process, the stability of qualitative and quantitative traits has been monitored from the perspectives of both brewing and cultivation requirements. However, due to significant temperature increases and often very low precipitation, there is a new perspective on hop breeding. In recent years, there has been a preference for breeding new varieties that are resilient to high temperatures and drought (Krofta et al., 2019). As a result, a series of new crossbreedings have been undertaken with the aim of obtaining new hop genotypes that are drought-resistant. This is why, since 2021, the research project QK21010136 *"Application of new drought-resistant hop varieties and genotypes into cultivation and brewing practice"* has been addressing this issue. Within the framework of this project, a variety of new genotypes are being tested for drought tolerance. The ultimate goal is to breed new hop varieties that shall exhibit very low interannual variability in hop yields and the content of significant brewing compounds.

The aim of this study is to determine the difference in performance of hop varieties between irrigated and non-irrigated sites, i.e. to ascertain the performance and variability, which is given by a difference in supplementary irrigation. The effect of the given year and weather is not monitored, but only information on the stability of performance for breweries.

2 Materials and methods

In the autumn of 2016, a field experiment with selected hop varieties was established in Chrášťany at the Agricultural Company Chrášťany, Ltd. The experiment consisted of two groups of hop varieties:

2.1 Bitter hop varieties

Rubín obtained by selecting progeny from the Bor variety and a male plant, which is a multiple crossbreed of hybrid material (Saaz and Northern Brewer).

Alpha acid content: 8.0 to 12.0% w/w, beta acid content: 3.5 to 5.0% w/w.

Aroma profile: Spicy, floral, and herbal. After reaching technical maturity, the aroma may occur sulphur notes. Medium intensity.

Registered in 2007.

Vital obtained from the parent variety Agnus and ongoing breeding material.

Alpha acid content: 11.0 to 13.0% w/w, beta acid content: 5.5 to 8.5% w/w.

Aroma profile: Hoppy to spicy, with a background of fruity and herbal notes. High intensity.

Registered in 2008.

Gaia obtained from the Agnus variety and a male plant from the English variety Yeoman, with breeding material from crossbred Czech and foreign hop varieties.

Alpha acid content: 11.0 to 15.0% w/w, beta acid content: 5.5 to 8.0% w/w.

Aroma profile: Hoppy to spicy, with a background of fruity and floral notes. Medium to high intensity.

Registered in 2017.

Boomerang obtained by selection of the hybrid offspring of multiple crosses of the Agnus, Magnum, and Premiant varieties, and ongoing breeding material with lineage from Saaz, Sládek, Northern Brewer, and Fuggle varieties.

Alpha acid content: 9.0 to 12.0% w/w, beta acid content: 5.5 to 6.5% w/w.

Aroma profile: Dominated by spicy aroma, with background notes of woody, herbal, and fruity scents. High intensity.

Registered in 2017.

Uran it is a multiple crossbreed of hybrid material from European and American bitter hop varieties.

Alpha acid content: 10.0 to 13.0% w/w, beta acid content: 5.5 to 7.0% w/w.

Aroma profile: Dominated by spicy notes, with hints of woody and forest fruits. After technical maturity, the aroma may exhibit an unpleasant garlic-like skunkiness. High intensity.

Its registration is expected between 2024 and 2025.

2.2 Aromatic hop varieties

Harmonie obtained as a multiple crossbreed of hybrid material (Premiant, ŽPČ, Northern Brewer), with 60% of its lineage originating from the Saaz semi-early red bine hops.

Alpha acid content: 5.0 to 8.0% w/w, beta acid content: 4.0 to 6.0% w/w.

Aroma profile: hoppy, with background notes of fruity, citrusy, and herbal scents. After technical maturity, the aroma may exhibit a garlic-like skunkiness. Medium intensity.

Registered in 2004.

Kazbek obtained by selecting progeny from hybrid material with Russian wild hop in its lineage.

Alpha acid content: 5.0 to 8.0% w/w, beta acid content: 4.0 to 6.0% w/w.

Aroma profile: Citrusy and fruity, with hints of spiciness and herbs. Higher intensity.

Registered in 2008.

Bohemie obtained by selecting progeny from the parent aromatic variety Sládek, with lineage from Saaz semi-early red bine hops in ongoing breeding material.

Alpha acid content: 4.5 to 7.0% w/w, beta acid content: 4.0 to 6.0% w/w.

Aroma profile: Hoppy, with background notes of herbs and flowers. Medium intensity.

Registered in 2010.

Saaz Brilliant obtained by selecting progeny from inbred crosses of the Saaz semi-early red bine hops.

Alpha acid content: 3.0 to 4.5% w/w, beta acid content: 2.0 to 3.0% w/w.

Aroma profile: Fine hop aroma, with background scents of flowers, herbs, and grass. Lower intensity.

Registered in 2019.

Saaz Shine obtained by selecting progeny from the parent variety Sládek and a male plant of Saaz semi-early red bine hops.

Alpha acid content: 2.0 to 5.0% w/w, beta acid content: 2.0 to 4.0% w/w.

Aroma profile: Fine hop aroma, with background notes of fruit and citrus. Medium intensity.

Registered in 2019.

Mimosa obtained from a parent plant from Czech breeding and a male plant from South African breeding.

Alpha acid content: 1.0 to 2.0% w/w, beta acid content: 3.5 to 6.0% w/w.

Aroma profile: Fruity and citrusy, with background notes of herbs, grass, and spiciness. Low intensity.

Registered in 2019.

2.3 Conditions of the agricultural experiment

The field experiment in Chrášťany was intentionally established due to water scarcity. These are locations with low precipitation, and the hop fields are not irrigated. The experiment was conducted in the Osvald clone 114 at a spacing of 300×114 cm. The field experiment was planted simultaneously with the entire commercial hop field. The varieties were planted with a minimum of 14 plants, and harvesting was always performed on the entire set of plants using the Volf stripping machine at the Hop Research Institute, Ltd. in Žatec.

An average sample was taken from the harvested hops for chemical analysis, hop quality assessment, and brewing tests. The yield was converted from fresh hops to t/ha = (yield of fresh hops per plant × 3000 plants) / 4 (i. e. dry matter coefficient).

The yield evaluation was performed in the second year of cultivation when the plants reach full fertility. For this reason, the yield was evaluated from 2018 to 2022.

2.4 Chemical analysis

The content and composition of hop resins were determined by the HPLC method (EBC 7.7). Chemical analyses were conducted from 2017 to 2022.

2.5 Sensory analysis

Hop aroma evaluation was performed organoleptically using the sense of smell. The assessment was carried out on dry hop cones within 14 days after harvest. The hops were dried at a maximum temperature of 54 °C. Basic aroma evaluation was performed for new promising genotypes to identify the most prominent aromas. The following aromas were assessed: hoppy, herbal, fruity, citrusy, floral, spicy, grassy, woody and sulphury. The intensity was categorized into 4 groups:

1. High – the aroma character dominates.
2. Medium – the aroma character is not prominent, but clearly identified.
3. Low – the aroma is of low intensity (on the background of a more prominent aroma).
4. None – no aroma type is present.

2.6 Statistical evaluation

The basic statistics, namely the arithmetic mean (x) and standard deviation (s), were computed. The relative measure of variability was used to compare datasets with different units. The obtained measures of variability are dimensionless numbers (usually in %), which allows for comparing the variability of statistical characteristics with different measurement units. The coefficient of variation (Vk) was used during data processing, representing the range of variability in % (Meloun and Militký, 1994).

3 Results and discussion

3.1 Yields of hop varieties tested

The highest hop yields were obtained from the varieties Uran (2.83 t/ha) and Saaz Shine (2.76 t/ha) as shown in Figure 1. Only these two varieties exceeded the limit boundary **x+s**, which is 2.49 t/ha. In addition to these varieties, also Gaia (2.33 t/ha) and Saaz Brilliant (2.13 t/ha) reached high yields.

Conversely, the lowest hop yield was observed in the Harmonie variety (1.17 t/ha), which was the only one falling below the lower limit boundary **x-s** (1.48 t/ha).

The other varieties showed an average yield within the observed range for the group of varieties. The achieved average yields were compared with the yields specified in the Hop Varieties Atlas (Nesvadba et al., 2022). Only the Saaz Shine variety exhibited a higher yield than the reported range of 1.7 to 2.2 t/ha. On the other hand, the varieties Harmonie (1.6 to 2.2 t/ha) and Kazbek (2.0 to 2.8 t/ha) exhibited a wider range than the average yield obtained in this dry location. In comparison with the yield results in the irrigated location at Stekník (Nesvadba et al., 2020b), the Harmonie (2.1 t/ha) and Kazbek (3.7 t/ha) varieties showed higher hop yields.

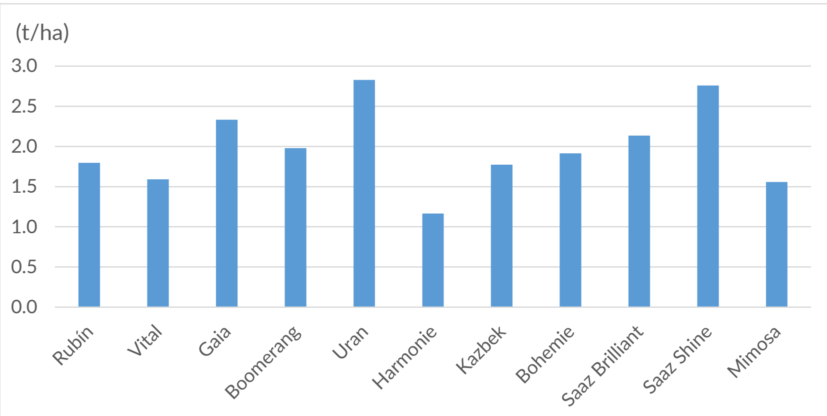

Figure 1 *Average hop yields (Chrášťany, 2018–2022)*

3.2 Yield variability of hop varieties tested

The evaluation of variability is a crucial characteristic regarding the stability of hop varieties' performance during cultivation. Interestingly, over the five-year period, the varieties with the highest yields (see Figure 2), namely Saaz Shine (Vk = 11.17%) and Uran (Vk = 12.53%), had hop yield variability below the lower limit boundary **x-s** (13.16%). Other varieties with low yield variability were Kazbek (14.20%), Boomerang (14.97%), and Saaz Brilliant (15.91%). In contrast, the varieties Bohemie (35.26%) and Harmonie (30.92%) exhibited the highest variability, surpassing the upper limit boundary **x+s** (30.25%). The remaining varieties showed yield variability ranging from 20% to 30%.

The results indicate that some varieties displayed high variability both in dry regions and abroad. For instance, the German variety Huell Melon exhibited a variability of 35% (Seigner et al., 2019).

Regarding the yield, Uran and Saaz Shine clearly demonstrated the best yield characteristics, as they had the highest yield and the lowest variability throughout cultivation. As well as the varieties Gaia and Saaz Brilliant, with hop yields above 2 t/ha and average variability could be suitable for growing on dry areas. On the contrary, the variety Harmonie exhibited the lowest yield and high yield variability and also the varieties Vital, Kazbek, Bohemie, and Mimosa may not be suitable for dry regions due to their low yield or high yield variability.

Saaz Shine was highly drought-tolerant compared to Saaz. The hop yield of Saaz without irrigation was 30% lower (Kopecký and Ježek, 2007). Saaz Shine showed nearly similar average yields from 2017 to 2021, at 2.54 t/ha in the dry, non-irrigated location, and 2.62 t/ha in the location near the river with irrigation (Nesvadba, 2022).

3.3 Bitter acids of hop varieties tested

Table 1 clearly shows that only the varieties Gaia and Uran had alpha acid content above the upper limit **x+s** (13.13% w/w). It is important to note that two groups of hop varieties were evaluated in this study, namely bitter varieties with alpha acid content above 10% w/w, and aromatic varieties with lower alpha acid content. The values marked in grey in the table represent the upper limit **x+s** or below the lower limit **x-s**.

Among the evaluated hop varieties, Mimosa had the lowest alpha acid content (1.56% w/w), and it is the only variety with alpha acid content below the lower limit **x-s** (4.12% w/w). Gaia (7.63% w/w) and Vital (7.34% w/w) had beta acid content above the upper limit **x+s** (7.01% w/w) while, Saaz Brilliant (2.91% w/w) and Saaz Shine (3.37% w/w) had beta acid content below the lower limit **x-s** (3.85% w/w). It needs to be emphasized that the Czech bitter varieties Vital, Gaia, and Boomerang were characterized by a high beta acid content. This influenced the high average beta acid content in the group, resulting in the aromatic varieties Saaz Brilliant and Saaz Shine having a lower beta acid content within the dataset.

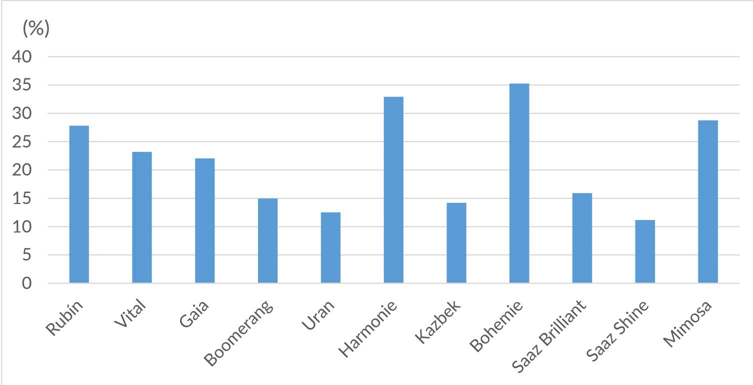

Figure 2 *Variability of hop yields (Chrášťany, 2018–2022)*

The variety Rubín (3.00) had the highest alpha/beta acid ratio and was the only one above the upper limit **x+s** (2.30). Among the bitter varieties, Vital (1.68) had the lowest alpha/beta acid ratio. The variety Mimosa (0.29) had the lowest alpha/beta acid ratio and, at the same time, was below the lower limit **x-s** (0.89), nearly reaching the limit **x-2s** (0.18). Mimosa was characterized by low alpha acid content and, on the other hand, it had high beta acid content. For this reason, many breweries use it for dry hopping.

The results indicated that the variety Kazbek had the highest average cohumulone content (36.67% rel.), and it was the only one above the upper limit **x+s** (31.02% rel.). Boomerang and Mimosa had an average cohumulone content above 30% rel. The variety Harmonie had the lowest average cohumulone content (21.08% rel.) and was the only one that met the criterion below the lower limit **x-s** (21.75% rel.).

The new aromatic varieties Saaz Brilliant and Saaz Shine had a higher average alpha acid content than reported by Nesvadba et al. (2020c), who evaluated these varieties at 6 locations from 2005 to 2019. Saaz Brilliant had an average alpha acid content of 3.77% w/w, and Saaz Shine had 3.56% w/w, while Mimosa had an average alpha acid content of 1.90% w/w. It should be mentioned, the opposite was observed for beta acids in the years 2005 to 2019, where Saaz Brilliant had an average beta acid content of 2.75% w/w, Saaz Shine 2.95% (w/w), and Mimosa 6.07% w/w.

The results indicate that, compared to Mimosa, the dry region was more favourable for aromatic varieties Saaz Brilliant and Saaz Shine. The findings of alpha acid content correlated with the results of Nesvadba et al. (2020b) from 2010 to 2019, where all mentioned varieties had almost identical average alpha acid content, except for Harmonie, which had an average alpha acid content of 7.00% w/w.

3.4 Variability of bitter acids of hop varieties tested

Table 2 presents the variability of hop resin content and composition. The values marked in grey in the table are above the **x+s** limit or below the **x–s** limit. The values in bold were above the **x+2s** limit. From the obtained results, it is evident that the Harmonie variety exhibited the highest variability in all observed parameters, which was consistently above the **x+2s** limit. Except for the alpha/beta acid ratio, where both, Harmonie and Mimosa varieties had variability above the **x+s** limit (25.80%). The results confirmed that the Harmonie variety was not unequivocally suitable for the dry region. In terms of alpha acid content, the Rubín, Saaz Shine, and Bohemie varieties had variability above 20%, while Uran and Gaia varieties had variability below 10%. Uran was the only variety with variability in beta acid content below the **x–s** limit (7.26%), at 6.28%, as well as the alpha/beta acid ratio below the **x–s** limit (10.38%), at 5.72%. Regarding beta acid content, all varieties (except Harmonie) had variability below 20%. For the alpha/beta acid ratio, the Bohemie, Saaz Shine, and Kazbek varieties had variability above 20%, while Boomerang, Rubín, Saaz Brilliant, and Gaia varieties had variability below 15%. All varieties (except Harmonie) had variability in the cohumulone ratio below 10% relative. It is interesting that the Mimosa variety had the lowest variability in the cohumulone ratio, at only 3.79%.

Among the bitter varieties, Gaia and Uran exhibited the best parameters of alpha acid content and its variability. Vital and Boomerang also showed good characteristics in terms of hop resin content and composition. Only the Rubín variety exhibited higher variability in the dry region. All aromatic varieties showed hop resin contents and compositions within the range specified by the Czech Hop Varieties Atlas (Nesvadba et al., 2022). Only the Harmonie variety demonstrated very high variability in the dry region.

3.5 Hop head aroma of varieties tested

Table 3 provides the evaluation of hop aroma during the five-year cultivation period. The most intense hop aroma was found in the Vital, Gaia, Saaz Brilliant, and Saaz Shine varieties. Uran, Harmonie, and Mimosa displayed a medium intensity of herbal aroma. The Mimosa variety was characterized by a high intensity

Table 1 *Average content and composition of hop resins (Chrášťany, 2017–2022).*

Variety	Alpha acid (% w/w)	Beta acid (% w/w)	Ratio alpha/beta	Cohumulone (% rel.)
Rubín	12.35	4.10	3.00	27.78
Vital	12.11	7.34	1.68	21.77
Gaia	14.66	7.63	1.94	23.75
Boomerang	12.73	6.68	1.91	30.80
Uran	13.53	5.96	2.27	24.30
Harmonie	5.81	4.76	1.17	21.08
Kazbek	6.29	4.85	1.31	36.67
Bohemie	6.54	6.68	0.99	24.62
Saaz Brilliant	4.75	2.91	1.63	23.43
Saaz Shine	4.51	3.37	1.35	25.77
Mimosa	1.56	5.49	0.29	30.27
x	8.62	5.43	1.59	26.39
s	4.505	1.583	0.709	4.639
Vk	52.26	29.14	44.47	17.58
x+s	13.13	7.01	2.30	31.02
x-s	4.12	3.85	0.89	21.75
x+2s	17.63	8.60	3.01	35.66
x-2s	-0.39	2.27	0.18	17.11

Table 2 *Average variability of hop resin content and composition (Chrášťany, 2017–2022).*

Variety	Alpha acid (%)	Beta acid (%)	Ratio alpha/beta (%)	Cohumulone (%)
Rubín	22.81	17.11	11.64	7.00
Vital	13.50	16.79	19.10	5.24
Gaia	8.61	9.78	13.22	5.44
Boomerang	11.31	10.25	11.85	4.87
Uran	6.16	6.28	5.72	4.96
Harmonie	**59.02**	**38.18**	**30.86**	**16.07**
Kazbek	18.67	13.61	20.75	5.68
Bohemie	20.41	11.78	25.58	7.75
Saaz Brilliant	17.81	14.97	12.56	4.05
Saaz Shine	22.46	18.83	21.33	5.88
Mimosa	15.76	13.99	26.40	3.79
x	19.68	15.60	18.09	6.43
s	14.140	8.336	7.711	3.398
Vk	71.83	53.45	42.62	52.85
x+s	33.82	23.93	25.80	9.83
x-s	5.54	7.26	10.38	3.03
x+2s	47.96	32.27	33.51	13.23
x-2s	-8.60	-1.00	2.67	-0.37

of fruity and citrus aroma. Kazbek exhibited a distinct citrus aroma. Only the Rubín and Bohemie varieties showed a medium intensity of floral aroma. Boomerang and Uran had a high intensity of spicy aroma, and they were the only ones with a woody aroma. Saaz Brilliant and Mimosa displayed a grassy aroma. The aroma evaluations are almost consistent with the Czech Hop Varieties (Nesvadba et al., 2022), with slight differences for these varieties:

- Vital – higher intensity of floral aroma;
- Rubín – higher intensity of fruity aroma;
- Harmonie – lower intensity of spicy aroma;
- Bohemie – lower intensity of spicy aroma;
- Mimosa – higher intensity of fruity aroma.

4 Conclusion

Testing of hop varieties in the dry area of the Rakovník part of the Žatec region brings significant benefits to hop growers who are not able to apply irrigation. In the dry area of Chrášťany, Czech hop varieties exhibit high diversity in performance and performance parameter stability. The results unequivocally indicate that the Harmonie variety is not suitable for the dry region, as it has the lowest hop yield and very high variability in both yield and hop resin content. Furthermore, the Vital, Kazbek, Bohemie, and Mimosa varieties are also unsuitable for this area, as they show either low yields or high yield variability. On the other hand, the bitter varieties Gaia and Uran are highly suitable for the dry region. In terms of alpha acid performance, these varieties produce 383 kg of alpha acids per hectare (Uran) and 342 kg of alpha acids per hectare (Gaia). Among the aromatic varieties, the Saaz Shine variety clearly exhibits the best characteristics, with a very high yield of 2.76 t/ha and a low variability of 11.17%. The Saaz Brilliant variety also shows good performance with a yield of 2.13 t/ha and a variability of 15.91%. In 2019, the first partial evaluation of this field trial was conducted, where the Saaz Shine variety showed a hop yield of almost 2.5 t/ha and the Saaz Brilliant variety 2.0 t/ha. As a result, these hop varieties have been planted on an area of nearly 1.5 ha. Since 2020, brewing tests have been conducted in several microbreweries (e.g., Pioneer Žatec, Cobolis Prague, Hauskrecht Brno, Nomád Děčín, Máša Řevničov, Proud Plzeň, Moravia Brno, Pivovar Prokopák, etc.) and also larger breweries (e.g., Zichovec, Holba Hanušovice, Zubr Přerov, Dudák Strakonice, etc.). The results conclusively indicate that some new Czech hop varieties will be suitable for both cultivation in dry regions and for Czech breweries.

5 Acknowledgement

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Table 3 *Evaluation of hop head aroma (Chrášťany, 2018–2022).*

Variety	Hoppy	Herbal	Fruity	Citrusy	Floral	Spicy	Grassy	Woody
Rubín	medium	low	none	none	medium	medium	none	none
Vital	high	low	medium	none	low	none	none	none
Gaia	high	low	low	none	low	medium	none	none
Boomerang	medium	low	none	none	low	high	none	medium
Uran	low	medium	low	none	none	high	none	high
Harmonie	medium	medium	low	none	low	low	none	none
Kazbek	low	low	low	high	none	low	none	none
Bohemie	medium	low	low	none	medium	low	none	none
Saaz Brilliant	high	low	none	none	low	low	low	none
Saaz Shine	high	none	low	low	low	none	none	none
Mimosa	low	medium	high	high	low	none	low	none

where (dark green) means high intensity of aroma;
(medium green) means medium intensity of aroma;
(light green) means low intensity of aroma;
(white) means no intensity of aroma.

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